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The Use of Multimethodology in Operational Research Practice Supporting Strategic Decision-Making:

Prevalence, Methods, Designs, and Causal Mechanisms

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[dstl]

In memory of my father, who always thought that writing a book would be a good thing to do, and who taught me the phrase, 'You have to play the cards you're dealt'.

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ABSTRACT

Recently, there has been renewed and significant interest amongst both operational research (OR) academics and practitioners in how qualitative analysis methods (such as problem structuring methods) can be used with quantitative analysis methods (such as optimization and simulation) to address complex, strategic issues with stakeholders. However, multimethodology – a term commonly used in OR and systems thinking to describe the use of multiple methods or methodologies within the same project or intervention – is a critical aspect of OR where there is a persistent gap between OR literature and OR practice in non-academic settings. While OR is widely used to tackle important problems in UK government, and it is claimed that UK government practitioners commonly combine qualitative and quantitative OR analysis methods, this is an area of practice where we have few published examples. Further, OR literature sets out a range of influences on practitioner method choice and several reasons (benefits and rationales) for using multimethodology, as well as barriers and challenges. However, there is a lack of empirical evidence of the *process* by which practitioners choose and combine methods, including the extent to which they use the many theoretical frameworks and typologies for multimethodology found in OR literature. In this dissertation, I present a new review of the prevalence of use of qualitative with quantitative OR, report a new set of six multimethodological designs (forms of multimethodology) that may be more widely applicable across OR practice and mixed methods research, and enhance understanding of the use of multimethodology in OR practice by investigating over 100 decision support interventions supporting strategic decision-making for or on behalf of the UK government. I present and analyse, using descriptive statistics and thematic analysis, 104 cases of multimethod intervention from a survey of 54 practitioners conducted for understanding the research context. I then present a multiple case study, with in-depth, comparative study of five interventions using a multimethod approach that includes insights from project documents and 50 interviews with practitioners and their clients and collaborators. Overall, this applied research provides understanding of theoretical frameworks and terminology for multimethodology, and empirical evidence from this research context of the prevalence of multimethodology, methods used and not used, how, and why, all of which can be employed to ground scholarship on multimethodology, and to support and inform future OR practice, training, apprenticeships, and education. The research adds unique, empirical insights to the growing body of evidence that multimethod practice is commonplace in non-

academic settings, and necessary for addressing complex, real-world issues. Moreover, for the multiple case study, and for the first time as far as I am aware, I operationalize critical realism for evaluating the practice of multimethodology in OR. I develop a new, theory-informed, critical realist analysis of a generic multimethodological OR intervention, synthesizing existing empirical research and theories in OR and recent developments in philosophy and social science. I employ the theoretical framework in aiming towards a more theory-informed, causal understanding of why OR practitioners use the methods and methodological designs they do, explaining the context and complex process of practitioners' methodological decisions using rich description, and structural and causal analysis. This new theoretical and methodological approach for evaluating multimethodological practice, developed and employed through the dissertation, can be extended in future in OR to investigate causal mechanisms leading to other individual and collective actions, and intervention outcomes including intervention success. It can also be used across other disciplines to theorize research design and evaluate mixed methods research projects, including their complexity and practical utility.

Keywords: critical realism, evaluation, method choice, multiparadigm multimethodology, OR in government, wicked problems

RESEARCH IMPACT

Publications

Articles (to date)

Christie, J. S., Mingers, J., Kotiadis, K., & Parr, M. (2024). *A new critical realist approach for evaluating multimethodological practice in operational research* [Manuscript under review, European Journal of Operational Research [ABS 4]]. Kent Business School, University of Kent.

Abstract

Understanding why practitioners and other individuals take the actions they do in operational research (OR) interventions, and the effects these actions have, is fundamental for evaluating and improving OR practice over time. But it is widely recognized in OR literature and amongst practitioners that objective, comparative evaluation of interventions is challenging if not impossible. Evaluation of multimethodology in OR practice is a recent development, and it is not clear how it should be undertaken. Critical realism has been advocated for exploring causation to evaluate OR interventions holistically, but not operationalized for such empirical research. For our collaborative research project evaluating multimethodological practice outside academia supporting strategic decision-making, we therefore needed to develop a new approach. In this paper, we explicate our theoretical framework – a critical realist analysis of a generic multimethodological OR intervention that builds on existing empirical research and theories in OR and recent developments in philosophy and social science – and empirical research design. We illustrate our development and employment of this new approach with a case – an analysis for a business case for future government investment in a national capability – showing how we investigated the complex process of practitioners' choice of methods and the intervention context using rich description, and structural and causal analysis. The new approach can be extended in future in OR to examine causal mechanisms leading to other individual and collective actions in interventions, and outcomes including intervention success, and to theorize and evaluate mixed methods research projects across other disciplines.

Keywords: Behavioural OR; Critical realism; Multimethodology; Wicked problems; OR in government

Phillips, C. J., Christie, J. S., Smith, C. M., Yearworth, M., & O'Brien, F. A. (2022). Celebrating the contribution of Robert Dyson to soft OR and problem structuring methods and looking to the future of the field. *Inside OR*, *621*, 10-11. https://www.theorsociety.com/media/7096/inside-or-dec-2022.pdf

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Book chapter (peer-reviewed)

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Internet publication

Christie, J. S., Jayakody, S., & Etokakpan, I. (2021). Talking together: The Kent Business School Research Colloquium. *The GradPost, Summer 2021*, 18. https://media.www.kent.ac.uk/se/20528/TheGradpostSummer2021.pdf https://kar.kent.ac.uk/92620

Presentations

Christie, J. S., Mingers, J., & Kotiadis, K. (2022). *Using problem structuring methods with quantitative OR: Six methodological designs*. 64th Annual Conference of the Operational Research Society (OR64), Warwick, UK. https://theorsociety.eventsair.com/or64-annual-conference/programme https://kar.kent.ac.uk/95264

Christie, J. S. (2017). *Supporting strategic decision-making in the UK government: Realizing benefits from the use of multi-methodology*. 11th NATO Operations Research and Analysis (OR&A) Conference, London, UK. https://kar.kent.ac.uk/97264

Christie, J. S. (2017). *Choosing and combining problem structuring methods in practice*. 21st Triennial Conference of the International Federation of Operational Research Societies (IFORS 2017), Québec City, Canada. https://ifors.org/wp-content/uploads/2019/08/program-ifors2017-Quebec.pdf https://kar.kent.ac.uk/90277

Posters

Christie, J. S. (2017). *Supporting strategic decision-making by executives in the UK government: Use of mixed methods by operational research practitioners*. University of Michigan Mixed Methods Research and Scholarship Program Summer Workshop 2017, Ann Arbor, USA. https://kar.kent.ac.uk/97249

Christie, J. S. (2016). *Supporting executive decision-making in UK government: Use of multi-methodology*. Assessing the Impact of Cabinet Decision Making on Public Policy Workshop, Kent, UK. https://kar.kent.ac.uk/97254

Christie, J. S. (2016). *Supporting executive decision-making in UK government: Use of multi-methodology*. 5th Annual Conference of the ESRC South East Doctoral Training College, Reading, UK. https://kar.kent.ac.uk/97253

Christie, J. S., & Parr, M. (2016). *Consulting with executives in UK government: Use of multi-methodology*. 33rd International Symposium on Military OR (33 ISMOR), London, UK. https://kar.kent.ac.uk/97265

Practical impact

To date, the following practical impact is noted:

1. Preliminary survey results on methods practitioners use were an input to a Defence Science and Technology Laboratory (Dstl) review of training of practitioners.
2. Preliminary survey results on the prevalence and success of multimethodology, and why practitioners combine methods in practice, were used in training materials for senior civil servants in UK Government.
3. My open access, peer-reviewed book chapter introducing the practice of multimethodology in operational research (Christie, 2023) has been used for training individuals for the UK Systems Thinking Practitioner Apprenticeship.
4. At the time of writing, this dissertation is being used for producing training material to improve understanding and use of multimethodology at Dstl.[1]

[1] Exploitation of empirical results will take into account that survey and multiple case data reported in this dissertation were collected in 2016 and 2017.

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LIST OF ABBREVIATIONS AND ACRONYMS

3Ws	Three aspects of the World – social, personal, material
4As	Four stages of an OR intervention – Appreciation, Analysis, Assessment, Action
ABM	Agent-Based Modelling
ABS	Agent-Based Simulation
AHP	Analytical Hierarchical Processing
ANP	Analytical Network Process
AIDA	Analysis of Interactive Decision Areas
BCG	Boston Consulting Group [matrix]
BOR	Behavioural Operational Research
BSC	Balanced Scorecard
C	Intervention Context
CATWOE	Customers, Actors, Transformation process, Worldview, Owners, Environmental constraints
CBA	Cost-Benefit Analysis
CMO	Context-Mechanism-Outcome
CMOC	Context-Mechanism-Outcome Configuration
COSO	Committee Of Sponsoring Organizations of the Treadway Commission [model]
CR	Critical Realism / Critical Realist
CSH	Critical Systems Heuristics
CSP	Critical Systems Practice
DA	Decision Analysis
DEA	Data Envelopment Analysis
DES	Discrete-Event Simulation
DG(S&A)	Director General (Scrutiny and Analysis) [UK Ministry of Defence]
DPSIR	Drivers, Pressures, States, Impacts, Responses [framework]
DSPSM	Decision Support and Problem Structuring Methods
DSS	Decision Support System
DSTL	The Defence Science and Technology Laboratory [UK]
Dstl	The Defence Science and Technology Laboratory [UK]
EFQM	European Foundation for Quality Management
EJOR	European Journal of Operational Research
ERD	Entity Relationship Diagram
ESRC	Economic and Social Research Council
FR	Franco and Rouwette (2022)
FMA	Framework of ideas, Methodology, Area of concern
GORS	The Government Operational Research Service [UK]
HA	Historical Analysis
HEO	Higher Executive Officer

HPM	Hierarchical Process Modelling
IFATE	The Institute for Apprenticeships and Technical Education [UK]
IFORS	The International Federation of Operational Research Societies
INFORMS	The Institute for Operations Research and the Management Sciences [US]
IP	Interactive Planning
IRS	Intellectual Resources System
IS	Information Systems / Intervention System (in Figure 43)
IT	Information Technology
JORS	Journal of the Operational Research Society [UK]
LST	Liberating Systems Theory
LP	Linear Programme/Programming
M	Available Methodologies and Methods
MADM	Multi-Attribute Decision Making
MCDA	Multi-Criteria Decision Analysis
MM	Munro and Mingers (2002, 2004)
MMR	Mixed Methods Research
MOD	Ministry of Defence [UK]
NAP	Non-Academic Practitioner
NATO	North Atlantic Treaty Organization
NGT	Nominal Group Technique
NPV	Net Present Value
OA	Operational Analysis
OB	O'Brien (2011)
OR	Operational Research
OR/MS	Operational Research/Management Science
ORS	The Operational Research Society [UK]
P	Intervention Participants
PCF	Participant Consent Form
PCS	Problem Content System
PEST	Political, Economic, Social, Technological [analysis]
PESTLE	Political, Economic, Social, Technological, Legal, Environmental [analysis]
PIS	Participant Information Sheet
Ppt	Participant
Prjt	Project
PSM	Problem Structuring Method
PSR	Public Sector Respondent
Q	Question
q	Question
RACI	Responsible, Accountable, Consulted, and Informed [analysis]
RAND	RAND Corporation [US]
RFH	Ranyard et al. (2015)

RQ	Research Question
RRRIREI(C)	Resolution, abductive Redescription, Retroduction, Inference to the best explanation, Retrodiction, Elimination, Identification of antecedents, Correction
S	Intervention Stakeholders
SADT	Structured Analysis and Design Technique
SA	Systems Analysis
SADT	Structured Analysis and Design Technique
SAST	Strategic Assumptions Surfacing and Testing
SCA	Strategic Choice Approach
SCS	Senior Civil Servant
SD	System Dynamics
SE	Systems Engineering
SEO	Senior Executive Officer
SME	Subject Matter Expert
SNA	Social Network Analysis
SODA	Strategic Options Development and Analysis
SODA-T	Strategic Options Development and Analysis of [SSM] Transformations [maps]
SOSM	System of Systems Methodologies
SS	C. M. Smith and Shaw (2019)
SSM	Soft Systems Methodology
STS	Socio-Technical Systems [thinking]
SWOT	Strengths, Weaknesses, Opportunities, Threats [analysis]
TOC	Theory Of Constraints
TS	Team Syntegrity
TSI	Total Systems Intervention
VM	Vanguard Method
VSM	Viable System Model
WEF	Workshops/Elicitation/Facilitation
YW	Yearworth and White (2014)

1 INTRODUCTION

1.1 INTRODUCTION

In this short chapter I introduce the research project, the collaboration partner, the research topic, and the chapters of this dissertation.

1.2 THE RESEARCH PROJECT:

Executive Decision-Making in Complex and Dynamic Environments

The research project was initiated by Martin Parr (Defence Science and Technology Laboratory [Dstl]) and John Mingers (Kent Business School) as a collaboration between a UK government department and the University of Kent to investigate the use of operational research (OR) and other analysis methods by practitioners. It was to focus on how quantitative and qualitative analysis methods are chosen and combined to deal with complex, ill-defined issues described as wicked problems (Rittel & Webber, 1973). These issues were characterized as situations in which evidence for executive decision-making was lacking, whether due to lack of data, or in relation to future scenarios, and where there was a need to balance conflicting objectives, for example, cost-cutting *and* providing a range of services (Parr & Mingers, 2015). In this research, practitioners' use of more than one method or methodology within the same project or intervention is referred to as multimethodology after Mingers and Brocklesby (1997) and Mingers and Gill (1997).[2] The aim of the research project was to evaluate the use of multimethodology in some example projects supporting executive decision-making in complex and dynamic environments.

1.3 THE COLLABORATION PARTNER:

The Defence Science and Technology Laboratory

> The OR capability within Dstl [the Defence Science and Technology Laboratory] helps decision makers and stakeholders across MOD [the Ministry of Defence] and wider Government with complex policy, planning and operational problems using analytical methods and techniques. It enables and supports evidence-based decision making on issues ranging from strategic policy setting, through overall balance-of-investment and trade-off analysis and support to specific capability procurements, to direct support to strategic and operational decisions related to ongoing military operations. (A. P. Robinson, 2023, p. 12)

[2] Single projects are referred to as interventions in OR. Unless otherwise stated, I use the terms project and intervention interchangeably in this dissertation.

I undertook this ESRC CASE PhD in collaboration with the Defence Science and Technology Laboratory, an executive agency of the UK's Ministry of Defence (MOD; The Defence Science and Technology Laboratory [DSTL], 2023b). Dstl's strapline is, 'the science inside UK defence and security, providing operational advantage and world-leading capabilities' (DSTL, 2023b, p. 6).

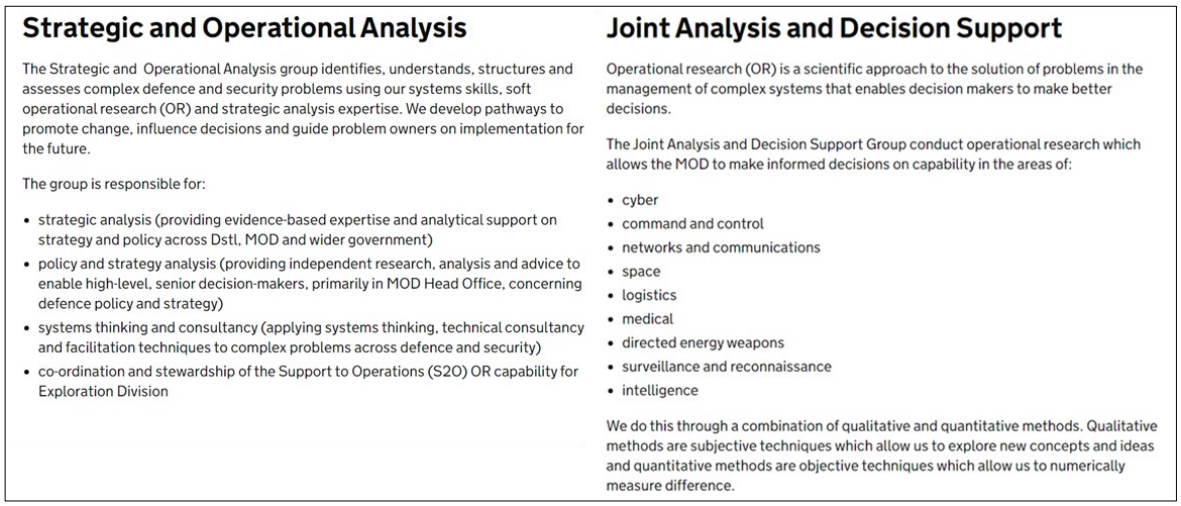
The UK faces a huge range of complex, interrelated, global and political issues (UK Government, 2021, 2023; MOD, 2018), and 'the pace of change continues to accelerate' (McLean, in MOD, 2020, p. 1). When making decisions regarding national security and defence, UK government ministers and other executive decision makers, particularly in the MOD, commission advice from Dstl (DSTL, 2023b, 2023d).

The context in which Dstl provide advice is complex and political, with rapid technological change, uncertainty, incomplete data, differing views, multiple dependencies and resource constraints, such as time and money (Collander-Brown, 2016; Hallsworth et al., 2011). There are many interrelated dimensions at play, with decisions taken at different points in time by different parties as issues develop, dynamically shaping issues as each party sees them. At the same time, defence decisions have their own impacts, and can constrain other decisions for decades (Solly, 2015). For example, in military requirements planning,

> The complexity of the problem covers the following issues: (1) uncertain context; (2) knowledge of system is incomplete; (3) some systems are inherently uncertain; (4) systems is subject to reflexive change across interactive sets of actors; (5) gaming is inherent; and (6) addressing systems change to gain an advantage results in the system being in perpetual flux. (The Grantham Institute, 2016, p. 11, summarizing Collander-Brown, 2016)

In this context, practitioners at Dstl provide evidence-based consulting, alongside partners in industry and academia, to support and enhance operational, strategic and policy decisions, and to provide accountability (Bourn, 2004; HM Treasury, 2015). Around 40% of Dstl's services are subcontracted (DSTL, 2023b, p. 20), including through the analysis for science and technology research in defence (ASTRID) framework (DSTL, 2023a). Dstl practitioners and their partners use a diverse range of methods and methodologies from OR (or OA, operational analysis, as they call it, including systems thinking) and other disciplines (including management/strategy; Forder, 2004; P. Jones, 2015; P. Jones & Forder, 2013; Morrill, 2007; A. P. Robinson et al., 2004). An introduction to Dstl's use of OR methods and multimethodology, with examples, written at the outset of this

doctoral research, is at Appendix A. Example applications are in Figure 1 below. In fact, OR has the status of one of around 20 strategic capabilities at Dstl and the MOD (DSTL, 2023b, p. 9).



Strategic and Operational Analysis

The Strategic and Operational Analysis group identifies, understands, structures and assesses complex defence and security problems using our systems skills, soft operational research (OR) and strategic analysis expertise. We develop pathways to promote change, influence decisions and guide problem owners on implementation for the future.

The group is responsible for:

- strategic analysis (providing evidence-based expertise and analytical support on strategy and policy across Dstl, MOD and wider government)
- policy and strategy analysis (providing independent research, analysis and advice to enable high-level, senior decision-makers, primarily in MOD Head Office, concerning defence policy and strategy)
- systems thinking and consultancy (applying systems thinking, technical consultancy and facilitation techniques to complex problems across defence and security)
- co-ordination and stewardship of the Support to Operations (S2O) OR capability for Exploration Division

Joint Analysis and Decision Support

Operational research (OR) is a scientific approach to the solution of problems in the management of complex systems that enables decision makers to make better decisions.

The Joint Analysis and Decision Support Group conduct operational research which allows the MOD to make informed decisions on capability in the areas of:

- cyber
- command and control
- networks and communications
- space
- logistics
- medical
- directed energy weapons
- surveillance and reconnaissance
- intelligence

We do this through a combination of qualitative and quantitative methods. Qualitative methods are subjective techniques which allow us to explore new concepts and ideas and quantitative methods are objective techniques which allow us to numerically measure difference.

Sources: DSTL (2023c) and DSTL (2023d), used under Open Government Licence v3.0

Figure 1: Examples of use of OR by practitioners in two groups at Dstl

'Aiding strategic decision-making' is a key way in which Dstl 'understand, shape and deliver novel and cutting edge capabilities, concepts and impartial evidence-based advice that enhances UK defence and security' (DSTL, 2023b, p. 6). Practitioners at Dstl address strategic issues such as future requirements for UK forces and equipment, the development of planning scenarios, contingency and crisis support, and the outsourcing of capabilities (DSTL, 2015b). Practitioners have come to be consulted on strategic topics such as change management and organizational design, requiring a focus on decision support methods, and the development of context-specific, pluralist methodologies, rather than quantitative model-based analysis (Richardson et al., 2003).

At the outset of this doctoral research, recent reviews of UK government decision-making for defence had called for more strategic, transparent and accountable approaches (The House of Commons Defence Committee, 2015a, 2015b), and for peer review of the processes that lead to the provision of information and advice to executive decision makers (Walport, 2015). The specific problem that this collaborative doctoral research would serve for Dstl practitioners was how to choose and combine (qualitative and quantitative) analysis methods for supporting evidence-based, strategic decision-making.

1.4 THE RESEARCH TOPIC:

The Use of Multimethodology in Operational Research Practice

It has been more than ten years since multimethodology was described as, 'One of the most important developments to have emerged in the management science literature in recent years' (Franco & Lord, 2011, p. 362). Some scholars have since asserted that the use of multimethodology in OR, and in management and social science research more generally, is becoming a norm (Ackermann & Howick, 2022; Mingers, 2014, 2015). More recently, in a review of reports of practice involving problem structuring methods, multimethodology 'for dealing with complex unstructured problems' has even been described as 'a trendy topic' (Gomes Júnior & Schramm, 2022, p. 74).

In fact, the practice of multimethodology is widely recognized as an essential part of the OR practitioner's role in addressing complexity (Ackermann & Howick, 2022; Dyson et al., 2021; French, 2022; Hämäläinen et al., 2013; Jackson, 2019; Mingers & Brocklesby, 1997; North Atlantic Treaty Organization [NATO], 2012a, 2012b; Ranyard et al., 2022; Wright et al., 2019). Yet multimethodology is a critical aspect of OR where 'the gap between academic research and practice' (Ranyard et al., 2015, p. 12, following Ackoff, 1979; Corbett & Van Wassenhove, 1993; G. C. Jones, 1993) persists.

It was also more than ten years ago that Howick and Ackermann (2011) concluded from their literature review that,

> … on reviewing this body of work [on mixing OR/management science methods] there appears to be little discussion between members of the community on the generic lessons that could be identified from mixing methods in practice. The extant literature is either focussed on the lessons learnt when applying specific mixed forms or, on the theoretical considerations of combining methods and possible frameworks. (p. 503)

Since then, there has been significant progress in OR literature in examining how specific methods and methodologies can be used together (Ackermann et al., 2014; Brocklesby, 2023) and in particular contexts (Christie, 2017a). Examples include problem structuring for multi-criteria decision analysis (MCDA) in environmental management (e.g., Ferretti, 2016; Lienert et al., 2013, 2015; Marttunen et al., 2017; Scholten et al., 2015) and hybrid simulation in health (e.g., Currie et al., 2020; Kar et al., 2024; Lamé et al., 2019; Nguyen et al., 2024; Tako & Kotiadis, 2015, 2018; Viana et al., 2014).

However, as Ackermann and Howick (2022) note in their recent interview study of experienced mixed modellers (focusing on insights relating to modelling teams), evaluations of multimethodology in practice that followed Howick and Ackermann's (2011) literature review, insightful though they are, have tended to focus on single cases. Although Ackermann and Howick do not mention them, more recent *literature reviews* have tended to focus on single case studies of the use of particular methodologies in and beyond OR (e.g., Abuabara & Paucar-Caceres, 2021; Hanafizadeh & Mehrabioun, 2018; Marttunen et al., 2017; Zolfagharian et al., 2018), while more recent *surveys* have revealed more of what non-academic OR practitioners do, but with less or no detail of single multimethodological projects (e.g., O'Brien, 2011; Ranyard et al., 2015). And tellingly, to review extant insights into the complex *process* of the practice of multimethodology across OR projects and methods, Ackermann and Howick (2022) return to Munro and Mingers' (2002) survey of the use of multimethodology in OR/systems practice – now more than twenty years old – and their own (2011) literature review.

Thus, while practitioners continue to ask how to choose and combine methods (hence this research project), including how to plan interventions and procedures in advance (e.g., Van Antwerpen & Curtis, 2016), we still lack understanding of the use of multimethodology across OR practice (Ackermann & Howick, 2022; Brocklesby, 2023; Christie, 2023; Howick et al., 2017; J. S. Morgan, 2013; Midgley et al., 2013; Wijnmalen & Curtis, 2013). More specifically, there continues to be a lack of understanding of how practitioners make methodological decisions, and limited understanding of multimethodological practice outside academic settings.

Therefore, with this research I aim to enhance understanding of the use of multimethodology in OR practice. Across multiple decision support interventions supporting strategic decision-making for or on behalf of the UK government, I explore how and why OR practitioners choose and combine OR methods.

As is characteristic of OR, this is applied research, linking theory and practice. This dissertation provides empirical evidence that can be used to support and inform future OR practice, training, and education, as part of longer-term capability building at Dstl and beyond.

1.5 THE DISSERTATION:

The Use of Multimethodology in Operational Research Practice Supporting Strategic Decision-Making: Prevalence, Methods, Designs, and Causal Mechanisms

The remainder of the dissertation is organized as follows. In chapter 2, I review literature on the practice of OR, methods used and combined, method choice, and multimethodology – its terminology, forms, benefits and challenges, and theoretical frameworks. I identify opportunities for future research and set out my research questions.

In chapter 3, I set out, using Checkland's (1985) FMA model, the key theoretical and philosophical ideas I used in crafting and responding to the research questions. I review my philosophical assumptions, and introduce my theoretical framework, which is a theory-informed, critical realist analysis of a generic OR intervention. The framework builds on existing theory in OR and recent developments in philosophy and social science, including De Souza's (2013, 2022) elaboration of Pawson and Tilley's (1997) context-mechanism-outcome (CMO) heuristic in realist evaluation.

In chapter 4, I describe and justify my empirical research design, using Bhaskar's (2016) RRRIREI(C) model of exploratory investigation.

In chapter 5, I present results from a survey of practitioners supporting strategic decision-making for or on behalf of the UK government, responding to the following research questions:

RQ1. How do OR practitioners choose and combine OR methods to support strategic decision-making?

RQ2. Why do practitioners take these approaches, multimethodological or otherwise?

In chapter 6, I respond to the above research questions with results of a multiple case study – an in-depth, comparative study of five interventions. I aim towards a more theory-informed, causal understanding of why practitioners use the methods and methodological designs they do.

In chapter 7, I discuss my findings (empirical, theoretical and methodological). In chapter 8, I then review limitations of the studies and future research opportunities, and summarize my research contributions to academia and practice, before concluding the dissertation.

2 LITERATURE REVIEW

2.1 INTRODUCTION

In chapter 1, I introduced the research project and the topic of this dissertation – the use of multimethodology in operational research practice – as well as the dissertation itself. In this chapter, I explore in detail literature on the practice of OR – specifically, methods used and combined, method choice, and multimethodology – its terminology, forms, benefits and challenges, and theoretical frameworks. I examine in detail existing studies and theories about how and why OR practitioners choose and combine methods. I then review the research gap identified and set out my research questions.

2.2 METHODS USED

> Typically, Operational Research Specialists will structure complex non-routine problems and formulate specific research questions. They will address these questions by evaluating and implementing approaches from the range of existing models, methods and techniques, developing and adapting these methods and adopting methods from other fields where existing approaches are insufficient. (The Institute for Apprenticeships and Technical Education [IFATE], 2020c, para. 4)

2.2.1 Operational research methods

OR has a rich history of practitioners developing, adapting, and using methods, including from other disciplines (Abdel-Malek et al., 1999; Ranyard et al., 2015; A. P. Robinson et al., 2004; Tolk et al., 2021), to analyse and model real-world issues in support of organizational and policy decision-making. For an introduction to the discipline and practice of OR as it relates to this research, and to the history of and need for methodologically plural (quantitative and qualitative), multi-disciplinary approaches for addressing complex, real-world issues, see Appendix B. In fact, a very wide range of methods have been used in OR – quantitative and/or qualitative, and with elements that can be used participatively (Petropoulos et al., 2024; Salhi & Boylan, 2022). OR methods include:

> ‘1. Optimization (including linear, non-linear, integer, goal and dynamic programming, and heuristics);
>
> 2. Simulation (including discrete-event [DES], continuous, agent-based [ABM]);

3. Network analysis (including critical path method); and,

4. Other stochastic modelling (including queuing theory and Monte Carlo methods)'

(Christie, 2023, p. 164, emphasis removed, after T. Williams, 2008);

5. Multi-criteria decision analysis (MCDA; Belton & Stewart, 2002; Keeney & Raiffa, 1976; L. D. Phillips & Bana e Costa, 2007);

6. Problem structuring methods (PSMs; Rosenhead, 1989; Rosenhead & Mingers, 2001a), 'qualitative/soft OR' more generally (Mingers & Rosenhead, 2011), and 'informal' methods and tools for generic problem structuring, such as checklists of questions (Pidd & Woolley, 1980; Woolley & Pidd, 1981); [3]

7. Systems thinking methods (Jackson, 2000, 2019; Midgley, 2003), such as system dynamics (SD; Sterman, 2000; Vennix, 1996), critical systems heuristics (CSH; Ulrich, 2005; Ulrich & Reynolds, 2020) and boundary critique (Midgley, 2000, 2023);

8. 'Management/strategy tools', such as benchmarking and scenario planning (O'Brien, 2011);

9. Business analytics (Hindle et al., 2020); and,

10. Gaming (Mayer, 2009; A. P. Robinson et al., 2004; Shephard, 1963).

Methods are employed in different ways by different OR practitioners working with different clients in different places, domains, and projects (Belton & Stewart, 2002; Corbett et al., 1995; Flood & Romm, 1997; Greene, 2015; Mingers, 2003a, 2011; Overmeer et al., 1998; Ranyard et al., 2015). As Christie (2021, p. 3) notes in her introduction to OR, 'Practitioners also use general research approaches, such as observation, questionnaires, and textual analysis for eliciting data for modelling, and must consider ethical aspects of their practice' (Lami & White, 2022; Ormerod, 2014b; Ormerod & Ulrich, 2013; Reisach, 2016). PSMs and critical methods (such as critical systems heuristics and

3 In defence, so-called 'soft OR' is also known as judgement-based OR, or subjective operational analysis (NATO, 2012a). 'Soft OR' is alternatively defined as qualitative intervention, with PSMs being the qualitative methodologies used within soft or mixed OR practice (Dyson et al, 2021).

boundary critique) are advocated for addressing ethical issues in intervention (Mingers, 2011; Ormerod & Ulrich, 2013), in method choice for interventions (Brocklesby, 2009), and in participative decision-making in interventions (Lami & White 2022).

2.2.2 Practitioner surveys

There is a history of surveying OR practitioners – and sometimes executives – about the methods they know about and use (Abdel-Malek et al., 1999; Bernroider & Schmöllerl, 2013; Clark & Scott, 1995, 1996; Fildes & Ranyard, 1997; Fildes et al., 1999; Henao et al., 2017; Ledington & Donaldson, 1997; Mingers & Taylor, 1992; Munro & Mingers, 2002, 2004; O'Brien, 2011; Ranyard et al., 2015; Stenfors et al., 2007). From responses to the most recent global survey of OR practice for IFORS (The International Federation of Operational Research Societies), conducted in 2008 and 2009, Ranyard et al. (2015) concluded that (by far) the ten techniques used (at least once per year) by the most OR practitioners, 'show little difference from earlier surveys: spreadsheets, statistics, optimisation, strategic planning tools, simulation and forecasting lead the way' (p. 5; Table 1 below). Ranyard et al. (2015) comment,

> … many OR (and related) techniques are used, at least occasionally, by most respondents. Respondents were also asked to note any additional techniques they used that were not on the pre-selected list but few did so and only two were mentioned more than once, Theory of Constraints (two mentions) and Mind Maps (two mentions). … The remaining techniques starting with the 11th, risk analysis, are noticeably less frequently used. The mean (and median) number of techniques used by the respondents is 11 from the 23 listed (where PSMs were counted as a single technique). (p. 5)

Using cluster analysis, Ranyard et al. concluded that 38% of respondents were regular users of 'Traditional [quantitative] OR', 31% were regular users of 'Decision Support/PSM' techniques, 25% were regular users of 'Business Analytics' methods, and 39% were 'Not engaged with any particular tool set' (p. 9).

Similarly, some years before, Munro and Mingers (2002) had concluded from their survey of the use of multimethodology by mostly UK-based OR and systems practitioners that for 22 practitioner respondents 'not clearly based in academia' (NAPs; Munro & Mingers, 2004, p. 91), 'statistics, simulation, forecasting and mathematical modelling—are more extensively used and known about' (2004, p. 92), with statistics used by 95% of NAPs (Table 2 below).

Table 1: Top ten techniques in Ranyard et al. (2015)

[REDACTED]

Adapted from 'Fig. 1 Understanding and usage of OR and related techniques (top 10 techniques).' in Ranyard et al. (2015, p. 6)

Table 2: Top ten methods for non-academic practitioners in Munro and Mingers (2002, 2004)

[REDACTED]

Adapted from 'Figure 1 Usage of different methods.' in Munro and Mingers (2004, p. 91)

2.2.3 Introduction to strategic decision-making: dealing with wicked problems or messes

> Managers are not confronted with problems that are independent of each other, but with dynamic situations that consist of complex systems of changing problems that interact with each other. I call such situations *messes*. Problems are abstractions extracted from messes by analysis. (Ackoff, 1979, p. 99, *emphasis in original*)

As set out in sections 1.2 and 1.3 (chapter 1), this research is about OR support for strategic decision-making, where differing views, future uncertainties and multiple interdependencies are at play. Strategic issues are practical issues requiring analysis, persuasion, and judgement (Ravetz, 1971, as cited in Rosenhead & Mingers, 2001a). They are conceptualized in OR and management as complex and, after Rittel & Webber (1973), as tending to be, or at least partly, 'wicked' in nature (Camillus,

2008; Grewatsch et al., 2023; Mingers & Rosenhead, 2011). 'Wicked problems' are ill-defined, multi-stakeholder problems, that can only be understood and defined judgementally and concomitant with resolution. There are no definitive, objective, true or false solutions, and there is always more to understand. Goals are disputed and wicked problems 'rely upon elusive political judgment for resolution. ... At best they are only re-solved—over and over again' (Rittel & Webber, 1973, p. 160). Further, organizational decision-making tends to be dynamic and emerging from the addressing of linked issue streams over time (Langley et al., 1995), so that strategic issues can also be characterized as 'messes' (Ackoff, 1979).

2.2.4 Introduction to problem structuring methods

> In principle, PSMs [problem structuring methods] can provide analysts with greater access to strategic problems—those engaging multiple relatively independent decision makers. PSMs' transparent methods of representation can capture differing perceptions of the situation, to help generate a consensus or to facilitate negotiations. (Rosenhead, 1996, p. 117)

Supporting strategic decision-making by organizational executives is not new in OR (Figure 2). Dyson et al.'s (2021) research into the work of the founders of OR highlights early links between addressing complex, strategic issues in practice and use of qualitative approaches (so-called 'soft OR').

> Howard was interested in strategic executive decision making where there were little or no data—the problems that kept executives awake at night. (Dyson et al., 2021, p. 731)
>
> Rivett noted that, in general, the problems that management face are ill-defined; he also developed approaches to policy analysis where not only problems were ill-defined but there was additionally only fragmentary information. (Dyson et al., 2021, p. 731)
>
> Morse focused on the hazy interface between science and high-level policy decisions—the latter usually dealing with complex objectives that are sometimes jealously guarded by the egos and financial or political fortunes of decision makers. (Dyson et al., 2021, p. 731)

Figure 2: Founders of OR and strategic decision-making – examples from Dyson et al. (2021)

Problem structuring methods (PSMs; Rosenhead, 1989, 1992b, 1996; Rosenhead & Mingers, 2001a) are amongst qualitative OR methods developed to address wicked problems or messes in a systematic way (Christie, 2023; Dyson et al., 2021). Rosenhead and Mingers (2001a) summarize key

dimensions of such complex conditions, arguing that they present particular requirements for process and technical aspects of OR methods (Table 3 below) that are met by PSMs. Thus, by definition, PSMs are associated with dealing with strategic issues (see also Pidd, 2004b).

More recently, Yearworth and White (2014) compiled a set of rules (a generic constitutive definition) for considering whether methodological approaches in systems engineering constitute PSM use, while C. M. Smith and Shaw (2019) used a literature review to develop an alternative list of criteria for PSMs. For overviews, see Franco and Rouwette (2022) and Yearworth and White's '2.20. Soft OR and problem structuring methods' in Petropoulos et al. (2024, pp. 428-430).

Table 3: Complex conditions – process and technical requirements for methods (Rosenhead & Mingers 2001a)

[REDACTED]

Adapted from 'Table 1.4 – Swamp conditions – process and technical requirements' in Rosenhead and Mingers (2001a, p. 15)

The most popular examples of PSMs are soft systems methodology (SSM; Checkland, 1981, 1999; Checkland & Poulter, 2020; Checkland & Scholes, 1990, 1999), strategic choice approach (SCA; Friend et al., 1988; Friend & Hickling, 1987, 2005), and strategic options development and analysis (SODA; Ackermann & Eden, 2020; Eden & Ackermann, 1998; Eden et al., 1983). While three of the eight methodologies that Rosenhead (1996) categorizes as PSMs have 'strategic' in the name (strategic assumptions surfacing and testing [SAST], SCA, and SODA), 'strategic' refers to different aspects of decision-making in the different methodologies (Rosenhead, 1989). However, some PSMs were developed for supporting strategy development, including SODA and SCA (Ackermann, 2012),

and early applications of PSMs included strategy development in industry, government and communities (e.g., Ormerod, 1995).

Recently, there has been a revival of discussions of the so-called 'generic problem structuring' (Dyson et al., 2021, p. 735; Ranyard et al., 2022) by which practitioners increase their understanding of issues so they can formulate and define problems and questions to address, and start modelling (Pidd & Woolley, 1980; Woolley & Pidd, 1981). Dyson et al. (2021) argue,

> … even for hard modelling, the exploration with stakeholders, the structuring of the problem, the development of diagrammatic representations, and the choice of methodologies are crucial stages that deserve the explicit systematic exploration of problem structuring rather than ad hoc approaches that are not open to scrutiny and may well lack rigor. This structuring may not involve specific problem structuring methods but should certainly involve the process characteristics of soft OR and often diagrammatic models. (Dyson et al., 2021, p. 735)

In fact, PSMs can be used for this generic problem structuring (also referred to as problematisation or problem framing) *and* throughout interventions, including for tackling constructed problems (Colorni & Tsoukiàs, 2024; Mingers, 2017) and in supporting procedural rationality or 'debate, deliberation and direction' (Pidd, 2004b, p. 799). This is because,

> PSMs [problem structuring methods] provide structured ways of learning about a situation, including stakeholders and their objectives. They provide ways of generating, categorizing, and analysing qualitative data, building and reviewing models with stakeholders, generating ideas, and identifying and agreeing actions for improvement (e.g., see Emes et al., 2017, 2019). (Christie, 2023, p. 169)

Thus, it is argued that PSMs are particularly suitable for questions of strategy where decisions come to be judged based on future situations (Rosenhead, 1989).

2.2.5 Methods used to support strategy

> … this research [a survey of mostly UK OR practitioners supporting the strategy process] demonstrates that OR/MS practitioners are genuine strategic actors and therefore as a unit of analysis they are worthy of further more detailed research, both in terms of the nature of their involvement and their practices in supporting the strategy process within organisations. (O'Brien, 2011, p. 914)

A number of scholars have examined the use of OR for strategic development and planning (Bryant et al., 2011; Bryson, 2015; Dyson, 2000; Eden et al., 2009; Franco et al., 2011; Henao et al., 2017; Kunc & O'Brien, 2019; Meadows & O'Brien, 2005, 2020; O'Brien, 2011, 2015; O'Brien & Dyson, 2007; O'Brien & Meadows, 2013; Ormerod, 2006b; Torres et al., 2017). Of most relevance to this research, though now over ten years ago, O'Brien (2011) found in her survey that the methods most frequently used by OR practitioners in supporting the strategy process amongst UK public sector respondents

were project management and statistical analysis, followed by cost benefit analysis, financial analysis/modelling, brainstorming, forecasting, and risk analysis (Table 4 below). Compared with previous surveys of both OR practice generally, and of practice supporting strategy, O'Brien found greater use of management/strategy tools, such as brainstorming and SWOT (strengths, weaknesses, opportunities and threats) analysis. However, 'soft OR/MS tools' were used least, 'though two of the tools (cognitive mapping [from SODA] and SSM) received quite high awareness scores' (p. 917), with only 8% and 13% of respondents, respectively, reporting they had never heard of them, as compared with 27% and 13% of NAPs in Munro and Mingers (2004, Figure 1).

Table 4: Top seventeen tools for public sector respondents supporting strategy process in O'Brien (2011)

[REDACTED]

Adapted from 'Table 3 Analysis of differences between private and public sector tool use: Median scores and percentages of respondents who have not heard of tools', 'Table A1 Summary statistics for OR/MS tools included in this survey', 'Table B1 Summary statistics for Management/Strategy tools included in survey' and 'Table C1 Summary statistics for Soft OR/MS tools included in survey' in O'Brien (2011, pp. 910, 919-920)

Overall, evidence about the use of PSMs by OR practitioners supporting strategy is mixed, and rather old. O'Brien (2011) concluded from her survey that, 'while awareness of some of the soft OR/MS tools may have increased since their original development, their use in supporting the strategy process is not as widespread as some of the traditional OR/MS and management/strategy tools' (p. 917).[4] O'Brien's findings were consistent with low use of systems methodologies by NAPs in Munro and

[4] Henao et al. (2017) reached similar conclusions in their study of the use of OR in the strategy process in Colombia.

Mingers' (2002, 2004) survey (Table 2 above) and her more recent interview study of four practitioners supporting the strategy process (O'Brien, 2015). However, O'Brien's (2011) findings were inconsistent with results from Howick and Ackermann's (2011) review of practical interventions in peer-reviewed OR journals from the mid-1990s to 2008 in that all the cases Howick and Ackermann reviewed that addressed strategic (not operational) issues involved the use of at least one of the methods they designated as qualitative, and especially the PSMs, SSM, SCA and SODA.

In Ranyard et al.'s (2015) global survey of OR practitioners, 38% of respondents reported that they use PSMs (62% in the UK, 27% in other countries), the most popular – by far – being SODA (cognitive mapping), SSM and SCA, in that order. PSMs were reported as used more by practitioners in the public sector, and Ranyard et al. found that 'Strategic Planning is primarily supported by those focussed on using Problem Structuring Methods and more broadly the DSPSM [Decision Support and Problem Structuring Methods] tool set' (2015, p. 10), where DSPSM comprised, 'Problem Structuring Methods (PSMs), risk analysis, system dynamics, and [the techniques of] strategic planning (defined as cost benefit analysis, performance management, balanced scorecard and scenario planning)' (p. 9). Ranyard et al. (2015) report,

> Unsurprisingly, those respondents working in strategic planning were much more frequent users of PSMs (48.9 percent) than those who were not (10.4 percent) whilst those using PSMs were more likely to engage with strategic planning (92.6 percent versus 7.4 percent). Those not engaged with strategic planning applications are typically non-users of PSMs (89.6 percent versus 10.4 percent). (p. 6)

Ranyard et al. also found a correlation between their strategic planning techniques ('Cost Benefit Analysis, Performance Management, Balanced Scorecard and Scenario Planning') and 'Risk Analysis, Multi-Criteria Decision Analysis, Decision Support and System Dynamics' (p. 6). However, their survey data is on techniques used by practitioners and practitioners' application areas, such as strategic planning, not actual interventions, so this only provides 'indirect guidance' (p. 6) on how PSMs and other techniques may be used.

Interestingly, Ranyard et al. (2015) also note that 'Users in this [DSPSM] group are heavily client and stakeholder oriented with much of their work based on facilitation' (p. 9). However, this appears to reflect an assumption that facilitation is required in using PSMs and more generally for 'messy (often strategic problems)' (p. 5), particularly process change projects, after Ormerod (1997b, 2014b). That is, it does not appear to be an observation based on survey data (see also Table 1 above).

More recently, in their informal, cross-sector survey for the Heads of OR and Analytics Forum in the UK (HORAF), 'Ranyard et al. (2022) found evidence of increased use of PSMs during the COVID-19 pandemic, 'partly because of a lack of reliable historic[al] data' (Ranyard et al. 2022, p. 1)' (Christie, 2023, p. 168). Using non-quantitative and judgemental methods, practitioners could also address dynamic complexity and behavioural issues they faced (Murray, 2021). More generally, Ranyard et al. (2022) report that the Head of the Government Operational Research Service in the UK (GORS) told them that, 'Soft tools are now regarded as belonging to the overall OR/Analytics toolkit' (p. 6). Yet Ranyard et al. also report that, 'We had difficulty in finding recent case studies, largely because of confidentiality issues, particularly from government but the Head of GORS said he would be happy to provide a general endorsement to the value of Soft OR in government' (Hopes et al., 2022, p. 19). In fact, Ranyard et al. (2022) provide details of ten case studies demonstrating use of PSMs (and systems thinking), particularly SSM, but they are mostly from academic practitioners.

2.2.6 Conclusion

In this section, we reviewed methods used in OR generally, and for addressing strategic issues. Survey evidence suggests that while PSMs have been associated in OR literature with addressing strategic issues, non-academic practitioners have tended instead to use quantitative OR (particularly statistical analysis) and management/strategy methods (especially brainstorming). While surveys have highlighted use of non-quantitative methods in practice (Abdel-Malek et al., 1999; Fildes et al., 1999; Munro & Mingers, 2002, 2004; O'Brien, 2011; Ranyard et al., 2015), overall, within the public sector context we are interested in, 'whether and how governments are using Soft OR remains little studied and poorly understood' (Leong et al., 2023, p. 2). This is an area where unpicking claims that soft OR, and PSMs more specifically, are part of the OR mainstream (Lowe & Yearworth, 2019; Ranyard et al., 2022) need backing up with evidence (Georgiou & Heck, 2020; Harwood, 2019; Ormerod, 2006b; White & Bourne 2007). Next, we look at methods that OR practitioners combine.

2.3 METHODS COMBINED

2.3.1 Practitioner surveys

A number of surveys of OR practitioners have provided insights into method combinations. Mingers and Taylor's (1992) survey of the use of SSM provided early evidence of the prevalence of

multimethodology in practice amongst academic and non-academic practitioners (NAPs), particularly in the UK. They found that combinations of two and three methods by their respondents were most common, mostly within quantitative OR, or combining PSMs. SSM, the subject of the survey, was predominant in reported method combinations.

Then in Munro and Mingers' (2002, 2004) survey of use of multimethodology by OR/systems practitioners, mainly in the UK, academic respondents reported use of quantitative OR with PSMs, and up to nine or ten 'soft OR' techniques in any one intervention (Munro & Mingers, 2002, p. 374). However, only one NAP reported use of a PSM (SSM). However, 22 NAPs (34% of all 64 respondents) provided 31 (19% of 167) examples of combining two methodologies (17 examples), three methodologies (13 examples), or four methodologies (one example). Consistent with survey responses on methods they used most (Table 2 above), NAPs listed simulation, statistics, optimisation and forecasting most frequently in their 31 multimethodology intervention examples (Table 5 below).

Table 5: Methods combined by non-academic practitioners in Munro and Mingers (2002, 2004)

[REDACTED]

Table adapted from 'Table 1 Popularity of methodologies used in combination (by the NAPs)' in Munro and Mingers (2004, p. 91)

Munro and Mingers (2002) observe that, across all respondents, 'The two most common [combinations of two or three methods] are statistical analysis combined with forecasting and simulation, which one might argue were indistinguishable anyway. Other common quantitative

combinations are mathematical modelling with simulation and with statistics' (p. 374). However, 'systems methodologies such as SSM, VSM [viable system model] and Cognitive Mapping were hardly used by non-academic practitioners … in designing multimethodology' (Munro & Mingers, 2004, p. 90).

In O'Brien's (2011) survey of UK OR practitioners, 56 of 135 respondents (41%) across the public and private sectors provided '65 instances of tools being combined, adjusted or created to support the strategy process' (p. 912). Tools were combined within and across 'OR/MS' (especially simulation and system dynamics), 'management/strategy' (especially SWOT analysis, PEST [political, economic, social, technological] analysis and scenario planning) and 'soft OR/MS'. The most frequently combined tools were simulation, scenario planning, SWOT, system dynamics, forecasting, statistical analysis and financial analysis/modelling (Table 6 below). In addition, 'Twelve respondents reported the adjustment of individual tools, including two responses indicating that statistical analysis was adjusted' (p. 912).

Table 6: Methods combined by OR/MS practitioners in O'Brien (2011)

[REDACTED]

Table adapted from 'Table 6 Combining two tools to support the strategy process' and 'Table 7 Combining three or more tools to support the strategy process' in O'Brien (2011, p. 913)

Overall, Munro and Mingers (2002) and O'Brien (2011) use their findings to argue, alongside then recent literature reviews, that multimethodology was prevalent, while O'Brien (2011) highlights use by OR practitioners supporting the strategy process of management/strategy tools (particularly scenarios and SWOT) and system dynamics. However, these scholars found little evidence of method combinations involving PSMs amongst non-academic practitioners.

In Ranyard et al.'s (2015) global survey of OR practitioners, while data on methods used in single interventions was not collected, two-thirds of 75 regular users of the 'Decision Support/PSM' toolset also regularly used 'Traditional [quantitative] OR' and/or 'Business Analytics' techniques, whereas 46% of 92 regular users of 'Traditional OR', and 31% of 60 regular users of 'Business Analytics' techniques, regularly used only one toolset (p. 9, Table 4). However, Ranyard et al. (2015) conclude that, 'relatively few of the strategic planning applications [can have] used a mixture of PSMs and traditional [quantitative] OR' (p. 10).

As already noted, recently, there has been renewed interest amongst practitioners in using qualitative OR (including PSMs) with quantitative modelling for addressing complex, cross-disciplinary issues. More generally, in their informal survey, Ranyard et al. (2022) found,

> ... that PSMs and soft systems thinking are often used with traditional [quantitative] OR in the UK private and public sectors. Practitioners reported use of cognitive and cause mapping from SODA and rich pictures from SSM at the start of interventions before using traditional [quantitative] OR. (Christie, 2023, p. 168)

The Head of GORS reported that, 'use of hard + soft (multi-methodology) is now commonplace' (Ranyard et al., 2022, p. 6), though only one UK government example was provided (a combination of VSM, SSM and stock and flow modelling at the Defence Science and Technology Laboratory [Dstl] dated 2014).

2.3.2 Literature reviews

> Some researchers have explored using SSM with more formal modelling approaches either in terms of an integrated approach (Lane and Oliva, 1998; Paucar-Caceres and Rodriguez-Ulloa, 2007) or in combination (Kotiadis and Mingers, 2006), while others claim more pragmatic reasoning for combining the hard with the soft (Ormerod, 2006a). This development can be seen in the growing number of papers which have integrated or combined SSM with approaches such as simulation or DEA [data envelopment analysis] (Lehaney and Paul, 1996a). (Mingers & White, 2010, p. 1152)

A number of literature reviews suggest increasing interest in and use of multimethodology involving qualitative OR. In their review of developments in the contribution of systems thinking to OR/MS

practice, Mingers and White (2010) highlight examples published in the 2000s of combinations of system dynamics (SD) with PSMs (SSM or cognitive mapping), SSM with simulation, DEA with SSM or group support systems, MCDA with conflict analysis, and participative SD model building in policy decision support.

Howick and Ackermann's (2011) systematic review of peer-reviewed OR journals from the mid-1990s to 2008 examined reports of 30 practical cases, each involving a modelling process and two or more OR methods. In eight cases, qualitative methods (especially SCA and SSM) were combined, and in 16 cases qualitative methods (in particular, SSM, SCA and SODA) were combined with quantitative methods (in particular, discrete event simulation [DES] and SD). As Christie (2023) notes, 'Nine of the 16 mixed interventions were reported in the [later] years 2005 to 2008' (p. 168).

More recent systematic literature reviews have focused on combinations of particular methods in and beyond OR. As Christie (2023, 2021) reports, these reviews suggest increasing use of combinations involving: SSM (or parts thereof), in papers from 2000 to 2015 (Hanafizadeh & Mehrabioun, 2018); cognitive mapping, in papers from 1989 to 2018, particularly in strategic and organizational management (Abuabara & Paucar-Caceres, 2021); quantitative SD modelling (Zolfagharian et al., 2018); and, MCDA and problem structuring using SWOT, scenario planning, DPSIR (drivers, pressures, states, impacts, responses framework), stakeholder analysis, cognitive mapping, or SSM (Marttunen et al., 2017). Marttunen et al. (2017) and Zolfagharian et al. (2018) together suggest increased use of PSMs (Rosenhead, 1989; particularly cognitive mapping and SSM, or parts thereof) for problem structuring with MCDA and 'within the qualitative conceptualization phase of SD modelling (prior to quantitative SD modelling) … although overall numbers of interventions reported … are low' (Christie, 2023, p. 169). Gomes Júnior and Schramm's (2022) review of ten years of PSMs in 128 peer-reviewed OR and non-OR journals also provides a small number of examples of multimethodological papers (especially with SSM), and claims multimethodology to be 'a trendy topic' (p. 74).

However, published multimethodology case studies tend to be led by academic researchers and are often reports of action research specifically investigating aspects of multimethodology (Christie et al.,

2022; e.g., Henao & Franco, 2016; A. Small & Wainwright, 2018b).[5] This may be expected of an applied discipline such as OR. Practical interventions reported in peer-reviewed OR journals often involve academic practitioners, some of whom hold positions in the organizations where the interventions take place. Further, interventions with more involved designs tend to be associated with longer, well-funded research projects (Christie, 2017a; e.g., Scholten et al., 2015). No wonder Howick and Ackermann (2011) described their study as 'only the tip of the iceberg' (p. 509)!

2.3.3 Interview studies

O'Brien's (2015) interview study provides examples of combinations of methods used by four practitioners in supporting the strategy process, but the methods are mainly quantitative. Ackermann and Howick (2022) captured multiple experiences of projects in their interviews of 15 expert academic and practitioner mixed modellers, with each participant being asked to base their answers on two mixed projects. They aimed to gain new, deeper, nuanced insights into mixed methods practice across a number of pre-determined themes developed from literature. However, they did not study each project in depth, and offer very little detail of methods combined.

2.3.4 Conclusion

As Christie (2023) concludes,

> These prevalence studies [surveys of OR practitioners and systematic literature reviews] suggest that practitioners have increasingly used traditional [quantitative] OR and PSMs [as defined in Rosenhead, 1989] over the last thirty years, at least as self-reported by self-selected practitioners in surveys, and researchers in peer-reviewed articles. Caution is also required in drawing conclusions because practical interventions in academic literature are a small subset of all OR practice, and incentives for academics to publish have increased in many countries. (p. 168)

However, taken alone, practitioner surveys suggest that when non-academic practitioners combine methods, they tend to combine quantitative methods, and when they support the strategy process, they tend to combine quantitative methods (particularly simulation) and management/strategy tools (particularly scenarios and SWOT) rather than PSMs (Rosenhead, 1989). Whereas in OR literature, there are few, recent, well-documented case studies of the use of PSMs (Rosenhead, 1989) with quantitative OR (Christie et al., 2022; see also Table 23.4 in Franco & Rouwette, 2022). Further, and

[5] Action research involves taking action within an organization and evaluating it in terms of its effects, and the learning that results (Eden & Huxham, 1996).

of interest for this research, while OR is widely used to tackle important problems in UK policy (GORS, n.d.-b; Pidd, 2004c), and it is claimed that multimethodology is commonly used, we have few published examples. Next, we explore evidence regarding method choice in OR practice.

2.4 METHOD CHOICE (WHY PRACTITIONERS USE PARTICULAR METHODS)

We know from surveys that OR practitioners analyse situations and build models using a wide range of methodologies, methods and tools from OR and other disciplines (Abdel-Malek et al., 1999; Clark & Scott, 1995; O'Brien, 2011; Ranyard et al., 2015). However, why practitioners use particular methods has tended not to be an area of focus in reports of single cases in OR literature, and there are few cross-case studies. In this section, I review what practitioner surveys, literature reviews, and interview and field studies of method choice have found.

2.4.1 Practitioner surveys

In their survey of the use of multimethodology in OR, Munro and Mingers (2002) found a link between two background disciplines (mathematics and engineering) and methods used more generally ('mainly hard' or 'mainly soft', respectively, p. 374), though the numbers of practitioners in their study are quite small (13 and 6, respectively). Ranyard et al. (2015), looking back at earlier surveys (Fildes & Ranyard, 1997; Fildes et al., 1999), suggest a link between methods used and the countries in which practitioner organizations are located, particularly Taiwan, concluding that 'some techniques are more heavily used in different countries and different organisations' (p. 5).[6]

Some practitioner surveys have asked practitioners what they use methods for. In strategy development, in her survey and later interview study, O'Brien (2011, 2015) asked practitioners to indicate which part of the strategy development process they used methods. However, surveys have tended not to ask why practitioners use particular methods in particular interventions.

An exception is that Munro and Mingers (2002) asked practitioners for 'open-ended description of particular multimethodology interventions concentrating on why methods were chosen' (p. 370). Using data from 47 respondents relating to 93 interventions, they derived three broad categories of

[6] Similarly, Biró et al. (2019) found in their review of European kidney exchange programmes 'that the variation in models and methods arises because of variation in country characteristics, policies, and ethics' (p. 447).

approaches to method choice – *unreflective*, *tacit* and *reflective* (summarized in Table 22, Appendix E). First, in the *unreflective* approach, practitioners' explanations were 'unproblematic statement[s] of objectives' (Munro & Mingers, 2002, p. 375). Methods – mostly 'hard OR/MS' – were described as 'simply 'required'', typically to solve a specific, defined problem (Munro & Mingers, 2002, pp. 375-376).

Second, in the *tacit* approach, practitioners' explanations were 'more open-ended and vague'. Practitioners referred to methods as 'appropriate', 'useful', 'familiar' or 'known', and referred to their own experiences, competencies and preferences in choosing methods. The authors suggest tacit knowledge may be relevant, hence the name of this category. Practitioners seemed to have an influential role in actively choosing methods, as theorized by Mingers (1997b), but did 'not generally articulate *why* the method was felt to be most appropriate in a particular situation' (Munro & Mingers, 2002, p. 376, *emphasis in original*).

Third, in the *reflective* approach, practitioners tended to describe 'relative merits' of 'different methodologies' they had used in '*ad hoc* combinations, tailored to the particular situation' (p. 376). Reflective practitioners tended to juxtapose their different reasons for using different methods, and together provided a range of reasons for using particular intervention methods (see Table 24, Appendix E). Some made interesting comments about the particular intervention situation, though they do not appear to have given reasons for *not* using other methods. Several respondents in the reflective category had already authored publications about their interventions. These practitioners included UK-based academics who were amongst the pioneers of multimethodological intervention involving PSMs (Christie, 2023; Munro & Mingers, 2004; Ormerod, 2004). Munro and Mingers (2002) conclude that,

> Choices about which methods to use are affected by the knowledge, experience and skills of the particular practitioner, and to some extent the academic or organisational context, as much as by the nature of the problem itself. (p. 378)

By re-examining data in Munro and Mingers' (2002) paper, we see a number of other themes. In fact, merits and/or limitations of different methods can be seen in a limited number of respondents' explanations across all three of the categories of approaches to method choice. An example in the *unreflective* approach is, 'Some categories of trim problems can be solved well by LP [linear programming]' (Munro & Mingers, 2002, Table 7, para. 2), and in the *tacit* approach, 'Influence

diagramming has proved a useful way of adding structure to scenario planning when in group workshops' (Munro & Mingers, 2002, Table 8, para. 4).

Looking further at responses categorized as *tacit*, there were also a number of other influences on method choice (Table 23, Appendix E). In some cases, lack of knowledge or experience of other methods was a constraint (Brocklesby & Beall, 2018; Kotiadis & Mingers, 2006; Mingers & Brocklesby, 1997; Mingers & Taylor, 1992), while a number of responses refer to experience developed over time across groups of practitioners and similar interventions (Corbett et al., 1995; Ormerod, 2002; Overmeer et al., 1998). Neither does the intervention context as an influence on method choice seem to be unique to the *reflective* approach (see also Biró et al., 2019; Brocklesby, 1993; Brocklesby & Beall, 2018; Mingers & Taylor, 1992; Ormerod, 1997a, 2008b, 2014b; Pidd, 2004c; A. Small & Wainwright, 2014, 2018a, 2018b).

In short, Munro and Mingers' *unreflective-tacit-reflective* characterization necessarily glossed over practitioners' detailed method choice considerations. Their research was limited by a lack of detailed responses to their long and complicated questionnaire, so that the three categories were necessarily superficial, as the authors acknowledge. Those respondents that did provide details were, as with any questionnaire, selective in what they wrote.

2.4.2 Literature reviews

In attempting to explain the dominance of SSM, DES, SCA, SD, and SODA/journey making in interventions in their literature review, Howick and Ackermann (2011) suggest that,

> It is possible that this is due to a series of reasons including; facilitator familiarity of a method and method mix – it has worked once so let's use it again, apparent logic of mixing other methods with this method (particularly when mixing qualitative and quantitative), or client familiarity of the method (through previous experience or word of mouth). (p. 506)

Howick and Ackermann conclude that, 'the choice of methods that are being mixed depends on who is doing the mixing – that the choice is very familiarity led' (p. 509; see also Corbett et al., 1995). They assert that their findings support Munro and Mingers' (2002) conclusion that, 'Many people do not consciously reflect on, or articulate, their methodological decisions' (p. 508), including any

paradigm strategy (Ackermann & Howick, 2022; Howick & Ackermann, 2011; Kotiadis & Mingers, 2006).[7] Generally, they found a lack of detail in case reports as to how methods are chosen.

From her literature review, J. S. Morgan (2013) concluded that, despite guidance on method choice and case examples being available in OR textbooks, how method decisions are made in practice remains unclear, and that this is particularly true across OR methods and interventions (Ackermann & Howick, 2022; Howick & Ackermann, 2011; Midgley et al., 2013). Key features of method choice decisions cannot be understood from simply analysing practitioners' reported models (Nguyen et al., 2024). Method choice reasons may be mentioned but not analysed in case studies, and they are spread across vast literature, including some method- and domain-specific reviews.[8] Further, where academics are involved, method choice may be influenced by academic agendas (Bennett et al., 1997; Midgley et al., 2013).

2.4.3 Interview studies

Ackermann and Howick's (2022) interviewees were 'asked to respond to the questions based on their experiences of two specific projects' (p. 1908) and 'discussed benefits that were gained from the use of individual methods' (p. 1914). However, the very few data that Ackermann and Howick report that include reasons for using single methods (in section 4.2, pp. 1913-1914) are employed in explaining reasons for the choosing, benefits, and perceptions of *mixed method* approaches, i.e., Ackermann and Howick do not claim any new findings on how single methods are chosen.

2.4.4 Field studies

Field studies have suggested that, over time, practitioners develop and draw on 'strands' of past practice and learning and collective 'webs of practice' that result from the particular settings in which they practise (Corbett et al., 1995; Ormerod, 2002; see also Brocklesby's, 1993, view of method choice

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[7] J. S. Morgan et al. (2017) further note that 'Work exploring the model building process of DES and SD empirically supports this commonly held view that modellers will embark on a study without first considering alternative modelling methods (Tako & Robinson, 2010)' (p. 914).

[8] For example, Zolfagharian et al. (2018) develop a framework from their systematic literature review of use of system dynamics (SD) with other methods, identifying 'four problem characteristics motivating the combination of SD with other methods: nature of the problem; variables and their causal relationships; diversity of agents involved; and context of the problem' (Kunc et al., 2018, p. 87). Another example is guidance in OR literature on choosing between MCDA approaches, including in defence (Balaban et al., 2016; Guitouni & Martel, 1998; Holzgrefe & Hester, 2016; Neves et al., 2009; Roy & Słowiński, 2013; Stewart et al., 2013; Wątróbski et al., 2018), with software available for choosing an approach (Cinelli et al., 2021).

as emergent from a practitioner's cultural and historical situatedness). Method choice in real-world interventions also involves negotiating with clients and other stakeholders (Eden, 1982; Midgley, 2000; Ormerod, 1997a; Tully et al., 2019; Velez-Castiblanco et al., 2016; Willemain, 1994). Further, some scholars emphasize the importance of selecting methods and designs that are appropriate to the culture of the organization (Bennett et al., 1997; Brocklesby & Beall, 2018; Pidd, 2004c; A. Small & Wainwright, 2014, 2018a, 2018b).

2.4.5 Conclusion

The limited cross-case evidence we have from surveys, literature reviews and field studies is of a range of influences on method choice including: practitioners' background disciplines, organizations, locations, experiences, their familiarity with methods, their knowledge and competencies (or lack thereof), preferences, and reasoning; practitioners' experience of methods, developed over time across similar interventions and groups of practitioners; relative merits and limitations of different methods; the nature of 'the problem' and intervention context (including its constraints, opportunities); negotiation with clients and other stakeholders; and, in the case of interventions by academic practitioners, academic agendas.

We are left wondering whether practitioners are as unreflective as some of the literature suggests. This would undermine OR as an applied discipline with implications for training and education of practitioners.

2.5 TERMINOLOGY FOR MULTIMETHODOLOGY

Before I explore literature on multimethodology further, I need to clarify some terminology used in OR and social science literature in describing, understanding and promoting multimethodology (Table 7 below), and review definitions of multimethodology and mixing methods, as well as paradigms. Reviews of definitions of mixed methods research and multiple methods research in the social sciences in relation to multimethodology are in Appendix C and Christie (2023).

Table 7: Terminology for describing multimethodology (licensed under CC BY 4.0)

Term	Definition	Reference(s)
Methodological pluralism	In OR and systems thinking practice, the use of diverse methodologies and methods in order to meet the various and particular needs within and across different interventions	Jackson (2019); Midgley (2023)
Intervention	'... the process in which practitioners seek to understand and analyse situations, make recommendations to organizational clients about possible improvements, and support organizational action (Mingers & Brocklesby, 1997)'	Christie (2023, p. 163)
Methodological partitioning	'... the practice of sectioning and recombining parts of previously distinct methodologies to address complex research issues ...'	Midgley (1990, p. 108)
Multimethodology (also referred to as multi-methodology)	The use of 'more than one methodology, or part thereof, possibly from different paradigms, within a single intervention', where 'part' refers to a methodological stage or technique/method. Combinations of wholes or parts of methodologies may be single paradigm or multiparadigm.	Mingers and Brocklesby (1997, p. 491)
Decomposition of methodologies	In multimethodology, the disconnection of single methodologies into methodological stages, techniques/methods, and tools. Practitioners may then use the detached elements in other methodologies, or new frameworks – see multiparadigm multimethodology below. For an example of the decomposition of a methodology into methodological stages, methods, and tools, see the summary for SSM in Christie (2023, Table 11.1).	Mingers and Brocklesby (1997)
Methodology	In multimethodology, not the study of methods, nor the approach taken in a particular study (Friend, 2006; Mingers, 2001c), but 'a structured set of guidelines or activities to assist people in undertaking research or intervention ... within a particular paradigm'. SSM and SODA are examples.	Mingers and Brocklesby (1997, p. 490)
Method (also known as technique)	Methodologies tend to specify or be associated with techniques (specific activities) or methods (Mingers, 2000b), like cognitive mapping in SODA. In this dissertation, I also use 'method' as an umbrella term for tool, method, technique and methodology.	Mingers and Brocklesby (1997, p. 491)
Tool	An artefact, such as a checklist or software used with a particular methodology or method.	Mingers and Brocklesby (1997, p. 491)
Paradigm	In multimethodology, 'a very general set of philosophical assumptions that define the nature of possible research and intervention'. More recently, '*a shared exemplar for scientific practice* ['consisting of metaphysical, sociological and artifactual/conceptual components'], *which communities of scientists and researchers agree in part or completely, that provide[s] models from which coherent scientific traditions may emerge*'. 'The sociological paradigm abstracts the multifaceted sources of influences within the scientific community and inspires the future researcher from past scientific achievements, political attainments, legal precedence or linguistic nomenclature. The conceptual and artifactual paradigm offers paradigmatic applications, instruments and tools for problem solving, embedded knowledge from their practice, and examples of their accomplishments.'	Mingers and Brocklesby (1997, p. 490) Hassan and Mingers (2018, pp. 576, 590, *emphasis in original*)
Multiparadigm multimethodology	A special case of multimethodology in which practitioners integrate parts (methodological stages and/or techniques/methods) of two or more methodologies from different paradigms in a new methodological framework.	Mingers and Brocklesby (1997)
Mixing methods	'... the mixing of any OR tools, techniques, methods, methodologies and/or paradigms within a single intervention.'	Ackermann and Howick (2022, p. 1908)
Multiple methods research (also known as multimethod research)	'... research that systematically combines, mixes, or integrates more than one research method/methodology/paradigms/analyses/etc. to produce a high-quality research study' (International Journal of Multiple Research Approaches, n.d., para. 6). Multiple methods research includes qualitative-based multiple methods research, quantitative-based multiple methods research, mixed methods research (MMR), and research studies that integrate multiple methods research and MMR.	Hitchcock and Onwuegbuzie (2019)
Mixed methods research (MMR)	The special case of multiple methods research (defined above) in which qualitative and quantitative approaches are used within a single research study	Hitchcock and Onwuegbuzie (2019)
Integration	'... the optimal mixing, combining, blending, amalgamating, incorporating, joining, linking, merging, consolidating, or unifying of research approaches, methodologies, philosophies, methods, techniques, concepts, language, modes, disciplines, fields, and/or teams within a single study'	Hitchcock and Onwuegbuzie (2022, p. 3); Onwuegbuzie and Hitchcock (2022, p. 598)

Adapted from 'Table 11.2: Summary of definitions of MMR terms used in this chapter' and footnote 4 in Christie (2023, pp. 167, 174), used under CC BY 4.0

2.5.1 Multimethodology and mixing methods

> Both 'mixing methods' and 'multimethodology' describe methodologically plural, single interventions that each include 'multiple methods research' and/or MMR [mixed methods research] (Hitchcock & Onwuegbuzie, 2019), ... (Christie, 2023, p. 166)

Multimethodology is used in OR and systems thinking (e.g., Flood & Midgley, 2022; Jackson, 2019; J. S. Morgan et al., 2017) to refer to use of more than one method or methodology within an intervention, after Mingers and Brocklesby (1997) and Mingers and Gill (1997), although strictly multimethodology refers to use of wholes or parts of methodologies (Mingers & Brocklesby, 1997; Table 7 above; Figure 40, Appendix C). It refers to a subset of *methodological pluralism*, since methodological pluralism also includes use of different methodologies and methods across interventions (see Table 7 above).

Multimethodology and Ackermann and Howick's (2022, after Howick & Ackermann, 2011) *mixing methods* include different ways of combining methodologies or methods (and/or tools in *mixing methods*) but do not require *integration*. Separate use of methodologies or methods (and/or tools) in series or parallel within a single intervention suffices. Zhu (2022) states that the term *mixing* also 'suggests [to him] an 'action' inclination' (p. 1).

Mingers and Brocklesby (1997) term the special case of *multimethodology* in which practitioners integrate parts of two or more methodologies from different paradigms in a new methodological framework, *multiparadigm multimethodology*. This brings *multimethodology* closer to definitions of *mixed methods research* that require *integration* of qualitative and quantitative aspects of research (see Hitchcock & Onwuegbuzie, 2022; Onwuegbuzie & Hitchcock, 2022; Appendix C).

Finally in this subsection, proponents of *multimethodology* argue that because of the multidimensional nature of real-world problem situations, qualitative and quantitative approaches are required in combination because quantitative models can only ever deal with the measurable, material part of a problem situation, while qualitative methodologies are necessary for personal and social issues but miss measurable features (Mingers & Rosenhead, 2004). Hence this research is concerned with the use of combinations of quantitative and qualitative OR analysis methods (Parr & Mingers, 2015).

2.5.2 Paradigm

In the 1980s and 1990s, when OR scholarship on methodological pluralism was increasing (see Appendix B), paradigm wars were raging. While *paradigm* has been defined in many different and sometimes inconsistent ways, for *multimethodology*, Mingers and Brocklesby (1997) define *paradigm*

as, 'a very general set of philosophical assumptions that define the nature of possible research and intervention' (p. 490). They distinguish paradigms based on ontology, epistemology and praxiology (effectiveness, ethics and morals), referring to three 'main' paradigms in then extant OR/systems literature – '*empirical-analytic* (positivist, objectivist, functionalist, hard), *interpretive* (subjectivist, constructivist, soft), and *critical* (critical systems)' (p. 490, *emphasis in original*). By defining paradigms beyond those of the natural sciences (as in Burrell & Morgan, 1979), legitimacy was claimed for social science disciplines (Hassan & Mingers, 2018). *Mixed methods research* itself was also claimed as a new paradigm (Freshwater & Carhill, 2023).

Moreover, appealing to postmodernism (Taket & White, 1993, 2023; White & Taket, 1997), then influential (Midgley, 2004), Mingers and Brocklesby argued that methodologies and methods could in fact be used across paradigmatic logics, and that structuration theory and critical realism provided potential philosophical underpinnings. This was their way of addressing arguments of paradigm incommensurability (also known as the incompatibility thesis [Hathcoat & Meixner, 2015]) in academic debates about philosophical and theoretical justifications of methodological pluralism. For a discussion of similarities and differences between Giddens' structuration theory and Bhaskar's critical realism, see Mingers (2014).

In fact, there have been numerous other proposals for philosophical justification of the practice of multimethodology over the years, including: discordant pluralism (W. J. Gregory, 1996); virtual paradigms (Yolles, 1996); pragmatic pluralism, drawing on post-structuralism and postmodernism (Taket & White, 2023; White & Taket, 1997); reflective pragmatism (Bennett et al., 1997); working within paradigm-specific generic methodologies in coherent pluralism (Jackson, 2000, 2003a, 2019); the systems (process) philosophy of systemic intervention (Midgley, 2000, 2001, 2023); deep complementarism and systemic boundary critique (Ulrich, 2003); complementarity (Pidd, 2004a); pragmatic realism (Kowalczyk, 2004); the paradigm-crossing interplay strategy, communicated using the yin yang symbol (Kotiadis & Mingers, 2006, after Schultz & Hatch, 1996, and Zhu, 1998); the process-structure ontological perspectivity for coherent pluralism (Bowers 2011); and American pragmatism (e.g., Jackson 2000, 2021, 2023; Ormerod, 1996a; 2006a, 2008b, 2014b, 2021b; Zhu, 2011, 2022). In mixed methods research more generally, arguments have been made for pragmatism, dialectical pluralism, the transformative paradigm, the performative paradigm, critical realism, and others (see Shan & Williamson, 2023, chapter 4).

However, Hassan and Mingers (2018) have since argued that the assumption in Mingers and Brockleby's multimethodology that each methodology is associated with a paradigm privileged philosophical or metaphysical aspects of paradigms, and that, 'Although there is a close relationship between metaphysics of the object of study and the epistemology for researching it, there is no direct one-to-one relationship between metaphysical paradigms and research methods' (Hassan & Mingers, 2018, p. 586). Hence, so-called 'non-standard' ways of using methodologies (Mingers, 1997b, 2006b), or 'oblique use' (Flood & Romm, 1995, 1997; Mingers, 2003a), are possible. For example, mathematical modelling can be used in an interpretive way.

Thus, it is argued that the 'requirements of a problematic situation' (Kotiadis & Mingers, 2006, p. 865), or the 'virtual paradigm' (Midgley, 2000, after Yolles, 1996) of the practitioner, or the 'philosophical positions' or 'mental models' of practitioners and other intervention participants 'rather than the adopted method define the paradigm' of any one intervention (Belton & Stewart, 2010, p. 219; Onwuegbuzie & Hitchcock, 2019). However, Hathcoat and Meixner (2015) argue that 'research questions/methodological activities', such as interviews, vary in the extent to which their use can be justified 'without adopting' particular ontological and epistemological assumptions (p. 14).

Moreover, Hassan and Mingers (2018), propose a move from

> … paradigms as epistemological and methodological worldviews … [to] … the transformative power of the paradigm concept [as interpreted by Masterman (1970)] with its exemplars, models, tools, and techniques that place focus on the core concerns of the research and help researchers solve problems and hasten progress … (p. 590)

More specifically, they argue for,

> Masterman's [1970] interpretation of the paradigm as consisting of metaphysical, sociological, and artifactual/conceptual components. … [which] offers researchers numerous possible ontological views into the workings and mechanisms of their phenomenon of interest beyond just positivism, interpretivism, or critical research. The sociological paradigm abstracts the multifaceted sources of influences within the scientific community and inspires the future researcher from past scientific achievements, political attainments, legal precedence or linguistic nomenclature. The conceptual and artifactual paradigm offers paradigmatic applications, instruments and tools for problem solving, embedded knowledge from their practice, and examples of their accomplishments. (p. 560)

A paradigm is thus redefined for multimethodology as '*a shared exemplar for scientific practice* ['consisting of metaphysical, sociological and artifactual/conceptual components'], *which communities of scientists and researchers agree in part or completely, that provide[s] models from which coherent scientific traditions may emerge*' (Hassan & Mingers, 2018, pp. 576, 590, *emphasis in*

original; Table 7 above). I would argue that we see this, for example, in J. S. Morgan et al.'s (2017) suggestion that DES has no clear 'single philosophy'. Rather, in line with arguments in Mingers and Brocklesby (1997), a methodology or methodologies have emerged from good practice.[9] We shall return to this in my theoretical framework in the next chapter. There are also some similarities with the concept of a practitioner's 'virtual paradigm', which reflects a practitioner's working theoretical assumptions in a methodologically plural intervention, or across a number of methodologically plural interventions, and which 'may also become a true paradigm' when shared within a community of individuals (Midgley, 2000, p. 252, after Yolles, 1996).

Further, Mingers and Brocklesby's (1997) multimethodology challenged Kuhn's (2012/1962) conception of paradigm in that Kuhn suggested that in the development of natural sciences, paradigms do not co-exist (cf. Burrell & Morgan, 1979). Rather, new paradigms are pre-paradigmatic, as could conceivably be the case in OR, or result from revolution and the replacement of one paradigm with another. Hassan and Mingers (2018) highlight that their wider conceptualization of paradigms is particularly useful for multi-disciplinary, pre-paradigmatic fields that 'borrow their paradigms from other disciplines and draw their direction of research, with few modifications, from those paradigms' (p. 577).[10] This contrasts with Zhu's (2022) recent proposal to 'contingently deploy' (p. 16) *with practitioners* an alternative conceptualization of methodological pluralism in OR, being Kuhn's notion of the proliferation – as the discipline of OR evolves – of overlapping specialties, each with a community-specific lexicon structure, *with* American pragmatism.

In summary, while paradigm was a much-debated concept at the time of early development of scholarship on methodological pluralism (e.g., see Zhu, 2022), there is broader agreement across scholars that any practical, multimethodological intervention should itself be justified theoretically and philosophically (e.g., Midgley, 2000; Ackermann et al., 2014). I shall discuss paradigms and paradigm incommensurability as it relates to this research in chapter 4. Next, we explore designs for

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[9] Mustafee and Powell (2018) would call the methodology 'discrete simulation', and DES a technique (or method; see Table 7 above and Figure 41, Appendix D).

[10] Hassan and Mingers (2018) write,

> What transpires during this preparadigmatic period, as we can see in the IS [information systems] field, is a situation where there is wide disagreement on fundamental issues and on the objects of study in the field, or at least in the objects that should be studied (Lee, 1999; 2010). The IS community disagrees on which theoretical principles are most relevant (Gray, 2003), and disagrees on whether the field has made any progress (Grover, Ayyagari, Gokhale, & Lim, 2006; Grover, Ayyagari, Gokhale, Lim, & Coffey, 2006; Wade, Biehl, & Kim, 2006a; 2006b). As many scholars argue (Alvesson & Sandberg, 2013a; Ravitch & Riggan, 2012; Rivard, 2014; Slife & Williams, 1995), progress in any field is made when underlying assumptions are uncovered and challenged, and much of these assumptions take the form of paradigms that have far-reaching consequences. (p. 577)

multimethodology and mixing methods, which, as we shall see, have been heavily influenced by debates about paradigm in/commensurability.

2.6 MULTIMETHODOLOGICAL DESIGNS (FORMS OF MULTIMETHODOLOGY)

In theory, the design of multimethodological interventions may be pre-planned or emergent, or some combination of these (Fetters, 2020). However, reviews of OR practice have found that method choice often 'evolves' through an intervention, as issues and stakeholders' views of them develop (Howick & Ackermann, 2011; Munro & Mingers, 2002; see also Tomlinson, 1984, p. 209). The resulting method combinations may take a variety of forms.

Various attempts have been made to categorize forms of multimethodology (Howick & Ackermann, 2011), though very few peer-reviewed studies have attempted to summarize multimethodological designs across OR practice. I review such studies below. For hybrid simulation and hybrid modelling, other conceptual frameworks focusing on combining methodologies and methods across paradigms and disciplines have been developed (e.g., Mustafee et al., 2020; Mustafee & Powell, 2018; Tolk et al. 2021). However, they are not included below as they do not focus on forms of multimethodology, i.e., different ways in which methods or methodologies from different paradigms or disciplines may be used together, e.g., in sequence, or in parallel (see also Brailsford et al., 2018). Figure 41, Appendix D refers. Other scholars have reflected on the complex nature of interventions by using the complex adaptive system metaphor to understand strategy development (A. J. Gregory & Ronan, 2015) and the evolution of an intervention and the 'entanglement' of PSMs and other OR methods (Hindle & Vidgen, 2018).

2.6.1 Mingers and Brocklesby's (1997) forms of multimethodology

Mingers and Brocklesby (1997) compiled the following forms of multimethodology from theoretical OR/systems literature and case studies as 'either as a set of logical possibilities, or as the preferred way of operating of particular agents' (pp. 491-492), depending in part on agents' views on paradigm in/commensurability:

- **Methodological isolationism** – single paradigm, single methodology or single parts thereof;
- **Methodology enhancement** – single or multiparadigm, one methodology with techniques from another;
- **Methodology selection** – single whole methodology (after Jackson & Keys, 1984);
- **Methodology combination** – combining whole methodologies (after Flood & Jackson, 1991a); and,
- **Multimethodology** – single paradigm (after Bennett, 1985; Ormerod, 1996b) or multiparadigm, combining parts of multiple methodologies (after Midgley, 1990).

Mingers and Brocklesby (1997) also note that practitioners have developed multimethods for particular types of complex situations. Examples include the compram method (DeTombe, 2001) and total systems intervention (TSI; Flood & Jackson, 1991a). We could add more recent examples, such as: hybrid VSM/HPM (Lowe et al., 2016); robust decision making (Lempert, 2019); systemic planning (Leleur, 2012, 2020; Sibbesen & Leleur, 2006); the thinking persons' institute approach (D. F. Andersen et al., 2006; Eden et al., 2009), and the wuli–shili–renli approach (WSR; Gu & Zhu, 2000; Li & Zhu, 2014; Zhu, 2023).

2.6.2 Howick and Ackermann's (2011) intervention categories

In their systematic literature review of mixed OR practice, Howick and Ackermann (2011) categorized interventions according to 'the order in which methods are used' (p. 504) or the 'form of integration' (p. 505), borrowing Schultz and Hatch's (1996) terms for combining approaches from different paradigms within management, as follows:

- In **sequence** – findings from one method used as input for another;
- In **parallel** – methods used independently, results compared; or
- **Interactively** – paradigm-crossing bridging or interplay at permeable paradigm boundaries.

These forms can be applied at the level of paradigms, methodologies, methods, techniques, or tools (cf. Pollack, 2009, who applies the terms serial and parallel multimethodology at the level of paradigms). Generally, Howick and Ackermann (2011) found that papers they reviewed lacked details as to the form of multimethodology (itself a reason for only having three categories), and found only

two examples of the parallel form, compared with 14 examples for each of sequential and interactive. They note that,

> In some of the cases the mixes involved entire methods (14 of the 30 reported) whereas in other cases the mix focused on a single method augmented by elements of another method (12). In one or two cases the mix was such that one method was used to provide *an over-arching framework* for the intervention. For example, a qualitative method was used to direct the design of the intervention with other methods used to undertake the analysis (Pauley and Ormerod, 1998). (p. 507, *emphasis added*)

2.6.3 J. S. Morgan et al.'s (2011, 2017) generic linking designs for OR/MS interventions

J. S. Morgan, Howick, and Belton (J. S. Morgan, 2013; J. S. Morgan et al., 2011, 2017) compiled the following provisional set of six generic linking designs for OR/MS interventions from Schultz and Hatch (1996) and theoretical literature on mixing OR/MS methods:

- **Isolationism** (after Mingers & Brocklesby, 1997);
- **Parallel or comparison** (after Schultz & Hatch, 1996, or Bennett, 1985);
- **Sequential** (after Schultz & Hatch, 1996; a form of Mingers & Brocklesby's, 1997, combination);
- **Enrichment** (Bennett, 1985) **or enhancement** (Mingers & Brocklesby, 1997) of one dominant method with another;
- **Interaction** across paradigm boundaries (after Schultz & Hatch, 1996); and,
- **Integration** (Bennett, 1985) **or multimethodology** (Mingers & Brocklesby, 1997) – synthesizing methods within a new, larger framework.

Again, these designs are 'applicable at the paradigm, methodology or technique [or tool] level' (J. S. Morgan et al., 2017, p. 910). The authors illustrate their typology with examples from literature on the combination of SD and DES, developing them into a toolkit for practitioners. The toolkit distinguishes the designs according to an intervention's *what* (aspects of the situation or system[s] represented by the methods), *why* (numbers of methods and their separable roles, and justifications for mixing methods) and *how* (dimensions of the design itself, in particular in relation to interaction between methods). The authors propose that the toolkit can be used by practitioners to open their minds to alternative mixed methods designs, and include it in their theoretical framework for practitioner method choice (reproduced as Figure 45, Appendix F). The authors also suggest that their toolkit of designs may be 'equally applicable' across OR methods and interventions, and that

there may also be other designs and sub-designs. Indeed, from a more recent review of literature on combining simulation methods, Nguyen et al. (2024) add:

- **Dynamically switching** where, 'The model dynamically alters among different SD-ABM [system dynamics - agent-based modelling] configurations' (p. 1154).

2.6.4 Christie's (2023) designs for combining PSMs with quantitative OR

Building on previous typologies in OR and mixed methods research, and a 30-year review of OR literature, a new set of multimethodological designs for combining qualitative and quantitative modelling has recently been proposed (Christie, 2021, 2023; Christie et al., 2022). Novelly, it foregrounds how PSMs (as defined by Rosenhead, 1989; Rosenhead & Mingers, 2001a), or parts thereof, are positioned within six different designs, thereby highlighting the use of PSMs beyond generic problem structuring (Mingers, 2011; Westcombe et al., 2006), and throughout interventions, alongside (more) quantitative OR (Christie et al., 2022). Christie (2023) provides examples of the designs across a range of organizations, and discusses reported benefits (examples of benefits are in Table 8 below). The designs, which can be combined, are:

1. **Sequential: PSMs for problem structuring activity** – PSMs used before quantitative OR (after Woolley & Pidd, 1981, p. 197, and Schultz & Hatch, 1996, p. 533);
2. **Sequential: PSMs for subsequent explanation** – quantitative OR used before PSMs (after Sachdeva et al., 2007, and Schultz & Hatch, 1996);
3. **Parallel: PSMs for comparison** – independent use of methods, with comparison at fixed points (after Kotiadis & Mingers, 2006, and Schultz & Hatch, 1996);
4. **Parallel: PSMs for interaction** – interactive use of methods over time (after Kotiadis & Mingers, 2006, and Schultz & Hatch, 1996);
5. **PSMs as design or intervention frameworks** (after Checkland & Winter, 2006, Eden, 1989, Howick & Ackermann, 2011, and Mingers & Rosenhead, 2001); and,
6. **PSMs in new multimethodological frameworks** – parts of PSMs and quantitative OR methodologies used in a new, integrative framework for a particular situation or purpose (after Bennett, 1985, and Mingers & Brocklesby's, 1997, 'multiparadigm multimethodology').

2.6.5 Conclusion

A small number of peer-reviewed studies have attempted to summarize how methods are used together across OR practice. However, they tend to be based on literature review. There remains an opportunity for future research to understand better and learn from the different ways in which OR practitioners, particularly outside academic settings, combine the wide range of OR methods available in practice. This could involve testing the typologies and their usefulness for practitioners addressing complex organizational issues. We now explore rationales for using methodology.

2.7 MULTIMETHODOLOGY RATIONALES AND BENEFITS

Since its outset, one of the themes in scholarship on methodological pluralism in OR has been benefits to be gained, and therefore reasons why multimethodology is and can be adopted by practitioners. In reporting their review of OR interventions published from the mid-1990s to 2008, Howick and Ackermann (2011) write that,

> Although there is disagreement in the extant literature regarding terminology, there is no disagreement regarding the desirability and feasibility of the use of mixing methods for OR practitioners and academics. Such benefits are well documented in the literature (Mingers and Brocklesby, 1997; Jackson, 1999; Mingers, 2000; Mingers, 2003). Many of these reasons have been confirmed or elaborated by those that have carried out the mixing of methods in the case studies reported here. (p. 504)

Similarly, in Ackermann and Howick's (2022) thematic analysis of interviews with expert mixed modellers, they conclude that,

> ... the rationale for mixing methods echoed many of the observations noted in existing work ranging from attending to different aspects of the problem, to more robust outcomes etc. (Howick & Ackermann, 2011; Jackson, 1999; Mingers, 2000; 2003; Mingers & Brocklesby, 1997). (pp. 1909-1910)

Thus, as shown in Table 8 below, which summarizes the interrelated theoretical benefits of multimethodology I compiled and review in the following subsections, benefits and rationales for using multimethodology have been discussed and analysed interchangeably.

Table 8: Theoretical benefits of multimethodology in OR literature

Theoretical benefits *(Note 1)*	**Theoretical rationales for using more than one method** *(Note 1)*	**Rationales from practical interventions in Howick and Ackermann (2011) and Ackermann and Howick (2022)**		**Example benefits and rationales from practical interventions in Christie (2023)** *(Note 2)*
		Themes from papers (2011) **or interview responses** (2022) *(Note 2)*	***Papers** (2011) or **ppts** (2022)*	
Rich understanding of complex issues from multiple perspectives	To view different aspect(s) of a situation and in different way(s)	• 'deal with a complex situation' (2011, p. 508)	*2*	'benefits from using PSMs [with MCDA or SD] of improved understanding and structuring of multiple stakeholder perspectives of situations' (Christie, 2023, p. 169, citing Marttunen et al., 2017, Table 3, and Zolfagharian et al., 2018, Appendix 3) In Brown et al. (2006), 'issues identified in the quantitative analysis were subsequently acknowledged and explored in workshops, … . The intervention resulted in 'a rich account, and understanding, of the possible changes' (Brown et al., 2006, p. 674)' (Christie, 2023, p. 171)
Triangulation or corroboration of findings	To compare results across methods for validity	• 'more robust outcomes' (2022, p. 1910)	*[not reported]*	In Sachdeva et al. (2007), 'cognitive mapping of interviews … after discrete event simulation … and other quantitative analysis' (Christie, 2023, p. 170) generated additional evidence of politically sensitive issues. In Brown et al. (2006), 'consequences of ideas from the workshops were later tested and compared with quantitative analysis, with qualitative conceptual models in the SSM analysis updated accordingly' (Christie, 2023, p. 171) In Howick et al.'s (2008) 'modelling cascade' approach, 'The models are … validated against each other, resulting in a transparent, robust and auditable modelling process' (Christie, 2023, p. 172)
Enhanced decision-making	To increase variety in results or improve decision-making process for better decision-making			
Complementarity of methods / overcoming deficiencies	To address an intervention need not addressed by another method	• 'methods chosen to complement each other' (2011, p. 508)	*1*	
		• 'overcome weaknesses of the individual methods' (2011, p. 508)	*8*	
		• '"the value was in having these two things talk to one another … the output of the optimisation would not be there unless the simulation was there"' (2022, p. 1914)	*1 (academic)*	
Serving multiple purposes or intervention activities	To intervene more comprehensively or holistically across intervention activities or aspects, or stakeholder purposes	• 'gain particular benefits from specific methods' (2011, p. 508)	*6*	Neves et al.'s (2009) 'use of SSM facilitated rich learning about the situation that contributed to the completeness of their [MCDA] modelling and their later engagement as consultants' (Christie, 2023, p. 170) 'Soft system dynamics methodology (SSDM) … integrates SSM with SD in order to develop a more holistic view of problematic issues, considering them from the perspectives of a number of different worldviews, and adding coherence across the modelling process by using root definitions in building quantitative SD models.' (Christie, 2023, pp. 171-172) Hindle and Vidgen (2018) 'used SSM for problem structuring, and then for business model mapping alongside the business model canvas (BMC) to set the strategic business context for exploration of charity data by data scientists, which in turn informed further problem structuring and business modelling, and the identification and prioritization of analytics opportunities' (Christie, 2023, p. 172)
		• 'support different stages of a project' (2011, p. 508)	*4*	
		• 'consider a wider system' (2011, p. 508)	*2*	
		• 'attending to different aspects of the problem' (2022, pp. 1909-1910)	*[not reported]*	
		• '"One thing [method] did this, fulfilled a particular objective. This other thing [method] fulfilled another objective."' (2022, p. 1914)	*1 (academic)*	

Theoretical benefits *(Note 1)*	**Theoretical rationales for using more than one method** *(Note 1)*	**Rationales from practical interventions in Howick and Ackermann (2011) and Ackermann and Howick (2022)**		**Example benefits and rationales from practical interventions in Christie (2023)** *(Note 2)*
		Themes from papers (2011) **or interview responses** (2022) *(Note 2)*	***Papers** (2011) or **ppts** (2022)*	
Achieving practical aims	To facilitate achievement of a practical goal	• 'test a framework' (2011, p. 508)	*1*	'Neves et al. (2009) initially used SSM to identify relevant stakeholders and reflect on issues to be addressed in their subsequent intervention … while Brown et al. (2006) also report using SSM as an intervention framework' (Christie, 2023, p. 171) In Crowe et al. (2017), 'In a final workshop with stakeholders, they used a visualization based on quantitative analysis (classification and regression tree analysis (CART)) with the qualitative SSM modelling so that possible service improvements could be targeted and prioritized for patient risk groups.' (Christie, 2023, p. 171)
		• support project management – one method "used as a recording device" and "mapping for the clarification of project objectives" (2022, p. 1913)	*2 (1 non-academic)*	
Emancipation and radicalism	To include and facilitate achievement of social justice			'Soft system dynamics methodology (SSDM) is a 10-step framework for social change that was developed in Peru and other Latin American countries (Rodríguez-Ulloa et al., 2011).' (Christie, 2023, p. 171)
Stakeholder engagement, understanding, and buy-in	To enhance intervention process or output for stakeholders to achieve their acceptance and possibly action	• 'gain decision maker involvement and thus model confidence and ownership' (2011, p. 508)	*2*	Use of SODA and SCA with MCDA 'contributed 'to an inclusive learning process that promoted legitimacy of the outputs and a sustained justification of the selection made' (Bana e Costa et al., 2014, p. 25). Their description suggests they implemented the methods in sequence, with a focus on reaching consensus.' (Christie, 2023, p. 170) In Sachdeva et al. (2007), 'By using all three methods, stakeholders gained a more complete understanding of issues, and a further simulation model was requested, which led over time to stakeholder buy-in for the implementation of actions' (Christie, 2023, p. 170) 'The combination of qualitative and quantitative OR analyses helped to generate findings of direct practical relevance to clinicians, policy-makers and commissioners regarding a complex service spanning multiple organizations' (Crowe et al., 2017, p. 649) ''PartiSim' is a participative approach to discrete event simulation (DES) that combines SSM with DES to enable stakeholders to participate in a non-technical way in group workshops for problem structuring, conceptual modelling, experimentation (with the DES model) and action planning (Tako & Kotiadis, 2015).' (Christie, 2023, p. 172) Howick et al.'s (2008) 'modelling cascade' approach provides a 'modelling process which stakeholders (e.g., lawyers, engineers and modellers) can engage with according to their different interests and needs. Howick et al. report that use of the framework facilitates common understanding, stakeholder communication, rich learning, more comprehensive modelling, and greater precision and confidence in the models' (Christie, 2023, p. 172)
		• buy-in from "multiple key stakeholders", including through demonstrating understanding of complexity of "their world" (2022, p. 1913)	*2 (both academic)*	
		• empowerment from soft OR/mapping with scientific procedural rationality from MCDA (2022, p. 1913)	*1 (academic)*	
Innovation, collaboration and communication	To facilitate transference of skills between practitioners and clients, learning, innovation, and renewal, enabling practitioners to address new problem areas and promote OR	• 'try something different' (2011, p. 508)	*1*	Hindle and Vidgen's (2018) use of SSM and BMC 'set the strategic business context for exploration of charity data by data scientists. … This led to agreement from the charity to pursue a number of analytics projects, including development of 'the UK's first dynamic visualisation tool for crises related to food poverty' (Hindle & Vidgen, 2018, p. 836)' (Christie, 2023, p. 172)
		• 'training opportunities' (2022, p. 1914)	*[not reported]*	
		• ''academic' benefits – learning and trying out new methods' (2022, p. 1914)	*1 (non-academic)*	
Cost efficiency	To save money			
Other rationales	The approach evolved	• 'recognise that simply the approach evolved' (2011, p. 508)	*2*	
	To build on previous interventions	• 'capitalise on something that worked well previously' (2011, p. 508)	*1*	

Ppts = Participants *Note 1: Source: Compilation and analysis by author* *Note 2: Allocation of benefits and rationales to theoretical benefits by author*

2.7.1 Rich understanding of complex issues from multiple perspectives

> … no analytical methodology can tackle all of the complexity that real-world problems face. (Van Wassenhove & Besiou, 2013, p. 95)

Using multiple methods can lead to rich understanding of complex, interrelated issues from multiple perspectives and at multiple levels of analysis (Greene et al., 1989; Jackson, 2003b; Midgley, 2000; Mingers, 2001b, 2014). Indeed, within critical systems thinking, methodological pluralism is seen as a response to complexity (e.g., see Jackson, 2019; Midgley, 1992a). In organizational settings, there are social and personal aspects that must be addressed even when dealing with what seems like a well-defined technical issue (Mingers, 2000b), so that variety of methodologies is required to address material, social and personal dimensions of the situation (Mingers, 2008; Mingers & Brocklesby, 1997). Using multiple methods facilitates adoption of different assumptions inherent in use of different methods (Shan & Williamson, 2023). The resulting richer understanding of issues can lead to better explanation, better bases for decisions, and/or revised or new subjects of enquiry (Greene et al., 1989).

2.7.2 Triangulation or corroboration of findings

Using multiple methods can lead to enhanced validity of and therefore confidence in results (Mingers, 2014, after Mingers & Brocklesby, 1997). Triangulation of data sources, viewpoints, and methods is possible (Mingers, 2015). Alternatively, differences in results lead to richer understanding of issues (as discussed in the previous subsection).

2.7.3 Enhanced decision-making

Methods may be added to interventions to enhance the process of decision-making. For example, using multiple methods can lead to enhanced variety in results that adds to decision options (Mingers, 2003a; Mingers & Brocklesby, 1997). In practice, generation of additional decision options may be prompted by client dissatisfaction (Ferretti et al., 2019). Another example is Ferretti's (2019, 2020, after Hertwig & Grüne-Yanoff, 2017) promotion of multimethodology 'process boosts' – the use of framing, objective-generation and preference elicitation techniques and tools from value-focused thinking – for improving decision quality.

2.7.4 Complementarity of methods: overcoming deficiencies

Different methods are seen as having different strengths and weaknesses that complement each other (Jackson & Keys, 1984). For example, some methods (e.g., SODA) provide guidance on working with clients, while others do not (Bennett, 1985). Therefore, OR practitioners need multiple methods. As Midgley (2011) states in the context of action research interventions,

> The reason that methodological pluralism is so important is that no existing methodology or set of methods can give us everything we might need to undertake a range of systemic action research projects in a variety of different contexts, so it is preferable to draw upon a multiplicity of traditions and methods than allow our practice to be restricted by an uncritical adherence to a more limited methodological language and associated tools (e.g., Jackson and Keys 1984; Oliga 1988; Jackson 1990, 1991, 2000; Flood 1990; Flood and Jackson 1991; Gregory 1992; Midgley 1992, 2000; Flood and Romm 1996; Mingers and Gill 1997; Taket and White 2000). (p. 11)

An example, promoted by proponents of evidential pluralism in philosophy, is that causal claims require support from both quantitative (correlational) studies and qualitative studies (explaining mechanisms; Shan & Williamson, 2021). Further, methods may be more or less appropriate, or feasible, for use in a particular research project, based on assumed standards for judging methods (Sandelowski, 2012). Alternatively, a particular method may be less suitable because it is used less well by particular practitioners (Sandelowski, 2012; Shan & Williamson, 2021).

2.7.5 Serving multiple intervention activities or purposes

It is typical in OR to describe an intervention as comprising overlapping phases or stages. Numerous scholars and practitioners have developed lists of the phases or activities of the process of OR (e.g., Ackoff, 1956; Churchman et al., 1957; DeTombe, 2001; Eden, 1982; Jackson, 2022b; Mingers, 2014; Mingers & Brocklesby, 1997; J. S. Morgan, 2013; Ormerod, 1996b, 1997a, 2018; Royston, 2013; Van Antwerpen & Curtis, 2016; Woolley & Pidd, 1981). These describe, in different ways (based on different contexts, application areas, and practitioner approaches), initial awareness and exploration of issues and initiation of an intervention through, in some cases, to evaluation following implementation of results, while often acknowledging some iteration, and parallel use of methods (Jackson, 1999, 2023; Midgley, 2023; Mingers & Brocklesby, 1997). There is also evidence that model building involves complex, non-linear sequences of stages (see Franco et al., 2021, for an overview). For Mingers and Brocklesby (1997), different, overlapping intervention activities (appreciation, analysis, assessment, and action; Table 26, Appendix F) present different requirements ('tasks and

problems') to the practitioner, for which different methodologies (and parts thereof) are more or less useful. Thus, variety of methods yields more comprehensive results across an OR intervention.

In fact, methods are used to address different aspects of issues, or different questions (Midgley, 1990; Shan & Williamson, 2023) and are required for achieving different stakeholder purposes (Midgley, 2023).[11] Within this benefit falls also using multiple methods to take a more holistic approach. This may involve including more stakeholders (Moumivand et al., 2021), or using different methods to model different aspects of a system (Ackermann & Howick, 2022; Noorain et al., 2019). An example is using SD to understand uncertainty, dynamics, time delay and conflicting stakeholder goals of complex real-world issues alongside the use of optimization to address particular aspects (Van Wassenhove & Besiou, 2013).

2.7.6 Achieving practical aims

Multimethodology is useful for achieving practical aims (Ormerod, 2014b), as in evaluation research (Johnson et al., 2007). Another example is that the introduction of new methods may bring competitive advantage for consultants and their organizations (Jackson, 1999). Relevant here is that multimethodology became a focus for scholars because it is what practitioners were doing (apparently successfully) in practice (Mingers & Brocklesby, 1997; Mingers & Gill, 1997), and because 'hard' (only) approaches in information systems (IS) were seen to have failed (Jackson, 1997, 2019). A more recent example is the argument that multi-disciplinary processes are necessary to improve public policy-making processes (Ferretti et al., 2019).

Ackermann and Howick (2022) add from their interview study that,

> One [academic] interviewee commented that one of the reasons for mixing methods was the fact that one of the methods "was used as a recording device" (A1). Another [non-academic practitioner] noted that they used "mapping for the clarification of project objectives" (P4) suggesting that the combination could be for project management purposes as well as resolution of the problem. (p. 1913)

[11] In mixed methods research literature, there are different views as to the extent to which research questions can be matched one-to-one to different types of data or methods or combinations thereof. For example, Plano Clark and Badiee (2015) present a typology of research questions, arguing that research questions should each be matched to one of quantitative methods, qualitative methods, or mixed research methods. Hence, by using quantitative and qualitative methods together to answer mixed research questions, synergy is achieved (Fetters & Freshwater, 2015). In contrast, Onwuegbuzie and Hitchcock (2019) argue for integration of methodological components and perspectives across all stages of mixed research, thereby creating in a research project a methodological approach that is an integrated 'whole' (p. 8).

The first reason seems to be like Belton et al.'s (1997) use of COPE software for cognitive mapping (in parallel with MCDA), which 'can ensure that the information is captured for future reference' (p. 126). The second reason seems akin to employing objectives generated in generic problem structuring (mapping) for managing a project against those objectives. These potential contributions to project management of an intervention are practical reasons for using multiple methods. Similarly, PSMs may be used to provide a framework for and in managing the process of an intervention, alongside the use of other methods (Checkland & Winter, 2006; Christie, 2021, 2023; Christie et al., 2022; Eden, 1989; Howick & Ackermann, 2011; Mingers & Rosenhead, 2001; Ormerod, 1997a; see sections 2.6.2 and 2.6.4 above).

2.7.7 Emancipation and radicalism

Multimethodology has been associated with emancipation and radicalism (Jackson, 1999). In systemic intervention, for example, methodological pluralism underpins flexibility and responsiveness to stakeholder concerns in socially just plans for change (Midgley, 2000). More generally, methodological pluralism was seen as a postmodern response to grand narratives (Mingers & Brocklesby, 1997; Taket & White, 1996, after Rorty), whereas now it may be framed as facilitating decolonization, diversity and inclusion (Mertens, 2007, 2022), or co-creation of positive social change (Taket & White, 2023).

2.7.8 Stakeholder engagement, understanding, and buy-in

Rationales for involving stakeholders in OR interventions generally include '(1) improving decision quality, (2) building consensus, (3) improving relationships, and (4) the intrinsic value of involving stakeholders' (De Gooyert, 2020, p. 220). Using multiple methods facilitates more flexible, innovative and effective engagement with stakeholders during different phases of OR-supported interventions (Bennett, 1985; Jackson, 1999; Midgley, 1992a, 2000, 2023; Mingers, 2003a; Mingers & Brocklesby, 1997; Mingers & Rosenhead, 2004). Variety of method (introducing novelty) may also help intervention participants focus on issues in comparison with repeated or continuous use of a single method (Mingers & Rosenhead, 2004).

In two reports of practice of multimethodology, Howick and Ackermann (2011) found increased client understanding and 'buy in', including where clients were involved and,

> ... useable products were generated throughout the interventions (rather than simply at the end). This meant that clients could go forward with actions and also feel reassured that the intervention (particularly when it was lengthy) was of use. Where clients were involved and clearly understood the outputs, then most appeared to be committed to action. (p. 508)

Using mixed modelling, practitioners have also achieved stakeholder model ownership, confidence and acceptance of results by better reflecting real-world complexity (Ackermann & Howick, 2022; W. Jones et al., 2022). However, non-client participants whose power is reduced by modelling outcomes may see multimethodology as problematic (Ackermann & Howick, 2022; Eden & Ackermann, 1996, 2004).

2.7.9 Innovation, collaboration, and communication

Combining methods facilitates transference of skills between practitioners and clients, learning, innovation, and renewal, enabling practitioners to address new problem areas and promote OR more widely in practice and across academic disciplines (Ackermann et al., 2014; Ackermann & Howick, 2022; Howick & Ackermann, 2011; Ormerod, 2021a; Ranyard et al., 2015; Tolk et al., 2021).

2.7.10 Cost efficiency

It is claimed that bringing together different models, for example, SD and DES, may lead to cost effectiveness and computational efficiency (Viana et al., 2014). However, caution is required as using multiple methods is, in the first instance, likely to require more time. In fact, as in social sciences more generally (e.g., see Fetters, 2020; Mingers, 2015), many within and beyond OR have expressed concern about the additional time and costs involved in using multiple methods (Ackermann & Eden, 2011a; Howick & Ackermann, 2011).

2.7.11 Conclusion

As for the influences on method choice reviewed in section 2.4 above, literature contains a range of reasons for using multimethodology, and a lack of empirical studies of the *process* of adopting a multimethodological approach in practice (see also Ackermann & Howick, 2022, discussed in section 2.4.3 above; Ormerod, 1997a). Most of the evidence of rationales for using multimethodology in OR comes from theoretical work and single cases reported in OR literature. A number of scholars have also developed theory by reflecting on their practical experience of OR interventions (e.g., Ormerod, 1997a), which we shall return to later. But there are few empirical, cross-case studies. Exceptions

include Ackermann and Howick (2022), Howick and Ackermann (2011), and Christie (2023), which I compared in Table 8 above, and Munro and Mingers (2002, 2004), reviewed in section 2.4.1 above.

2.8 MULTIMETHODOLOGY BARRIERS AND CHALLENGES

> Of course, it should be noted that potential problems [with mixing methods for OR practitioners] have also been identified (Mingers and Brocklesby, 1997; Jackson, 1999; Mingers, 2000; Kotiadis and Mingers, 2006). (Howick & Ackermann, 2011, p. 504)

Mingers and Brocklesby (1997) identified a number of potential cognitive, cultural and philosophical difficulties with multimethodology in practice, and in particular barriers to use of PSMs in multimethodology practice, which I discuss in this section alongside more recent developments.

2.8.1 Cultural barriers

Mingers and Brocklesby (1997) argue that OR training tends to focus on traditional methods (not PSMs) and many OR practitioners enter the profession from the natural sciences or engineering. Some practitioners specialize and/or are socialized in one method or methodology. Practitioners who are skilled in both quantitative OR and PSMs constitute a minority, although PSMs are now introduced in university courses (Ormerod, 2021b) and professional training (ORS, n.d.-a), at least in the UK. Hence, OR practitioners outside academia have been more likely to combine methods from the same tradition or paradigm (Munro & Mingers, 2002, 2004). In general, adopting new approaches is seen as challenging when individuals have been acculturated to, for example, positivistic outlooks and ways of doing things (Kotiadis & Mingers, 2006). They may be suspicious or even resistant to PSMs that cannot easily be evaluated compared with traditional methods (Midgley et al., 2013; Checkland & Scholes, 1990). Their beliefs, values and assumptions about the world may be reinforced by academic, organizational and geographically-based cultures that form part of their identities. Further, institutions, clients and other stakeholders may accept only some approaches.

More recently, Ackermann and Howick (2022) argue on the basis of their interviews with expert mixed modellers that successful mixing requires practitioners to 'speak the different modelling languages' (p. 1913). They point to a need to develop organizational culture in which mixed modelling is encouraged and supported through ongoing training and development of staff with a range of appropriate technical and process skills, willingness to learn, and desire to integrate methods.

2.8.2 Cognitive issues

While quantitative methods require technical skills, PSMs also rely on people skills, and critical approaches imply social purpose. Therefore, difficulties in working across different paradigms could conceivably be related to personality or 'cognitive processing preferences', for example, a preference for precision from aggregate data, or for involvement with people and working towards consensus (Mingers & Brocklesby, 1997, p. 499). Use of PSMs often involves facilitation, which modellers may be less familiar (Fildes & Ranyard, 1997) and less comfortable with (Ormerod, 1997a). Switching between approaches may be challenging and developing a range of expertise demanding. Multimethodology requires a range of skills, such that it is unlikely that people become expert multimethodologists, but not impossible, even if to some it may seem implausible (Kotiadis & Mingers, 2006). Most researchers will not be experienced in a range of research methods, though training and apprenticeships, collaboration and the division of roles may help (Ackermann & Howick, 2022; Pidd, 2004a). In fact, intervention designs and activities and the combining of results from different methods are said to benefit where practitioners' knowledge of methods overlaps, even if each practitioner is responsible for implementing a different method (Howick et al., 2017). And recently, we have seen renewed calls for well-documented case studies and practical guidance on combining particular methods in theoretically sound ways (e.g., Abuabara & Paucar-Caceres, 2021; Marttunen et al., 2017).

2.8.3 Practical challenges

> Only a small number of papers (4) actually discussed negative issues that arose when considering client value. These included the time expended (both of staff time and duration), cost and the uncertainty of process, although one paper also referred to the potential drawbacks of carrying some tasks out in parallel, rather than enabling the output from one task to inform another task (Brown et al., 2006). (Howick & Ackermann, 2011, p. 508)

Other potential challenges include the extra time (Eden et al., 2009), costs and other resources required to use multimethodology, challenges of collaboration (Mingers, 2015), and the risk of losing oversight of the whole study while focused on any one method (Bennett et al., 1997). Multimethodology may take longer to explain to participants and stakeholders in an intervention, and to readers of journals with word limits.

There are practical issues such as which method to use when, how to link methods (Tolk et al., 2021), how to synthesize findings, and how not to confuse stakeholders with too much added complexity. And a challenge of pluralist practice is that an OR practitioner cannot know all methods (Ormerod, 2008b). Franco and Lord (2011) highlight the challenge of 'how data is collated, coded, and manipulated' (p. 364). Hämäläinen and Lahtinen (2016) warn of the risk of path dependence affecting the outcome of an intervention where one method is used before another. Compared with single method approaches, using multiple methods requires additional skills, openness, flexibility, project management, team working and leadership (Ackermann & Howick, 2022; Eden et al., 2009; Howick et al., 2017).

In their experiment comparing single and multimethod group model building, Herrera et al., (2016) noted differences in participant behaviour. There were more divergent contributions and a higher degree of cognitive change amongst participants with a multimethod approach, with more content-related contributions about problem causes and more commitment to the final solution with a single method approach. This supports arguments that multimethodology can be used to reveal and address multiple perspectives, but that there are challenges.

2.8.4 Theoretical and philosophical justification

Ackermann et al. (2014) warn that combining methods must be justified in that innovation must be achieved cognizant of the rigour and theoretical foundations of methods, which must inform the approach – as one would expect in an applied academic discipline (see also Eden, 1990). Further, it is argued that practitioners should be able to justify their approaches philosophically and have a position on paradigm incommensurability (section 2.5.2 above).

However, paradigms have largely been a concern of academics and fuelled by paradigm wars, whereas 'the indications are that there is a strongly pragmatist [instrumentalist] orientation throughout OR practice' (Ormerod, 2021b, p. 15; Ormerod, 2006a). Interestingly, a distinction in the UK OR Practitioner apprenticeship requires that the apprentice, 'Uses multiple approaches in parallel or combination and reconciles their inconsistencies to deliver practical results' (The Institute for Apprenticeships and Technical Education [IFATE], 2020a, p. 33). Neither did most of the practical multimethodology papers reviewed by Howick and Ackermann (2011) explicitly address any of the 'difficulties associated with tackling incommensurability' (p. 508).

2.8.5 Conclusion

There are many reasons why OR practitioners may not choose to use particular methods or multimethodology, and broad consensus that multimethodological interventions are demanding in theory and in practice. Next, we explore available theoretical frameworks for explaining method choice and use of multimethodology in OR practice.

2.9 THEORETICAL FRAMEWORKS FOR MULTIMETHODOLOGY

Since the 1980s there has been a proliferation of theoretical frameworks, i.e., attempts to explain and theorize pluralist OR practice (Christie, 2017a; Franco & Lord, 2011; Mingers, 2017) – both theory- and practice-led (Keys, 1997) – not least to support practitioners facing a proliferation of OR methods (Brocklesby, 2023). In this section, I review theoretical frameworks and tools for multimethodology.

2.9.1 Method choice by type of problem

Some OR practice may involve rational choice of a method based on understanding the type of problem to be addressed (or 'OR archetype', as in IFATE, 2020c, para. 9 [Duty 3]) and then applying an appropriate method from a textbook (e.g., Churchman et al., 1957; Jackson, 2019; T. Williams, 2008) or another theoretical framework.[12] This might suggest that there is a best method that can be identified, subject to biases and heuristics of practitioners (J. S. Morgan et al., 2017; Kahneman et al., 1982), and that practitioners will apply them. However, this is contested on a number of grounds, particularly amongst practitioners of qualitative methods and in multimethodology. No one approach is necessarily best in any particular context (Henao & Franco, 2016), and a number of different ways of modelling may be used to solve a problem (Ackoff, 1956). Further, it is unlikely to be straightforward to assign real-world problems to a small number of types (Mingers, 1992).

In fact, it is widely accepted that 'There is no one-to-one correspondence between problems and techniques' (Ackoff, 1956, p. 285), nor 'between purposes and methods' (Midgley, 2023, p. 12), including in strategy development (Dyson, 2000, p. 10, Figures 9-10; O'Brien, 2011, p. 916). Method choice based on diagnosis of problem type is unlikely to be particularly helpful in supporting the

[12] Cf. Munro & Mingers' (2002) 'unreflective approach' (p. 375; section 2.4.1 above). See also discussion of *system* archetypes in Cabrera & Colosi (2008), Cabrera et al. (2008), Midgley (2008), and Weaver et al. (2020).

whole gamut of strategic decision-making (section 2.2.3 above). And there is unlikely to be a single problem to solve (Mingers, 2017). Mingers follows Ackoff in arguing that 'objectivity can only be the result of many subjectivities: it is value-full not value-free' (Mingers, 2006, p. 234). In fact, for OR for strategy development, Dyson (2000) proposes use of a *checklist* of possible methods to identify 'methods and models available to strengthen … any elements [of an intervention being evaluated that] are perceived to be deficient' (p. 10).

2.9.2 System of systems methodologies (Jackson, Keys) and critical systems practice (Jackson)

Jackson and Keys' (1984) system of systems methodologies (SOSM), as developed by Jackson (2001, 2006a, 2007, 2019), maps methodologies in a grid according to their assumptions along two dimensions of perceptions of 'problem contexts' – problem complexity (simple, complicated, or complex) and the nature of the relations between participants (unitary, pluralist, or coercive). See Table 25 and Figure 42 (Appendix F). This framework, while valuable in raising awareness of a range of quantitative and qualitative OR methods that practitioners could employ (Brocklesby, 2023; Flood & Midgley, 2022), is limited in the extent to which it can support method choice across organizational strategic issues, for the reasons set out in 2.9.1 above (e.g., see Mingers, 1992). Although the approach encourages consideration of stakeholders' multiple viewpoints, it tends towards mono-methodology and lacks theoretical justification (Jackson, 1999). SOSM also underplays the role of the practitioner, and the operation of power and politics in organizational decision-making. SOSM was developed in total systems intervention (TSI; Flood & Jackson, 1991a; cf. Flood, 1995a), coherent pluralism (Jackson, 1999), and critical systems practice (CSP; Jackson, 2001; 2019). For recent overviews, see Brocklesby (2023), Flood and Midgley (2022), Jackson (2019), and Zhu (2022).

In the most recent version of CSP (Jackson, 2020, 2021, 2022a, 2022b), the grid is abandoned in favour of choosing 'appropriate systems methodologies' (Jackson, 2021, p. 598) for 'complex real-world problem situations' (Jackson, 2021, p. 594) using systems metaphors (machine, organism, cultural/political, societal/environmental) in a different way. Primary and secondary intervention issues are identified during an initial phase in which a situation is explored by practitioners with stakeholders. The metaphor(s) most 'productive in highlighting significant issues' identified in this

phase are matched with systems (and other OR) methodologies, for example, systems engineering for addressing 'technical issues' identified with the machine metaphor. Methods and models are then chosen as suitable for the methodology(ies) and intervention context, including based on what practitioners know about their suitability from past interventions. Jackson points practitioners to B. Williams and Hummelbrunner's (2010) book for inspiration as to 'methods, models, tools and techniques' (2021, p. 12). This method choice process is recommended in place of SOSM to help practitioners use CSP in practice.

2.9.3 Framework for method selection for hybrid simulation (Morgan, Howick, Belton)

According to J. S. Morgan et al.'s (2017) framework for method selection (after Lorenz & Jost, 2006; reproduced in Figure 45, Appendix F), in choosing methods, practitioners should take into account the 'object' of the modelling (or 'the system' to be modelled) and the 'purpose' of a model (or 'the problem'; Lorenz & Jost, 2006, as cited in J. S. Morgan et al. 2017, pp. 914-916). Practitioners' method choice will then be affected by their perception of the situation and problem, and practitioners should consider other ways in which they could combine methods by using J. S. Morgan et al.'s (2017) toolkit (section 2.6.3 above). The theoretical model and toolkit were developed for combining SD and DES rather than more generally for combinations of qualitative and quantitative OR methods. However, as already shown with the empirical evidence in section 2.4 above, the dimensions of method choice may be more generally applicable.

2.9.4 Multimethodology (Mingers, Brocklesby)

In the theory of multimethodology, there are a number of tools for method choice – specifically, two lists of questions (reproduced in Figure 43 and Figure 44, Appendix F) for highlighting important dimensions of an intervention context (including possible methodologies) and constructing an initial problem statement (Mingers, 1997b, 2006b, 2017), and two grids for analysing characteristics of parts of or whole methodologies (philosophical assumptions, what methodologies do, and intended results or purpose) and for mapping strengths of (combinations of) methodologies to intervention requirements or aspects (material, personal, social) and phases (appreciation, analysis, assessment, action; Mingers, 2003a, 2014; Mingers & Brocklesby, 1997). For definitions of key terms, see Table 7 above. Accordingly,

> The actual *process* of critical multimethodology will be a continual cycle of reflection, judgement and action. It will bring in and knit together methodologies and techniques as seems appropriate to assist action. Such choices depend on both the stage of the intervention and the particular domain of interest at the time [social, personal or material] as well as the wider context of relationships … (Mingers, 2006b, p. 255, *emphasis in original*)

The relationships Mingers (2006b) refers to are from his framework of three interrelated notional systems that constitute the context of a multimethodology intervention (after Checkland, 1981, and Cropper, 1990b) – the problem content system (the real-world situation of concern including the perceived client, other actors and the context), the intervention system (the practitioner and other people involved) and the intellectual resources system (available theories, methodologies and techniques). See Figure 43 (Appendix F). OR practitioners consider these systems and their interrelations, which are influenced by and change the intervention, as they take action, design the intervention and shape it through a process of ongoing critical reflection.

Methods are chosen based on, for example: the practitioner's views of and commitments to stakeholders, resources, values and power; the nature of the problem situation – whether it presents a technical or strategic task, is well-defined, messy, includes multiple views and politics; the practitioner's understandings, skills, experience, history and cognitive style; the organizational culture and history of the situation, including what is viewed as legitimate; the operation of power in methodology discourses; and the relevance, values and feasibility of particular methods in particular contexts. Mingers also argues that practitioners will have methods they are more skilled and experienced in, and favoured methods they are more comfortable using (as embodied practitioners). Rationality and emotion play a part, context is key, and the practitioner (agent) is placed at the centre. In other words, there are many more dimensions relevant to method choice than assumed in simpler models such as SOSM (Mingers, 1992).

In theory, a 'fully comprehensive' intervention (Mingers, 2014, p. 186) would employ qualitative and quantitative methodologies to address all three dimensions of an intervention situation across all four stages of an intervention (Mingers, 2008; Mingers & Brocklesby, 1997; Table 26, Appendix F). However, it is acknowledged that in practice, practitioners will focus on particular dimensions.

2.9.5 Systemic intervention and creative design of methods (Midgley)

In Midgley's systemic intervention methodology (Midgley, 1990, 1992a, 1992b, 1992c, 1997a, 1997b, 2000, 2011, 2015, 2018, 2023; Midgley & Pinzón, 2011; Midgley & Rajagopalan, 2021), there is also a focus on the multi-dimensional nature of interventions and the centrality of the practitioner(s), as well as group dynamics, and needs of clients and stakeholders. Systemic intervention involves boundary critique (involving critical thinking and debate with stakeholders), theoretical and methodological pluralism, and creative design of methods.

Boundary critique is used participatively alongside talking with stakeholders 'individually and confidentially' (to understand power issues) for defining issues from different perspectives and issues to be addressed, and for setting and choosing boundaries for an intervention. Intervention approaches and methods are chosen that together address different aspects or levels of practitioners' analysis (similar to Mingers and Brocklesby's use of Habermas' psychological, social, and material worlds), including, for example, that a practical need to gain commitment to a planning process may lead a practitioner to choose a participative approach because theory suggests that stakeholders are more likely to be committed to a process if they are involved in it (Midgley, 2000, p. 226).

Intervention purposes, which 'evolve' through an intervention (Midgley, 2000, p. 241), may be expressed as questions: 'boundary questions' for boundary critique 'leading to the design of methods for defining issues'; 'issue-related questions' about how to address defined issues or achieve particular outcomes (e.g., stakeholder participation and engagement in an intervention, dealing with power issues, or addressing particular planning issues); and, 'knowledge-related questions' about agents and their available methodologies and methods (after Mingers, 1997b) for exploring knowledge and expertise required in an intervention (Midgley, 2000, p. 229). Then,

> To know which methods it might be appropriate to use in any particular situation, the agent(s) involved in an intervention may draw upon their intuitive resources and/or they may consider various methods' purposes, principles, associated theories, ideological assumptions and examples of past practice. (Midgley, 2000, p. 241)

Practitioners each develop their own '*continually developing* methodology' (Midgley, 2023, p. 12, *emphasis in original*). Midgley defined methodology as 'the set of theoretical ideas that justifies the use of a particular method or methods', and method as 'a set of techniques operated in sequence (or sometimes iteratively) to achieve a given purpose' (Midgley, 2000, p. 105; cf. Table 7 above). Thus,

the creative design of methods in methodologically plural practice involves 'learning from other people's methodologies' *and* '*drawing upon and mixing methods* from other methodologies' (Midgley, 2023, p. 12, *emphasis in original*), as well development of 'entirely new approaches and methods' as required (Midgley, 2023, p. 13). Synergies are sought from combining methods sequentially over time, as in Sydelko et al. (2021), or from full integration of methodologies or methods, such as critical systems heuristics and interactive planning, as in Boyd et al. (2004). During an intervention there may be a cycle back to rethink boundaries and methods, with the need for action for achieving improvement of a situation being an 'enabling constraint' for, 'the setting of boundaries and design of methods that can be justified as "good enough", with the practitioner and others being open to dialogue on what "good enough" means' (Midgley, 2023, p. 4).

2.9.6 Transformation competence perspective (Ormerod)

> My starting point is that OR is defined by its practice. By this I mean both that what OR workers do defines OR and that it is not defined by the maintenance of its body of knowledge. (Ormerod, 2002, p. 477)

Compared with the theory-led approaches described above, Ormerod's (1997a, 2008b, 2014b) transformation competence perspective (TCP), is intended to provide 'a more flexible, *ad hoc*, heuristic process' for method choice or intervention or OR practice over time (Ormerod, 2008b, p. 1436). TCP is based on Ormerod's extensive experience of practising OR and the practicalities of doing so. Accordingly, method choice is pragmatic, and depends on practitioners' 'personal experience and the context in which they find themselves' (Ormerod, 1997a, p. 416). More specifically, single, multiple or parts of methods are selected by practitioners for the contribution they could make in particular intervention phases to the *transformation(s)* that the intervention is initiated to effect, rather than the methods' theoretical underpinnings (as per Jackson, 2000, and Mingers, 2003). In TCP, the transformation potential of a method or part method is a judgement by practitioners based on their experience, and also reflects practitioners' preferences and attitudes to intervention risk. In choosing methods, practitioners take into account their and participants' interests and competencies, the intervention context (including organizational agendas and culture), and practical constraints, such as time, place, and commercial issues (Ormerod, 1997a, 2008b).

Ormerod shares three metaphors for thinking about how to manage cognitive change and political issues in an intervention (theatre, learning cycle, and legal evidence and argumentation), and

proposes three theories relevant to practitioners employing TCP (pragmatism and its focus on consequences [see Ormerod, 2006a], Boothroyd's articulate intervention and its notion of stakeholders' action programmes, and Ulrich's critical systems heuristics for negotiating boundaries). Ormerod (1997a, 1998, 2014a, 2016) also proposes that case studies – and more specifically, observation and questionnaires – are needed to understand the actual process of intervention design in OR practice.

2.9.7 Role and use of theoretical frameworks

> From a pragmatic point of view, however, we must accept that frameworks are essential in providing at least a focus or starting point to analysis. What we must be strongly aware of is that the theoretical insights offered by any framework should not be used to determine our explorations, but considered as an offering of direction, or simply as a source of creativity to fuel the exploration process. (Richardson et al., 2003, p. 25)

Building on Checkland's (1985) claim that groundlessness underlies all OR that is concerned with human affairs in that neither theory not practice is prime, rather each leads to the other, Mingers (2006c) and others argue for interchange between academia and OR practitioners, with theoretical frameworks informing, guiding and legitimizing OR practice. However, there are limitations in the usefulness of theoretical frameworks, some of which have been discussed above. Brocklesby and Beall (2018) suggest that a theoretical framework can provide a good starting point. It can be useful to know, for example, that soft OR tends to work in community settings, but there is a limit to the amount of pre-planning that is possible in OR intervention, not least given the huge variety of contexts in which OR is applied, the range of methods and practitioners, and that each framework will only deal with a limited number of contingencies. In contrast, Ormerod calls for 'guidelines, examples, stories, metaphors for use in planning an interaction, in carrying out the interaction, and in reflecting on it afterwards' (2008b, p. 1447) rather than theoretical prescription.

For the OR practitioner there are a number of issues in relation to theoretical frameworks for multimethodology. First, there are many of them (Christie, 2017a; Franco & Lord, 2011). Second, they do not generally actually tell you how to combine methods or design a multimethodological intervention. Even frameworks that are multi-dimensional tend not to be so prescriptive as to tell you which methods to use when. For example, the process of multimethodology does not tell practitioners how to combine methods into a methodological design. It provides frameworks to help 'design a multimethodology suitable for a particular situation' (Mingers, 2006b, p. 217). In fact,

Mingers (2014) refers researchers to wider mixed methods research literature for guidance on, 'the actual processes or mechanisms for combining methods' (p. 187). And in many frameworks, such as SOSM, features of problem situations and types of issues have tended to be discussed in a general way (Mingers, 2003a; 2017).

However, some theoretical frameworks have been very influential in OR/systems scholarship (e.g., see Flood & Midgley, 2022, on SOSM and Jackson's wider theoretical contributions to multimethodology scholarship). Academic practitioners have drawn on the theoretical frameworks reviewed above in their interventions and related research (e.g., for multimethodology, see Castellini & Paucar-Caceres, 2019; Davies et al., 2005; Franco & Lord, 2011; Henao & Franco, 2016; Ishino & Kijima, 2005; A. Small & Wainwright, 2014, 2018b; Yearworth et al., 2013; Yearworth & White, 2013). However, evidence of use of the theoretical frameworks and their underlying philosophies (section 2.5.2 above) to guide intervention design *outside academia* is limited (Brocklesby, 2023; Cabrera, 2023; Ormerod, 1997a, 2008b; Zhu, 2022; but see Appendix A for an overview of use of multimethodology and TSI in OR in defence).

2.9.8 Recent moves to foreground problem construction and practical issues

Recently, there have been further moves away from proposing method choice based on broad characterizations of complex situations in which practitioners intervene, towards foregrounding the construction of issues or problems with stakeholders, and the addressing of other practical issues that practitioners face in using multimethodology, including the operation of power, and how to integrate different methods. Jackson's rejection of SOSM in his latest four-part version of CSP (discussed in section 2.9.2 above) can be seen as an example of this. A second example is that in behavioural OR, Luoma (2016) proposes a typology of possible uses of OR in organizations for routine and non-routine decision-making, suggesting that practitioners choose methods that minimize disruption to customary organizational decision-making behaviour thereby reducing risk and conflict. Third, Mingers (2018) has proposed a grid for matching tasks constructed with stakeholders (specific issues to be addressed or functions to be performed) to questions that practitioners can address with specific, listed action methods designed for complex decision environments (Table 27, Appendix F). Fourth, Yearworth and White (2021) use Callon's (1980) 'forces of problematization' or 'mechanisms though which reality is problematised' (Callon, 1980, p.

198) in proposing observation over problem categorization for method choice, particularly where categorization involves dichotomous division of OR methods into 'hard' and 'soft' (see Dyson, 2022; Dyson et al., 2021; Yearworth, 2022a, 2022b). This is because a 'problematic situation is a dual process of construction and de-construction' in which power is exercised by stakeholders, resulting in 'a problematic situation with specific demarcations – the un-analysed, the network of certainties, and the area of suspicion' (Yearworth & White, 2021, p. 12). Like Mingers (e.g., 2015), Yearworth and White here promote a view that complex real-world issues are both hard and soft.

Fifth, Tolk et al.'s (2021) framework for cross-disciplinary development of hybrid modelling (Figure 41, Appendix D) has a 'focus on the integrateability and interoperability of methods in different stages of a simulation study' (e.g., using PSMs before simulation). In addition, Tolk et al. (2021) propose that,

> ... evaluation of case studies against the[ir] framework could, for example, determine where lack of alignment at the application, tool, method, theory or research levels have reduced opportunities for real-world impact. For instance, poor alignment, particularly at the higher levels, can lead to a lack of stakeholder trust in M&S [modelling and simulation] solution[s] and outcomes (Harper, Mustafee, & Yearworth, 2021). (p. 1088)

Sixth, and most recently, Nguyen et al. (2024) have criticized J. S. Morgan et al.'s (2017) multimethodological design framework as too abstract for use in choosing simulation methods in practical applications. Instead, Nguyen et al. propose an iterative, practical framework for choosing simulation methods involving: (1) problem exploration with stakeholders; (2) assessing the appropriateness of combining specific simulation methods (considering: expected benefits over single method approaches given a particular context, practical issues, and model validation); (3) designing model components (modules), identifying a method for each module; and, (4) designing links between modules (flows of information, interfaces, and information exchange rules). The framework is based on SD and ABM, and the authors propose a set of interface designs for model components (modules) that describe how information flows from one SD or ABM module to the other, i.e., how different models are integrated. However, the authors suggest that the framework may be extended to include interface designs for a wider range of OR/MS methods.

2.9.9 Domain-specific frameworks

Other frameworks and toolboxes have been developed for particular methods and/or domains, including in health (e.g., Viana et al., 2014), complex project management (Gorod et al., 2019), healthcare (Jun et al., 2011), evaluating healthcare interventions (Cooper et al., 2007), for addressing the COVID-19 pandemic (Currie et al., 2020), in designing facilitated modelling (Franco & Montibeller, 2010), and for choosing MCDA methods (Guitouni & Martel, 1998; Cinelli et al., 2020, 2021). PSMs have also been proposed for use in method choice (e.g., Ferreira, 2013; Ormerod, 1997a).

2.9.10 Conclusion

There are many theoretical frameworks for multimethodology in OR that practitioners could draw on when deciding which methods to use and combine to support strategic decision-making, which I have summarized in this section. However, given the proliferation of methods and frameworks, and the complexity of strategic issues faced by OR practitioners, perhaps it is no wonder that we lack evidence that practitioners outside academia use the frameworks in choosing and combining methods (Christie, 2017a). The 'real-world relevance' (Westcombe et al., 2006, p. 777) of the frameworks in non-academic practice should be tested.

2.10 RESEARCH OPPORTUNITIES AND RESEARCH QUESTIONS

> ... OR/MS needs theories, be sure; yet the theories OR/MS needs should be answerable primarily to practitioners, start with practice, and end in practice, too. ...
> It is time, I would posit, for MP [methodological pluralism] theorising to be strongly pluralistic and responsive. ... (Zhu, 2022, p. 13, 15)

A number of questions and opportunities arise from the literature discussed above that motivate my research questions. Specifically, the research gap identified is a lack of understanding of the use of multimethodology in OR practice, especially in non-academic settings, and a lack of causal understanding of the process of practitioners' methodological decisions. I review each of these in turn in this section and derive my research questions, which are concerned with how and why OR practitioners choose and combine analysis methods in the context of supporting strategic decision-making in UK government.

2.10.1 The use of multimethodology in non-academic settings (prevalence, methods, designs)

Prevalence of use of multimethodology by practitioners

> In light of complex societal issues, including the COVID-19 pandemic, there has been a resurgence of interest amongst OR practitioners and researchers in using qualitative methods – particularly 'problem structuring methods' (PSMs) (Rosenhead, 1989) – alongside traditional, quantitative OR methods to facilitate better organizational and policy decision-making (Murray, 2021; Ranyard et al., 2022). (Christie, 2023, p. 163)

Given that multimethodology is widely recognized as an essential part of the OR practitioner's role in addressing complexity, and the claim that UK government OR practitioners commonly combine qualitative and quantitative OR, it is interesting that my literature review has revealed that researchers have not explored the extent to which practitioners adopt multimethodology in their day-to-day work. While a few practitioners in O'Brien's (2011) and Munro and Mingers' (2002, 2004) surveys provided more than one method combination example, participants were not asked about frequency, and Ranyard et al. (2015) did not collect data on single projects (Christie, 2023). In the wider mixed methods literature, there has been a proliferation of prevalence studies investigating the extent to which mixed methods have been adopted for research within particular disciplines (Molina-Azorín & Fetters, 2016). However, the practice of OR spreads far beyond that reported in OR literature and therefore literature review-based prevalence studies in OR. Therefore, there is a lack of empirical evidence on the extent to which OR practitioners actually use multimethodology.

Methods practitioners use and combine

Second, OR literature lacks detail as to how multimethodology works in practice. We have seen that surveys have revealed more of what non-academic practitioners do, but they lack detail on single interventions, and those that do provide details of methods combined in single interventions (Munro & Mingers, 2002, 2004; O'Brien, 2011) were undertaken a long time ago. While there has been a flurry of recent literature reviews providing evidence of reported cases of combinations involving qualitative OR methods, these reviews have tended to focus on particular methods and/or lack details of how multimethodology was used. Anyway, literature reviews tend to identify single case studies reported by academic practitioners, so that practice in non-academic settings is

underrepresented (Christie, 2023; Howick & Ackermann, 2011; Munro & Mingers, 2002; Wijnmalen & Curtis, 2013).

While OR is widely used to tackle important problems in UK policy (GORS, n.d.-b; Pidd, 2004c), and it is claimed that UK government practitioners commonly combine qualitative and quantitative OR, this is a specific area of practice where we have few published examples. More generally, while PSMs (as defined in Rosenhead, 1989) have been associated in OR literature with addressing the sort of strategic issues we are interested in with this research, there are few, recent, well-documented case studies of the use of PSMs with quantitative OR (Christie et al., 2022; see also Table 23.4 in Franco & Rouwette, 2022). The survey evidence we have suggests that when non-academic practitioners combine methods, they tend to combine quantitative methods, and when they support the strategy process, they tend to combine quantitative methods and management/strategy tools rather than PSMs.

In short, there is a gap in the literature regarding the methods used and combined by practitioners, particularly in non-academic settings, and in the specific context of OR supporting strategic decision-making for or on behalf of UK government. In addition, other avenues for future research identified by Howick and Ackermann (2011) that are still current (see also Ackermann & Howick, 2022; Hopes, 2021; Ranyard et al., 2015) are relevant to this research. These include a need to explore the issues that practitioners address using multimethodology, including types of problems, their owners, and dimensions such as time available. More specifically, Howick and Ackermann conclude that, 'More research also needs to be done to understand why mixes of quantitative methods tend to address operational problems whereas mixes of qualitative methods are used for strategic issues' (p. 507).

Forms of multimethodology (methodological designs)

> In OR literature, there have been renewed calls for more integrated OR practice that benefits from theory and experiential learning from use of traditional [quantitative] OR and PSMs (e.g., Dyson et al., 2021), and for guidance and well-documented case studies showing how these methods can be used together. Reports of such MMR [mixed methods research] approaches and their added value can inform future OR practice, attract clients, and be used in training practitioners (Hopes, 2021; Howick & Ackermann, 2011). (Christie 2023, p. 163)

Third, a small number of studies have attempted to categorize how methods are used together across OR practice in order to provide practitioners with insight into how methods might be combined. As

a next step, Howick and Ackermann (2011) concluded that, 'it would be interesting in future to categorize case studies further using the other labels mentioned in the literature' (p. 506). J. S. Morgan et al. (2017) did this for SD and DES, and suggested that their toolkit of designs may be more broadly applicable across OR. Christie (2023) has contributed further by building on J. S. Morgan et al.'s set of designs and other previous typologies (in OR and mixed methods research more generally) in compiling a set of designs used in OR across public, private and third sector organizations specifically for combining PSMs with quantitative OR, with examples and reported benefits. There remains an opportunity for research to understand better and learn from the different ways in which OR practitioners, particularly in non-academic settings, combine the wide range of OR methods available in practice. This could involve testing the typologies and their usefulness for practitioners addressing complex issues.

Research question

In sum, these three areas of opportunity for research into the use of multimethodology by OR practitioners in non-academic settings (in short: prevalence, methods, designs) led me to my first research question (RQ1):

> ***RQ1. How do OR practitioners choose and combine OR methods to support strategic decision-making?***

I seek to understand the prevalence of use of multimethodology by OR practitioners supporting strategic decision-making for or on behalf of UK government, and to describe the methods these practitioners use and combine, and forms of multimethodology (methodological designs) they use.

2.10.2 Why practitioners use particular methods and multimethodology (causal mechanisms)

We have identified in literature a range of influences on practitioner method choice and a number of reasons (benefits and rationales) for using multimethodology, as well as barriers and challenges. However, we have also found a lack of empirical evidence – across OR – of the *process* by which practitioners, particularly in non-academic settings, choose methods and multimethodology for their interventions, as well as the extent to which they use theoretical frameworks.

Howick and Ackermann (2011) suggest that in-depth, semi-structured interviews with practitioners and review of written records of interventions should reveal more regarding the process of choosing combinations of methods. They conclude that, 'exploring more about where and why the different combinations of qualitative and quantitative methods are used would be beneficial' (p. 507). J. S. Morgan (2013) also suggests that further work could ask practitioners about 'the motivation, rationale and acceptance of mixing methods', including barriers to the use of multimethodology, and the examination of case studies for practicalities (p. 255).

Research question

Hence, my second research question (RQ2) is:

> ***RQ2. Why do practitioners take these approaches, multimethodological or otherwise?***

I aim towards a more theory-informed, causal understanding of mechanisms that account for why OR practitioners supporting strategic decision-making for or on behalf of UK government use the methods they do, and why they use (or do not use) multimethodology.

2.10.3 Summary of research questions

Therefore, my research questions are:

> ***RQ1. How do OR practitioners choose and combine OR methods to support strategic decision-making?***
>
> ***RQ2. Why do practitioners take these approaches, multimethodological or otherwise?***

In the next chapter, I set out my approach to the research, my philosophical assumptions, and my theoretical framework for responding to the research questions.

3 THEORETICAL FRAMEWORK

3.1 INTRODUCTION

I concluded the previous chapter by setting out my research questions, which were motivated by questions and opportunities arising from the literature reviewed. In this chapter, there are three parts. First, I summarize, using Checkland's (1985) FMA model, my approach to the research, including the key theoretical and philosophical ideas I used in crafting and responding to the research questions. To be awarded a doctorate I must demonstrate 'the creation and interpretation of new knowledge' (The Quality Assurance Agency for Higher Education, 2024, p. 27; The University of Kent, 2023, p. 13). I also aim to contribute to OR practice and government policy. A number of philosophical issues therefore arise, including how knowledge is defined and created, values inherent in my research, and how my work will be used. Second in this chapter, I therefore review my assumptions relating to knowledge, causation, generalization, and science. I discuss methodology, paradigms, and axiology in the following chapter on my research design. Third in this chapter, I introduce my theoretical framework – a theory-informed, critical realist analysis of a generic OR intervention. The framework builds on findings from the literature review in the previous chapter and recent developments in philosophy and social science. It provides a basis for developing extant theory in OR.

3.1.1 Critical realism

There have been calls for more use of social science in the study of OR practice (Brocklesby, 2016; Franco & Rouwette, 2022; Ormerod et al., 2023), for mechanistic accounts of what happens in OR interventions (Franco, 2013, 2014), and for 'middle ground' between variance and process approaches (Franco et al., 2021; Mohr, 1982). I adopt critical realism, claimed as 'the most thorough and consistent articulation of a mechanisms-based approach' (Mingers & Standing, 2017, p. 187).

Critical realism has been introduced and advocated as a suitable philosophy for OR (Kotiadis & Mingers, 2006; Mingers, 1997a, 2000a, 2003a, 2006a, 2014, 2015), and for research into OR interventions (White, 2006, 2009, 2016b). While sociomaterial approaches such as actor network theory (Keys, 1997; Ormerod, 2014a; Ormerod et al., 2023; White, 2009; Yearworth & White, 2018)

have been useful in foregrounding the role of social and material aspects of OR interventions and their relations, critical realism affords the additional possibility of examining causality (Elder-Vass, 2015b; Modell, 2020; O'Mahoney et al., 2017).

To date, critical realism has been used by scholars in research about how to use particular methods in multimethodological interventions and research (Hector et al., 2009; Kotiadis & Mingers, 2006; J. S. Morgan, 2013; Shaw et al., 2017, 2019; Steenmans, 2017; Yearworth & White, 2013), and to understand problem structuring practice (E. Reynolds, 2021; Yearworth & White, 2014). In summary, scholars have started to apply critical realist concepts to OR practice and research, and useful recommendations have been made for its future use in OR (see also Franco et al., 2021), but its use remains limited (White, 2016b; Yearworth & White, 2014). Of particular relevance for this research is that critical realism has been specifically recommended for exploring causation and generative mechanisms in order to understand behaviour in OR interventions, develop middle range theories, and evaluate OR interventions holistically, but not operationalized for such research (White, 2016b).

As I show in this and subsequent chapters, critical realism provides a framework for investigating the complex social process of an OR intervention (Franco & Greiffenhagen, 2018; Horlick-Jones & Rosenhead, 2007; Keys, 1997; Midgley, 2000) that includes the interrelated and interacting causal influences of both social structure and practitioner agency (cf. Franco, 2014, who proposes affordances over deterministic, realist approaches for exploring influences on social behaviours), as well as the practitioner as a reflexive decision-maker (Elder-Vass, 2022). This makes critical realism particularly suitable for addressing my research questions, given their focus on the role of OR practitioners in intervention design (Cropper, 1990a; Keys, 1997).

3.2 OVERVIEW OF RESEARCH

One way of summarizing any research approach is using the FMA model from Checkland (1985) and Checkland & Holwell (1998), which I illustrate for this research in Figure 3 below.[13] I took research themes and concepts for my framework of ideas (F) from the research proposal, my literature review in the previous chapter, and my philosophical assumptions in this chapter. I applied the (F) in developing my research methodology (M; chapter 4) for studying the area of concern (A). The area of

[13] Cf. Nichol et al.'s (2023) framework for developing conceptual architecture, especially with critical realism.

concern (A) I sought to learn about was the use (and non-use) of multimethodology in OR practice supporting strategic decision-making for or on behalf of the UK government.

[REDACTED]

Figure adapted from 'Fig. 2. Elements relevant to any piece of research.' in Checkland and Holwell (1998, p. 13)

Figure 3: Overview of research elements using Checkland and Holwell's (1998) FMA model

Thus, my research was designed to lead to learning about the use (and non-use) of multimethodology in OR practice supporting strategic decision-making for or on behalf of the UK government (A), the intellectual framework of ideas about the use of multimethodology in OR interventions (F), and use of my research methodology (M; Checkland & Holwell, 1998).

3.3 PHILOSOPHICAL ASSUMPTIONS

3.3.1 Knowledge

Knowledge is classically defined in Western philosophy, following Plato, as 'justified true belief' (Mingers, 2008). Generally, philosophers have sought to distinguish it from speculative belief. However, this is challenging and unresolved (Mingers & Standing, 2020). In my research, I sought evidence in order to derive *justifiable* research insights, drawing on existing theory to derive my research questions and explore my results. Truth can then be derived over time from discourse (Mingers, 2009). More generally, knowledge tends to be discussed in terms of dimensions,

particularly ontology and epistemology (discussed in the following subsections), as well as methodology and axiology (discussed in chapter 4).

3.3.2 Realist ontology

Ontology is about the nature of being, about what is assumed to exist. I assumed a realist ontology – that there are entities (referred to as things in Fleetwood, 2009) that exist whether or not they are perceived, recognized, or understood. Taking a critical realist approach (Bhaskar, 2008, 2016; Danermark et al., 2002, 2019; Easton, 2010; Edwards et al., 2014; Elder-Vass, 2010; Mingers, 2000a, 2004b, 2004c, 2004d, 2014, 2015; Mingers et al., 2013; Sayer, 1992), these real entities have causal powers and liabilities in that they may lead to an event or change happening in one way or another, or not happening (Sayer, 1992). Their causal efficacy provides evidence that they exist. For example, that knowledge of the physicality of the human body and the effects of medicine have been used in medical science to improve health outcomes suggests that there is some consistency in the existence of humans and chemicals over time.

An alternative approach, ontological relativism, would suggest that not only can we not be sure that there are real entities, but all we can know is our personal, moment-to-moment experience. However, this approach leads to the conclusion that knowledge cannot be built cumulatively and therefore provides an unsatisfactory basis for an applied, scientific discipline such as OR, in which cumulative knowledge of methods and the practice of OR is applied to change or improve real-world situations.

In critical realism, realist entities are material, conceptual, or social, and include 'ideas and concepts, feelings and reasons, languages, meanings, norms, practices and social structures' (Mingers, 2004a, p. 150; Wynn & Williams, 2020). Entities may be 'complex or simple, structured or unstructured' (Easton, 2010). They have emergent properties, and, in relation to other entities, they have powers and liabilities to change those other entities (Mingers & Standing, 2017).

Realist entities may be observable or unobservable. Inferential evidence for unobservable entities comes from their effects on people's thinking and views, what they say, and material objects (Bhaskar, 1997). Unobservable entities cannot be measured, but better explanations can be sought. Entities that are independent of observers and their observations of them are described as

intransitive (Bhaskar, 2008), while transitive entities are socially derived, person-dependent objects, such as theories and data (Mingers, 2017; Zachariadis et al., 2013).

My critical realist approach involved focusing on entities because I did not believe it was possible for me to understand sufficiently the context and detail of particular OR interventions by reducing their complexity to a number of variables for modelling or practical experimentation (cf. Finlay, 1998; Franco et al., 2021). There were: too many interrelated factors at play, including many that I was not aware of, at least initially; practical issues with control, including knowing which interventions were sufficiently comparable for detecting causal relationships by induction; and, qualitative and unobservable aspects that were not measurable. It would not have been possible – practically or ethically – to control variables and use experiments to answer my research questions, and how people act in a situation anyway depends on their interpretation of their view of it, and their history, which my empirical research needed to take into account. Moreover, taking a systems view, there were likely to be emergent properties of the context and interventions at different hierarchical levels that a reductionist approach would miss. Adopting critical realism also meant I could acknowledge that theory is modified by experience (Quine, 2003/1951).

3.3.3 Relativist epistemology

Epistemology is about the nature of knowledge and truth. It influences the choice of methodology and methods, since it suggests, for example, what is visible, touchable and measurable. I assumed a relativist epistemology. This is different from a positivist paradigm that assumes a realist epistemology – that we can know that things exist. Critical realism acknowledges Heisenberg's uncertainty principle: undertaking research has effect on what is studied and changes results.

I adopted epistemic relativism. 'Observation is fallible' (Easton, 2010, p. 123) and our experiences follow from previous understandings. Objective reality is socially mediated. Everything a researcher does is influenced by personal and social histories, motivations, values and interests (Al-Amoudi & Willmott, 2011; Lawson, 2003).

Unlike purely interpretivist and phenomenological approaches, I did not adopt judgmental relativism as my view is that it is possible to judge and conclude that some explanations are better than others

(Bhaskar, 2008). This is achieved by collaborating with others, and justifying results empirically and in light of extant theory.

3.3.4 Mechanistic, plural causation

I did not assume Humean causation relying on constant conjunction of events, as in positivist research, but rather explored causation and moved towards action for change by going beneath and behind events using a critical realist framework in which it is recognized that empirical evidence is partial, objective reality is socially mediated, and social science is value full. In short, I sought to understand 'why things are as they are' (Easton, 2010, p. 119). If they are as they appear to be, what must have led to that?

Critical realism is aimed at explaining how events (or changes) reflected in empirical data in the empirical domain come about. Retroduction is used to propose underlying generative causal mechanisms in the real domain of ontologically real, enduring mechanisms and structures (Easton, 2010, p. 119), while retrodiction is used to propose antecedent causal events in the actual domain of events generated by the mechanisms in the real domain (Mingers, 2014).[14] Figure 4 illustrates this stratification. We seek: (1) events, reflected in; (2) (observable) experiences in research data; and, (3) causal explanations (Elder-Vass et al., 2023; Fryer, 2022).

[REDACTED]

Adapted from 'Table 1.1 Domains of the real, actual and empirical' in Bhaskar (2016, p. 7)

Figure 4: Three domains (Bhaskar 2016)

[14] In other words, as Elder-Vass (2015a) writes, 'Given that events are always the outcome of multiple interacting causal powers, explaining them requires two [different, iterated] activities. In retroduction we identify individual causal powers [of entities] and the mechanisms that produce them, and in retrodiction we investigate what mix of causal powers interacted in what way to produce any particular event' (p. 81).

Critical realism then provides a logical framework for causal explanation in case research (Easton, 2010), both diachronic and synchronic (Mingers & Standing, 2017), based on entities with causal powers and liabilities, and mechanisms that cause events under specific conditions (Easton, 2010; Sayer, 1992). It can be seen as a theoretical lens or a philosophical framework for guiding a methodological approach (Maxwell, 2022a). That methodological approach must be plural because, 'there is not just one form of causation but many as Cartwright (1999, p. 119) argues – necessary conditions, sufficient conditions, agents, interventions, contraventions, modifications, enhancements, inhibitions etc' (Mingers & Standing, 2017, p. 172).

3.3.5 Transfactual generalization

For practical and philosophical reasons, my research data were not intended to constitute statistically representative samples from which I could generalize to a wider population of practitioners' decision support work, though some interventions were described to me as typical. Nor did I study samples constructed solely to make theoretical generalizations, as proposed by many for case study research (Yin, 2014). Instead, with the critical realist assumption of open systems (Bhaskar, 2008), I assumed a separation of causality and generality (Porpora, 2016, p. 209) and sought transfactual generalization to more plausible explanations of the use and non-use of multimethodology in practice.

3.3.6 Science

Popper (2003/1934) proposed that science involves the making of bold conjectures, which are then debated and sometimes falsified, with clear communication for debate being fundamental to progress. However, falsification is flawed in that it is doubtful whether falsification itself is falsifiable, and the replication of research, in order to see if conjectures can be falsified, is problematic. Where research is replicated and a result is not replicated it may not be clear if that is due to a theory being incorrect, the replication being inadequate, or results being interpreted in different ways. Anyway, importing notions of replicability from the natural sciences will not be appropriate for all research (Pratt et al., 2020).

Confirmation and induction have roles in science too despite criticism, such as that it is never clear whether enough evidence has been obtained in order to develop a theory. Logical positivists would

maintain that science involves seeking explanations purely from observation of what exists in nature rather than inference, whereas for Chalmers (2013), the progress of science is such that the theories that fit the most survive.

With critical realism there are no proven answers, only more plausible conjectures, refined over time by further retroduction, retrodiction, collaboration and justification. That was my scientific approach – to consider, develop, and refine alternative plausible explanations (Maxwell, 2004).

3.3.7 Conclusion

I have shown in this section some of the range of philosophical issues that arose from my doctoral research and the assumptions I made to deal with them. In philosophy there are many unanswered questions. I am not claiming to have answered these, but rather to have come to a set of justifiable and workable assumptions on which to base my research, and to derive plausible theoretical developments and practical insights open to criticism and testing by others.

3.4 THEORETICAL FRAMEWORK

> Since CR [critical realist] theorizing revolves around actual events, a CR theory is fundamentally a process theory. (Okoli, 2022, p. 10)

3.4.1 Introduction

In this section, I introduce my theoretical framework, which is a critical realist analysis of a generic OR intervention that builds on existing theory in the previous chapter. I define an OR intervention as 'the process in which practitioners seek to understand and analyse situations, make recommendations to organizational clients about possible improvements, and support organizational action' (Christie, 2023, p. 163, after Mingers & Brocklesby, 1997).[15] It is a complex process that unfolds over time, and includes practitioners' choices, actions, activities and events, ordering, sequences, and multiple outcomes (Franco et al., 2021; Gehman et al., 2018; Keys, 1997; Langley, 1999; Langley & Abdallah, 2016).

[15] Cf. Franco and Hämäläinen's definition of an intervention in their overview of Behavioural OR as, 'a structured process comprised of designed OR-related activities such as, for example, modelling, model use, data collection, interviews, meetings, workshops, and presentations' (Petropoulos et al., 2024, p. 547).

3.4.2 Events and experiences

I conceptualize an OR intervention as a 'series of events' (Mingers, 2014) or observable changes (or non-change; Sayer, 1992), some of which may be experienced (observed) by those involved or present – in the empirical domain (Bhaskar, 2008, 2016; Fleetwood, 2009; Fryer, 2022). This is a subset of all events that actually occur (and events that do not happen) in the actual domain. The events are the result of one or more causal mechanisms in the real domain (Figure 4 above). Events are changes in structures or entities (Mingers & Standing, 2017) and their relations.

I conceptualize methods as one dimension of an OR intervention, which, in turn, is part of a wider context. That there are many other dimensions to practical OR interventions is captured in Keys and Midgley's (2002) statement that literature on the process of OR (concerned with theory of the practice of OR intervention with organizations) is,

> ... about how people can make meaningful value and boundary judgements, negotiate stakeholder participation, deal with power relationships, structure messy situations, engage with multiple viewpoints, address conflict, work on the choice of methods, develop strategies for the implementation of proposed solutions, etc. (p. 123)

Depending on the particular research question and extant theoretical understanding, different subsets of events must be selected as of particular interest; any research must be bounded, so 'we carve events out of the ongoing flux according to our interests' (Mingers & Standing, 2017, p. 177). For my research questions, the events of an OR intervention (may) include the choice, use and combination of methods by practitioners (RQ1). We are interested in why practitioners adopted the methodological approaches they did and not others, i.e., causal mechanisms that led to particular methods being used, and to the use (or non-use) of multimethodology (RQ2).

3.4.3 Entities

> Entities only attain meaning if they are embedded in a theoretical framework. Of course in exploratory research entities may be chosen then accepted, modified or discarded as useful ways of try to understand data. (Easton, 2010, p. 125)

In an OR intervention there will be observable entities, including practitioners and other intervention stakeholders, and reports. There are also unobservable entities, including ideas, such as notions of appropriate methods. Following Bhaskar (1997), I conceptualize all these as real entities (section 3.3.2 above) with powers 'to generate or cause a particular outcome *to or with some other*

entity or system, within a particular context' (Mingers, 2014, p. 72, *emphasis in original*). That other entity or system has a corresponding liability. Entities have powers and liabilities generated by their properties, where,

> A particular power depends on the properties of the system but also on the properties of the affected system. ... In terms of the relationship between the power and the property there can be multiple – a single property can generate a single power; several properties may be necessary to generate the power; or a single property may generate several powers. (Mingers & Standing, 2017, p. 178)

While I later develop the theoretical framework with empirical findings, we start the conceptualization of an OR intervention with the following interrelated and overlapping elements from a synthesis of extant OR literature reviewed in the previous chapter:

1. Intervention stakeholders;
2. Intervention context; and,
3. Available methodologies and methods.

The three elements follow from evidence of practical OR interventions from surveys, literature reviews and field studies (reviewed in section 2.4), rationales for and barriers to multimethodology (sections 2.7 and 2.8), and theoretical frameworks for method choice and method combination (section 2.9). In particular they are similar to – but different from – the three interrelated and dynamic notional systems that constitute the context of a multimethodology intervention in the theory of the process of multimethodology (Mingers, 1997a, 1997b, 2003a, 2006b, 2014), which I develop within a critical realist framework. See Figure 43 (Appendix F). More specifically, the three elements follow, but are different from Mingers' (2006b, Figure 10.1) conceptualization of the 'Context of an intervention' as comprising the notional 'Problem Content System' (the intervention situation, including stakeholders, after Checkland), 'Intervention System' (intervening practitioners), and 'Intellectual Resources System' ('available theories and methodologies'; p. 217). Mingers' process of multimethodology is a critical realist account, but its critical realist basis is not always spelled out.

The three elements align broadly with Franco and Hämäläinen's (2016b) framework for empirical behavioural OR studies, which links context with OR actors (practitioners and other intervention participants), methods and praxis (intervention activities), as well as OR outcomes. Franco and Hämäläinen (2016b), however, define methods more broadly than I do – as methods, tools, routines and other approaches used, and other method guidance, including 'for intervention design, data

collection, training and teaching and embedding OR-supported processes in organizational routines' (p. 6). The three elements are also broadly consistent with the first three of the four 'foci' (context, purposes, methods and outcomes) in Midgley et al.'s (2013) framework for evaluating PSM use. Midgley et al. (2013) adopt purpose(s) in place of stakeholders, purposes being *of* stakeholders. The three elements are therefore also broadly consistent with Howick et al.'s (2017) themes for evaluating mixed methods interventions, which add 'Modelling Team' to Midgley et al.'s foci (Ackermann & Howick, 2022, p. 1907). More practically, the three elements coincide with the first three elements of an OR intervention to be described in practice papers for the UK Journal of the Operational Research Society (JORS) according to Ormerod's (1998) guidelines, the other elements being about events and outcomes, and the style of writing.

In other words, for an OR intervention in this research, there is context, including issues that may be considered problematic by stakeholders (Mingers, 2017), and practitioners who draw on methods in intervening in an intervention context, with stakeholders, including practitioners' organizational clients. We take these intervention elements and conceptualize them further below.

3.4.4 Intervention stakeholders (S)

> For CR [critical realism], conscious agency is just intentional (i.e., purposive) behavior. And behind intentional behavior there always lies a doer, a center of consciousness that is the intending agent. (Porpora, 2016, p. 141)

Conceptualizing and categorizing stakeholders

Our first intervention element is intervention stakeholders (S).[16] Stakeholders include practitioners, and their knowledge and skills (Easton, 2010), or competences (White et al., 2020), collectively, (P), as well as other intervention stakeholders, including clients, and stakeholder purposes (Midgley, 2000; Midgley et al., 2013) and expectations (Mingers, 2006b).

For intervention stakeholders, I started this research using Ormerod's (2001, 2008a, 2008b) categories (doers, done for, done with, done to, and done without), based on his reflections on his

[16] M. S. Reed (2022) highlights that the word 'stakeholder' is unacceptable to some individuals of indigenous groups. It is regretted that that there was insufficient time to address the issue in finalizing this dissertation. It is noted that Franco and Hämäläinen use 'individuals of interest' rather than stakeholders in their writing on behavioural OR in Petropoulos et al. (2024, p. 428).

extensive OR practice (Table 9 Table 9below). The categories indicate individuals' roles in relation to intervention activities, with the aim of being comprehensive. They include individuals potentially 'affected by' the project (following Freeman, 1984, p. 52) but not taking part in intervention activities.

Table 9: Stakeholder categories (Ormerod 2008a)

Stakeholder category	Examples
Doers	practitioners/consultants/analysts/facilitators
Done for	clients/customers/commissioners
Done with	workshop participants
Done to (involved but considered outside project)	data providers/interviewees
Done without (not involved but affected by outcome)	others

Source: Categories and some of the examples from Ormerod (2001, 2008a, 2008b)

Conceptualizing stakeholder action

I draw on Bhaskar's conceptualization of 'immediate, formative components of action' that are 'learnt, formed, developed' and 'necessary for action' (cognitive, conative, affective, expressive and performative; Bhaskar, 2016, p. 64). Accordingly, a person's causal powers to act (or liabilities) may result from their beliefs, values, sentiment, desire, motivation/drive, dispositions, and practical competences (including tacit knowledge), as well as facilities (being access to resources, and contributing to a person's transformative capacity). Opportunities to act are possibilities and circumstances (including a person's capabilities, after White et al., 2020) in multiply determined contexts. Bhaskar (2016) proposed that,

> The following can be put forward as a rough formula for the formation of action:
>
> > social structural conditioning + circumstances + reflexive deliberation + values (in relation to capacities/capabilities + feasibility) = determination of the appropriate course of action
>
> (p. 66)

Accordingly, understanding practitioner (or other stakeholder) action requires consideration of the intervention context (and its history) and practitioner reflexivity, including, 'in relation to her capacities or capabilities and the feasibility (including chances of success) of the course of action being considered' (Bhaskar, 2016, p. 64).

3.4.5 Intervention context (C)

> Ontologically, the social world is an emergent, concept- and activity-dependent, value-drenched, and politically contested part of the natural world. In it, social structures pre-exist and enable or constrain human activities, which are in turn (through the intentional causality of reasons) causally efficacious in the material world (Bhaskar 1998: chs. 3.1 and 3.2). (Bhaskar, 2014, p. ix)

Our second intervention element is the intervention context (C). An OR intervention comprises socially-situated activity (Keys, 1997; White, 2016b). The intervention context includes the real-world situation or intervention issues (that may be) addressed, and the broader, dynamic context of 'constant change' (Howick et al., 2017) or 'flux' (Checkland & Scholes, 1990).

To recap, in this research we are interested in practitioner actions in relation to method choice and use. We therefore need to consider the agency of practitioners (and other stakeholders) in OR interventions, *and* generative mechanisms of social structures, as well as 'experiences, interpretations, and responses of the actors involved [in this case, intervention stakeholders and research participants]' (Porter, 2015, p. 244). We start with individual reasons for actions or non-action and then look to make sense of those in context.

Ontology of a multimethodological OR intervention (three domains)

I conceptualize the context of an OR intervention as comprising: social and organizational structures that include positions or roles (with related power, duties/responsibilities, and rights); related practices, rules and norms; culture; agency; and, their relations (Archer, 1995, 1996, 2010; Bhaskar, 2016; De Souza, 2013, 2016, 2022; Easton, 2010; Elder-Vass, 2010; Fleetwood, 2005, 2008, 2009, 2021; Mingers, 2006a, 2014; Porpora, 2016; Sayer, 1992; Wynn & Williams, 2020). There will also be material resources and artefacts in OR interventions, including technology, such as software and physical representations of models (Franco, 2013, 2014; Ormerod, 2014a; Paroutis et al., 2015; Yearworth & White, 2014), and agents or individuals (the stakeholders identified section 3.4.4 above). Figure 5 below shows Bhaskar's three domains (from Figure 4 above) annotated to reflect

some of my key assumptions. In short, Figure 5 below provides an overview of the ontology of an OR intervention.

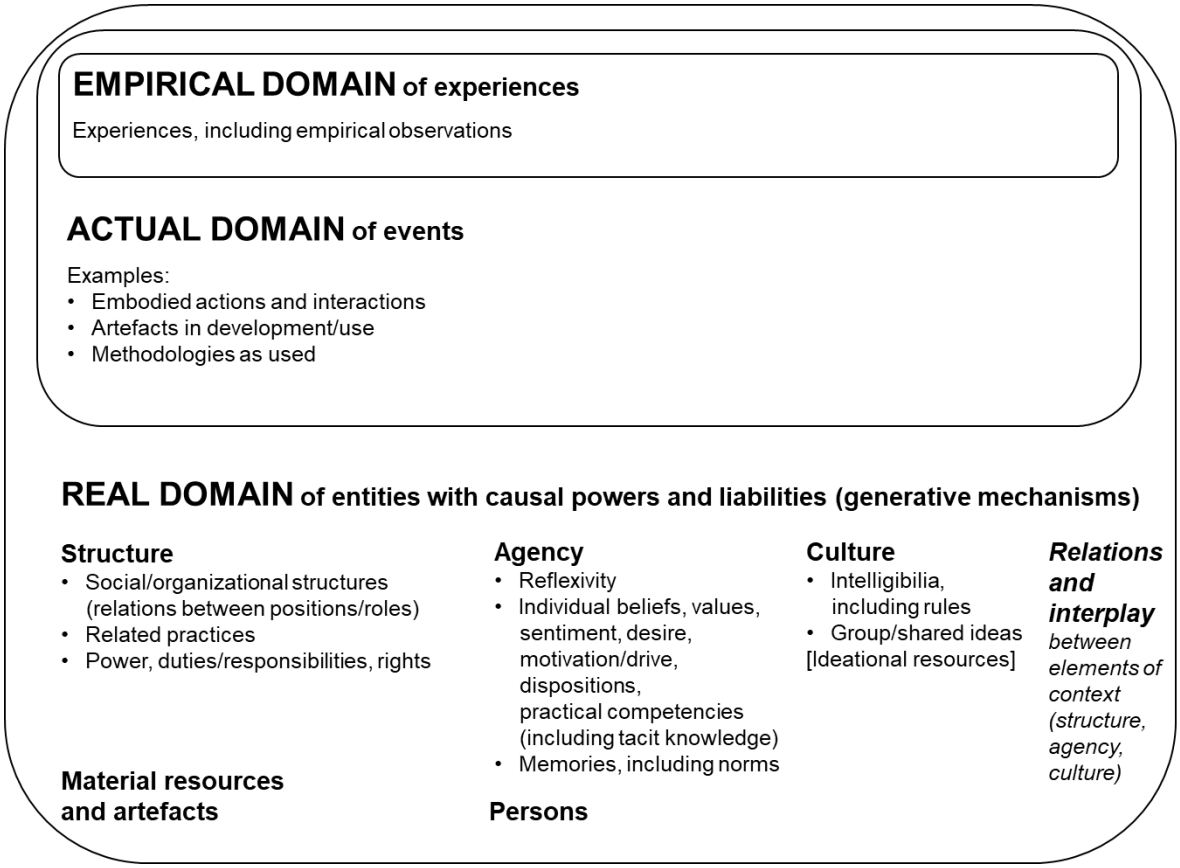


Figure 5: Ontology of a multimethodological OR intervention (three domains)

Mechanisms: agent reasons, and enabling and constraining conditions

> ***Agency.*** Individuals in society engage in action or non-action under the influences of structural and cultural conditions. Critical realism also assumes that they do so with intention and reflexive self-monitoring of their own individual interventions in the world (Bhaskar, 1998: Chapter 3). (De Souza, 2013, p. 145)

An illustration of my conceptualization of generative mechanisms we are interested in, including conditions that enable and constrain stakeholders' (agents') reasoning and actions, is in Figure 6 below. In this conceptualization, what agents do (their actions and non-actions) is conditioned by generative mechanisms of social structures (structure, agency, culture, and their relations). This conceptualization draws on Archer's (1995) linking of agency and structural and cultural context in

her morphogenetic approach, which I discuss in subsequent sections.[17] The agent actions that we are particularly interested in are practitioners' method choice and use. These, and other agent actions (and non-actions), are then a subset of all intervention events.

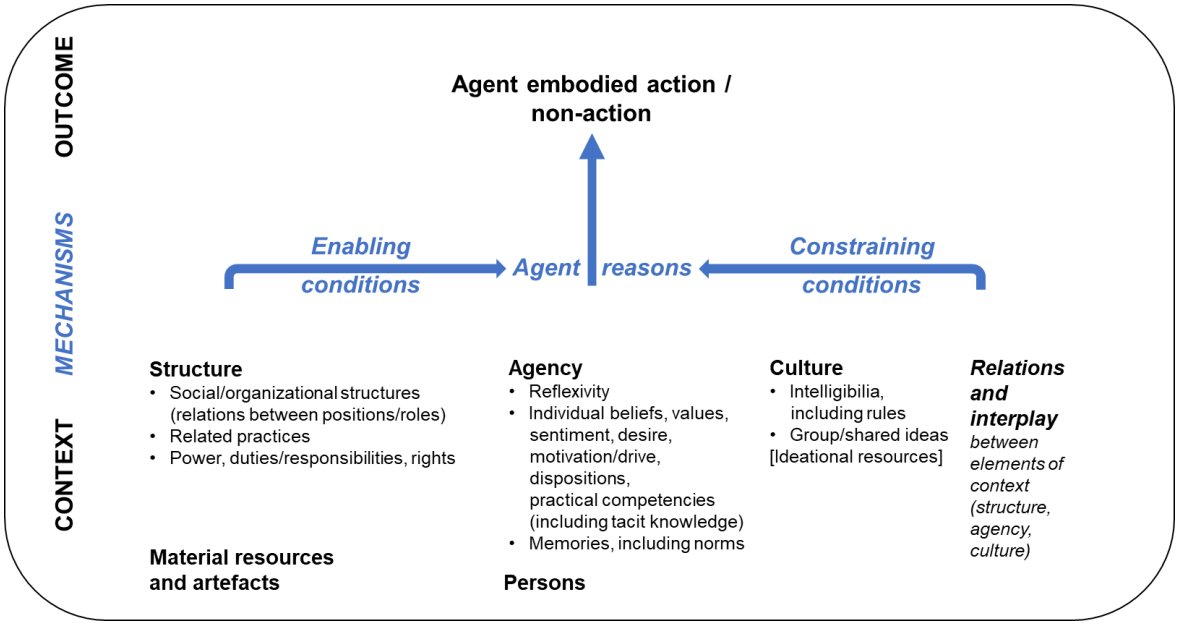


Figure 6: Conceptualization of mechanisms in agent actions in a multimethodological OR intervention

According to Bhaskar (2016), commenting on how critical realism may be combined with Sen and Nussbaum's capability approach,

> ... we may regard the agent's reasons (for an action or a course of action) as a causal mechanism that triggers a particular course of action. Such a course of action may be regarded as a tendency, subject to the play of enabling and constraining ['personal, social and environmental'] conversion factors ['that account for differences between people in converting their capabilities into achievements'] (p. 67)

[17] Thus,

> ... whilst structural and cultural antecedence means that they exert conditional influences upon agency, predisposing towards different courses of action, the former in no way determines the latter. It cannot do so on two accounts, both of which hinge on the fact that agency itself is the bearer of emergent powers. Thus, on the one hand, *any form of socio-cultural conditioning only exerts its effects on people and is only efficacious through people*. Hence, no conditional influence works as a hydraulic pressure, but is subject to reflective (if often imperfect) evaluation by agents who weigh it against their other concerns, due to their own emergent properties of self-consciousness and self-monitoring. On the other hand, agential relations themselves represent emergent powers (PEPs or people's emergent properties) with their two defining features - that is they modify the capacities of component members (affecting their consciousness and commitments, affinities and animosities) and exert causal powers proper to their relations themselves *vis-à-vis* other agents or their groupings (such as association, organization, opposition and articulation of interests). At any given T^1, these agential features (PEPs) are the outcome of prior interaction in anterior socio-cultural contexts during previous morphogenetic cycles. (Archer, 1995, p. 184, *emphasis in original*)

Mechanisms as emergent from the pre-existing intervention context

My conceptualization of the context of an OR intervention builds on De Souza's (2013) elaboration of Pawson and Tilley's (1997) context-mechanism-outcome (CMO) heuristic in realist evaluation. De Souza argues that 'from a critical realist perspective, Pawson and Tilley's (1997) "context-mechanism-outcomes" is better understood as "conditions-mechanisms-outcome"' (De Souza, 2022, p. 8). Her elaboration draws on critical realism (Bhaskar, 1998; Collier, 1994), Archer's (1995, 1996) morphogenetic approach to social contexts, and realist research methodology (Sayer, 1992).

De Souza conceptualizes the pre-existing action context of a social programme to enact change in an organizational setting as comprising interrelated, 'aspects of structure, culture, agency and relations' (De Souza, 2013). See the first three columns in Table 10 below. These four aspects are institutional or organizational conditions in which enduring mechanisms are already located (Porter, 2015), and in which agents take action in designing and introducing programmes to enact change (De Souza, 2022).[18] In the pre-existing context, 'Structural and cultural mechanisms providing constraining conditions' and 'enabling conditions', together with 'agent-activated mechanisms stemming from interactions with social structures' (Figure 6 above), may result in a particular, novel social (change) programme emerging (De Souza, 2022, p. 83; Figure 5 above). The emergent programme will have stated aims, and will, in turn, comprise mechanisms, the outcomes of which can be evaluated (De Souza, 2022; Porter, 2015).[19] Following Archer (1995, 1996), the 'action context', comprising 'configurations of components' of 'structure, culture, agency and relations', may be transformed, reproduced, or remain the same (De Souza, 2013, p. 148).

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[18] De Souza (2013, 2022) uses the words 'institution' and 'organisation' interchangeably, whereas Archer (1995, p. 202) distinguishes between the two, using 'institutional' as a broader term, encompassing, for example, the role of a married person in society. De Souza (2022) also states that '*Social structures* may be broadly defined as the way in which social objects are organized and made to function. They *may include an organization, people, nations, a class, a community, an association, or society* (Quinton, 1975).' (p. 6, *emphasis added*). Similarly, Eastwood et al. (2021) state, 'The task of critical realist research and evaluation is to make explicit the mechanisms orchestrating the observed phenomenon and to understand their interplay in a specified *organisational/institutional/social* structure' (p. 634, *emphasis added*). See also Fleetwood (2008) and Hodgson (2006) on defining institution, organization, and social structure.

[19] 'A social programme for change' has been defined as, 'a political strategic plan in order to transform a problematic social phenomenon to the better and an *evaluation* is made to compare the plan with the actual outcome' (Danermark et al., 2019, p. 207, *emphasis in original*).

Table 10: Pre-existing action context of a social programme to enact change in an organizational setting (De Souza 2013, 2022)

[REDACTED]

[REDACTED]

Adapted from Table 1 in De Souza (2013), Table 37.2 in Eastwood et al. (2021), and Figure 2 in De Souza (2022)
.

In De Souza's original work, the interrelated organizational conditions are features of context one would need to change in an education programme, being based on an educational institution (De Souza, 2013). De Souza then applied her conceptualization 'one level up' in a systemic analysis of the emergence of a tertiary education to work training programme in Australia (De Souza, 2022, p. 72). Example interacting mechanisms, at different social levels, shaping the emergence of the work training programme are in the final column of Table 10 above.[20] Like the social programme in De Souza's conceptualization, I conceptualize an OR intervention, including the methodological approach used by practitioners, as emergent from the pre-existing intervention context, which comprises aspects of structure, culture, agency and relations (Figure 5; Figure 6 above).

De Souza's structure, agency, culture, and relations: historicity and power

> By assigning equal importance to the cultural dimension, the elaboration of the CMOc [context-mechanism-outcome configuration] will further encourage investigations into intersubjectivities and the various discursive strategies operating in an action context. (De Souza, 2013, p. 151)

[20] Eastwood et al. (2021) also propose application of De Souza's conceptualization for integrated care settings.

In effect, De Souza follows Archer (1995, 1996) in arguing that treating culture as analytically distinct from structure (and agency, after Bhaskar) facilitates (separate) consideration of ideational aspects of social dynamics. De Souza's (2013, 2022) further (analytical) separation of relations appears to be to facilitate researcher focus on changes in the distribution over time of power (relating to social positions, and associated with access to material and ideational resources), duties/responsibilities (relating to roles), and rights (relating to law and rules). For De Souza (2013), 'duties, rights and powers are said to be emergent properties essential to social relations' (p. 150), while Bhaskar's 'relational conception of society',

> ... allows one to focus on a range of questions, having to do with the distribution of the structural conditions of action, and in particular with differential allocations of: (a) productive resources (of all kinds, including for example cognitive ones) to persons (and groups) and (b) persons (and groups) to functions (for example in the division of labour). In doing so, it allows one to situate the possibility of different (and antagonistic) interests, of conflicts within society, and hence of interest-motivated transformations in social structure. (Bhaskar, 1998, p. 45, as cited in De Souza, 2013, p. 151)

De Souza's separation of relations also serves to highlight the historicity of pre-existing contexts that condition action (De Souza, 2016, after Archer, 1995). This is evident in her diachronic analysis of the emergence of the tertiary education to work training programme, where De Souza (2022) concludes that an Australian not-for-profit was able to 'draw on the *relational mechanisms* that they[*sic*] had developed [in the past] such as their good reputation and their trustworthiness in delivering proposed outcomes' in securing a number of partnerships and government funding for the programme (De Souza 2022, p. 14, *emphasis added*). Thus, her analytical separation of 'structure, culture, agency and relations' builds on, and is to some extent different from Archer's analytical separation of structure, agency, and culture, as we see from De Souza's later writing,

> While Porter [2015] has recommended the need to add the critical realist conception of agency to the original CMOc [context-mechanism-outcome configuration] formula in order to provide a sufficient depiction of the causal chains prevailing in society, De Souza (2013), also drawing on Archer's contributions, has suggested viewing context in the CMOc formula as comprising the components of structure, agency, and culture (Archer, 2012) *and the interplay and relations between them*, elaborating on but leaving the integrity of CMOc intact. ...
>
> (De Souza, 2016, p. 218, *emphasis added*)

and

> Archer has suggested that the problem of linking structure, agency, and culture can be satisfactorily resolved by "examining the *interplay between them over time*" (Archer, 1995, p. 65)
>
> (De Souza, 2016, p. 218, *emphasis in original*)

What De Souza captures in the reputation-based and trust mechanisms that she categorizes as relational (final column, Table 10 above), is that past actions of individuals in roles in an Australian not-for-profit resulted in the emergence of, 'social capital and the track record they had established for over a decade as a not-for-profit organization working with young adults with Down syndrome, their parents, and business and government supporters and sponsors' (2022, p. 14). This social capital and the track record presumably emerged as properties of the not-for-profit.[21] The mechanisms are triggered when creation of the new social programme is sought. In other words, the securing of partnership working and funding from other organizations results – at least in part – from the causal powers of the not-for-profit as a real entity *in relation to* those other organizations. The partnership working and funding (as with the past actions that led to the emergence of the social capital and track record) constitute events that (by definition) change the organizations as entities, and their relations, and therefore the structural and cultural action context (or conditions). Whereas, more generally, Archer observes that, 'to realists *all* emergent properties [be they structural, cultural, or agential] are *relational*' (Archer, 2000, p. 465, *emphasis in original*).

The securing of partnership working and funding presumably also involved other (prior) events (such as negotiations, and applications for funding), i.e., other aspects of structure (e.g., funding rules), of agency (e.g., individuals' motives and motivation), and of culture (e.g., group ideas), and 'the interplay *and relations between them*' (De Souza, 2016, p. 218, *emphasis added*). In fact, De Souza acknowledges that,

> … some possible mechanisms operating in an action context have been suggested and the usefulness of their identification has to be tested out in research practice. The mechanisms suggested thus far are not meant to be exhaustive or understood as being 'deal-breakers'. It would be more likely than not that more mechanisms will be identified, especially where agency is concerned (see Archer, 2000, 2003, 2007b, 2010b). (De Souza, 2022, p. 152)

Overall, then, there are a number of different ways in which relations can be understood in De Souza's conceptualization of the action context of a social programme. In particular, she draws attention to changes in social structures (and, more generally, conditions) over time, and the power,

[21] This presumption is based on De Souza's references to the Australian non-for-profit as 'they'. She does not (otherwise) refer to individuals within the not-for-profit in her discussion of relations.

duties and rights they are associated with, some of which are actually exercised with (inter)actions. As she concludes that, in her elaboration of CMO in realist evaluation,

> … reinstating the critical aspect and highlighting relations as an aspect operating in contexts of action allow researchers to examine or evaluate the possible changes in the distribution of power in the delineated socio-structural context of action. (De Souza, 2022, p. 152)

De Souza's work also reminds us that there are multiple social structures and entities to consider in any consideration of (the conditions of) social context and causes of actions, which we review next specifically for OR interventions.

Social structure in OR interventions

Fleetwood claims that, 'Critical realists use the term 'social structures' as a portmanteau term to refer to configurations of causal mechanisms, rules, resources, relations, powers, positions and practices (see Fleetwood, 1995)' (Fleetwood, 2005, p. 199). Fleetwood's own definition is,

> A social structure is a latticework of internal relations between entities that may enable and constrain (but cannot transform) the intentions and actions of agents who draw upon, reproduce and/or transform these relations. (2008, p. 259)

In my critical realist conceptualization of the context of an OR intervention (Figure 5 above), practitioners (and other stakeholders) have organizational roles, and, more generally, social positions. Following Bhaskar, social structure is relational – for example, not comprising relations between persons, but relations between positions (in the case of social structures generally), or roles (in organizations; M. I. Reed, 2009). Social structures are emergent from (prior) action (Archer, 1995). Ontologically, social structures are real entities, having causal powers. They are not material (Fleetwood, 2005, p. 201; cf. Porpora, 2016, who uses 'material' to mean 'real' rather than physical, as here). Power, duties, responsibilities and rights are related to social positions and organizational roles. Roles are associated with access to material and ideational resources, as well as other individuals (Elder-Vass, 2010). Bhaskar's *position-practices* link social structure and action (Mingers, 2014, p. 99). Thus, positions and roles are associated with practices.

Rules and norms underly practice in that they condition action (Fleetwood, 2021). After Fleetwood's argument that rules are 'always located in artefacts' (2021, p. 632), I conceptualize the 'meaningful content' (Porpora, 2016, p. 159) of rules as part of Archer's 'cultural system' (1995, p. 229), i.e., aspects

of culture, which is itself analytically and ontologically separate from structure and agency. Norms, however, are 'always located in agents' cognitive systems … as memories of past actions' (Fleetwood, 2021, p. 632), and are therefore within what Bhaskar and Archer distinguish analytically and ontologically as agency. See Figure 5 and Figure 6 above. Rules and norms may be constraining or enabling in relation to agents' particular projects, where 'the term 'project' stands for any goal countenanced by a social agent, from the satisfaction of biologically grounded needs to the Utopian reconstruction of society' (Archer, 1995, p. 198).

Archer's morphogenetic cycle: a framework for diachronic and synchronic analysis

> While social interaction is continuous, at any moment the emergent structure depends on past activities, not on the actions of current agents. Agents in turn are shaped and reshaped as they engage with the structures they confront, but did not create (Archer 1998). (Volkoff et al., 2007, p. 835)

De Souza describes hers as 'a diachronic analysis exploring the social [structural] conditioning or T1 phase' (2022, p. 11) of Archer's (1995) morphogenetic cycle (Figure 7 below), which builds on Bhaskar's transformational model of social activity (TMSA). To the extent that De Souza implicates past interaction between the Australian not-for-profit and other organizations (with the relational mechanisms she proposes), I would argue that she is, to some extent, exploring interaction and elaboration phases of prior morphogenetic cycles. Elsewhere, De Souza argues that her elaboration of Pawson and Tilley's (1997) CMO heuristic with Archer's (1995) morphogenetic approach facilitates diachronic *and synchronic analysis* of the pre-existing context:

> In terms of providing a framework that accounts for complexity in the relationships between historical contextual processes and their possible present-day effects on program effectiveness, the position of the critical realists, notably in the work of Archer's (1995) realist social theory, provides a viable and fairly unexplored framework for dealing with complexity in evaluation science. It enables *the synchronic and diachronic analyses of a context comprising structural, cultural, and agential components and their relations, and their operations prior to* and during *program implementation*, contributing to the observable patterned outcomes at the point of investigation and their possible developmental trajectories. (De Souza, 2016, p. 219, *emphasis added*)

Archer's morphogenetic approach (Figure 7 below) is derived from two theoretical assumptions – 'that, (i) structure necessarily pre-dates the action(s) which transform it, and, (ii) that structural elaboration necessarily postdates those actions' (Archer 1995, p. 168). In the morphogenesis of each of structure, culture, and agency, there are three phases – 'Emergence-Interplay-Outcome' (1995, p. 168). Each cycle, 'has relative autonomy and yet interacts with the others' (pp. 192-193). There is also 'the double morphogenesis, where agential powers are elaborated in the process of socio-cultural

transformation' (p. 185), providing a way, for example, of conceptualizing changes in practitioners' knowledge and skills (competences) over time, and 'triple morphogenesis' of actors in social positions and roles (p. 274), providing a way, for example, of conceptualizing changes in social identities of practitioners and other stakeholders.

(1) Structure

[REDACTED]

(2) Culture

[REDACTED]

(3) Agency

[REDACTED]

Adapted from Archer (1995, Figure 10 'The morphogenesis of structure', Figure 11 'The morphogenesis of culture' and Figure 12 'The morphogenesis of Agency')

Figure 7: Morphogenesis of structure, culture, and agency (Archer 1995)

The applicability of Archer's morphogenetic cycle

Archer (1995) was interested in explaining population-level change and the actions of groups or 'large sections of the population' (p. 216). In using Archer's morphogenetic approach in realist evaluation, De Souza (2013) argues that,

> … researchers assume that institutions in the health, educational, prison and other social domains are micro-scaled versions of society; and institutional changes resulting from the introduction of social programs can be understood and explained in the same way that realists explain the society/person connection.
> …
> … and that the kinds of possible societal changes can be similarly observed in an action context when a specific social program is introduced.
>
> (pp. 142, 147)

De Souza (2022) also mentions Mutch's assertion that,

> … it is important to note Archer's argument that the framework she proposes could be used at any scale of activity. As she puts it,
>
> > Analytical dualism can be used by any researcher to gain theoretical purchase on much smaller problems where the major difficulty of seeing the wood from the trees becomes much more tractable if they can be sorted out into the components of temporal cycles of morphogenesis - however short the time-span involved may be (Archer, 1996: 228).
>
> (Mutch, 2017, p. 501)

Actually, Mutch has also pointed out that Archer herself claimed that morphogenesis provides a framework for *any* social situation. His particular focus recently has been re-examination of and opportunities for strategy-in-practice research – as follows:

> … the claim for Archer's approach is that it can be applied to any situation in social life, whether that be a detailed examination of local strategic practice or the unfolding of relationships between organizations at a societal level. As she writes at the conclusion of her 1995 book
>
> > Other investigators of entirely different problem areas will find nothing here which will enable them to dispense with doing their own footwork (though hopefully it indicates a useful path to tread), for this is the reason why throughout this book social analysis has been held to entail *practical* social theorizing. (Archer, 1995: 327-8; *emphasis in original*)
>
> (Mutch, 2020, p. 8).

Thus, we can adopt the morphogenetic cycle to underpin our understanding of the emergence, from the pre-existing context of an intervention, of a practitioner's or practitioners' methodological design for the intervention. To apply Archer's morphogenetic approach in this research, we 'break into the cycle at some point and impose an analytical starting point' (Fleetwood, 2005, p. 203, after Archer, 1995).

Emergence of issues to be addressed in the OR intervention context

> … speaking for the pragmatists, Neil Gross tells us that mechanisms are "chains or aggregations of actors confronting problem situations." But actors apart, what are problem situations? Might they not stem from relational conditions such as conflicts of interest? And as such would they not be ontologically objective, motivating mechanisms in themselves? Gross does not say, but to admit as much would move us outside the confines of his brand of pragmatism. (Porpora, 2016, p. 121)

For this research, I conceptualize that, at the outset of an OR intervention, real issues to be addressed, and their being seen as problematic by stakeholders (Mingers, 2017), are emergent from the history of the situation. As the intervention proceeds, real issues, and how they are viewed by practitioners and other stakeholders, are emergent from the history of the intervention.[22] This importance of history, as well as the interaction of aspects of an intervention context, including practitioner reflection, as intervention proceeds, are emphasized in Mingers' (1997b, 2006b, 2014) account of multimethodology (see Figure 43, Appendix F), though without detailed ontological specification as set out above (for use in my empirical research). Some of these important dimensions are also found across other theoretical frameworks, as we see, for example, from Yearworth and White's (2014) conclusion that, as problem structuring activity proceeds,

> Since PSM use is a form of "organized finding out" it is likely that knowledge of the problem situation is not static but dynamic throughout the engagement (Mingers & Rosenhead, 2004), Jackson's CSP [critical systems practice] also supports this view (Jackson, 2001), as does Ormerod in his description of the mangle of OR practice and the dynamic nature of the interplay of human, material, and conceptual components (Ormerod, 2013a). This also echoes the notion of boundary critique (Midgley, 2000, pp. 103–104, 131–133; Ulrich, 2003) and its role in determining the context for evaluation in (Midgley et al., 2013). (p. 937)

Conclusion

My critical realist conceptualization of the ontology of an OR intervention (summarized in Figure 5 and Figure 6 above), together with Archer's morphogenetic approach, provide a framework for this

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[22] Similarly, as we see from Danermark et al.'s (2019) alternative conceptualization, after Archer, of a successful social programme (in applied interdisciplinary research), we could conceptualize an OR intervention as the development of a succession of CAIMO [Context, Action, Intervention, Mechanism, Outcome] configurations:

> To begin with, the social structures and the mechanisms that generate the problems practitioners want to do something about must be identified (T^1). But it is only through people's interaction (T^2-T^3) – the context in the CAIMO [Context, Action, Intervention, Mechanism, Outcome] configuration – that structures can be reproduced or transformed. The researcher in applied social science therefore also has to analyse those actions – and resources for actions – that are necessary for pitting the problem mechanism out of play. To be sure, the outcome, or the elaboration (T^4), is to be the change that the program tries to obtain and that in its turn forms a new T^1.
> The procedure thus means that the researcher successively develops a CAIMO configuration. When it comes to applied social research it is, however, important that this takes place in interaction with decision makers, practitioners, and participants. (Danermark et al., 2019, p. 202)

empirical research for synchronic and diachronic analysis of causal mechanisms that lead to OR practitioners' actions in relation to method choice and use.

3.4.6 Available methodologies and methods (M)

> Ideas, and ideational connections (including category mistakes, logical contradictions etc.), are part of everything, and everything is real. To deny the reality of a part of everything (of anything), such as ideas (or say persons, or consciousness, or agency, or values—or mind, or body) extrudes or detotalizes it or them from the world, that is the rest of the world of which they are in principle causally explicable and causally efficacious parts. This inevitably produces an implicit dualistic or split ontology. (Bhaskar, 1997, p. 139)

We now move to our third intervention element, available methodologies and methods (M). OR practitioners have an interest in identifying 'what specific methods or methodologies should be used in a particular situation and how they should be combined' (Parr & Mingers, 2015, p. 7). We are therefore interested in extant methodologies and methods (as defined in Table 7, chapter 2).

In multimethodology, Mingers' (1997b, 2006b) notional Intellectual Resources System 'consists of those theories, methodologies, and techniques that could potentially be relevant to the problem situation, although not necessarily within the practitioners' or researchers' current repertoire' (Mingers, 2006b, p. 218). As captured in section 2.9.5 above, Midgley (2000) draws on this notional system in systemic intervention, concluding that practitioners develop their own methodologies drawing on methodologies of other practitioners. Ormerod (2008b) distinguishes between public and private methods, following Keys (1997), who writes:

> Methodologies are statements which guide and inform an analyst's practice and a distinction may be recognized between *public methodologies* and *private methodologies*. Public methodologies are those which, for various reasons, are statements about process available for public scrutiny and debate. The most well known methodologies are public, in this sense. ... Private methodologies are those not available for public scrutiny and are not written down or given other public forms. Every analyst will have such a methodology, it may be a personal interpretation of a public methodology or the result of experience and totally personal to that individual. (p. 7, *emphasis in original*)

Ontology of methodologies and methodological design

In my conceptualization, OR methodologies, as ontologically real entities, come into existence through their development and use over time. A methodology, such as soft systems methodology (SSM), is emergent from (pre-existing) knowledge, scholarship, and practice (Checkland & Scholes, 1999). Practitioners develop knowledge of and skills in particular methodologies (which would also suggest that the methodologies have some existence over time) and apply their knowledge and skills in designing interventions and intervening.

While methodologies in use may have material aspects, such as software and visualization, some of which may (or may not) be referred to as tools (Howick & Ackermann, 2011), methodologies – generally, in OR – are conceptual intervention resources (Mingers, 1997b, 2006b, 2014) that practitioners draw on, develop and adapt (Mingers & Rosenhead, 2004; O'Brien, 2011). For Bhaskar (1997), all concepts or ideas are real because of the causal effect they have on anything and everything through, '(a) material transactions with nature; (b) social interactions between people; (c) social structure; and (d) the stratification of the embodied personality' – his '*four-planar social being*', or the 'four dimensions' of 'all social activity' (Bhaskar, 2016, p. 53, *emphasis in original*).

In practice, all methodologies and methods are adapted and used in different ways by different people to suit particular contexts (Greene, 2015; Mingers, 2011), so that they are best characterized – for any single intervention – *in use* (Maxwell & Loomis, 2003; Sandelowski, 2012), taking into consideration, for example, practitioners' mental models (Onwuegbuzie & Hitchcock, 2019) or paradigm strategies (Kotiadis & Mingers, 2006), or 'the philosophical positions of the actors' (Belton & Stewart, 2010, p. 219) in particular interventions. And any one methodology may be more or less essential (Mingers, 2006b) or dominant (Jackson, 1999) in any particular multimethodological intervention.

Methodologies are further developed over time by individual practitioners and intersubjectively. While practitioners and scholars may use methodologies in different ways, disagree over details, and develop different versions, there are many generally recognized methodologies in OR (Gomes Júnior & Schramm, 2022; Mustafee & Katsaliaki, 2020; Petropoulos et al., 2024; Ranyard et al., 2015). Over time, different versions and variations will be developed and become established, as in system dynamics and group model building (Vennix, 1996, 1999), and linear programming and data envelopment analysis (Sinuany-Stern, 2022). OR methodologies can therefore also be considered social.

Methodologies are social products with material aspects, for example, the ink used in describing them in books, artefacts such as the software, visualization, and checklists that practitioners use, and recordings of their use or explanations thereof, as well as physical aspects of memories. They are in practitioners' heads (part of their individual psychological reality), and in their embodied actions in interventions.

Methodologies therefore include what Archer (1996) terms 'intelligibilia' – 'meaningful content', purposively 'designed to communicate to or to otherwise influence others' (Porpora, 2016, p. 159), i.e., socially emergent products of the minds of their creators that are independent from particular interventions or practitioners. As intelligibilia, they form part of Archer's 'cultural system', which she separates ontologically from structure and agency for analytic purposes, as follows:

> As an emergent entity, the CS [cultural system] has an objective existence and autonomous relations amongst its components (theories, beliefs, values, arguments, or more strictly the propositional formulations of them) in the sense that these are independent of anyone's claim to know, to believe, to assent, or to assert them. …
> Consequently … contradictions exist independently of people noticing them or caring about them …
> (Archer, 1995, pp. 180-181)

There are logical relations between components of the cultural system. They need interpretation and can be interpreted in different ways. Further, as part of the morphogenetic cycle,

> At any moment the CS [cultural system] is the product of historical S-C [socio-cultural] interaction, but having emerged (emergence being a continuous ideational process) then *qua* product, it has properties of its own. Like structure, culture is a human product but it too escapes its makers to act back upon them. The CS contains constraints (like the things that can and cannot be said in a particular natural language), it embodies new possibilities (such as technical applications undreamed of in the pure theory on which they are based), and it introduces new problems through the relationships between the emergent entities themselves (the clash of theories), between these and the physical environment (mastery or ruin), and between these and human agents (makers and openers of Pandora's box). (Archer, 1995, p. 181)

Methodologies then, as realist entities, are material *and* conceptual *and* social; they have more than one 'mode of reality' and may conceivably change modes over time (Fleetwood, 2005, p. 199).[23] In other words, there are a number of different ways in which they are real (have causal powers). Like all 'cultural objects', their location can be said to be 'ontologically peculiar' (Porpora, 2016, p. 169).

As we saw in the previous chapter, empirical evidence suggests that in multimethodological OR practice, practitioners develop their methodological approach through an intervention (Howick & Ackermann, 2011; Munro & Mingers, 2002).[24] I therefore conceptualize methodological design as among the events and outcomes of an intervention. Methodological design is a characterization of methods *as used* by practitioners (Christie, 2023, after Maxwell & Loomis, 2003) in the actual domain. This conceptualization of methodologies is summarized in Table 11 below where I

[23] Fleetwood (2005) proposes four modes of reality – 'material, ideal, artefactual and social' (p. 199).
[24] This appears broadly consistent with Dewey's pragmatist theory of (scientific) inquiry (Ormerod, 2006a) to the extent that practitioners iteratively test and refine their methods through an intervention to address (social contextual) issues as they develop and as intervention has effect on those issues over time, including through stakeholder learning from participative intervention activities.

distinguish between methodologies in the pre-existing intervention context (methodologies *as guidelines*), methodologies in intervention activities (methodologies *in action*), and methodologies as used in past interventions (methodologies *as used*).

Table 11: Conceptualization of methodologies in an intervention

Intervention stage	**Role**	**Description**	**Examples**	**Domain**	**Ontology**
Methodologies in ***pre-existing context***	Methodologies ***as guidelines***	Pre-existing methodologies	Descriptions of methods and activities in discourses and documents, e.g., OR literature, books, organizational guidance, case studies (descriptions of past use) Pre-existing physical representations, including software, models, scripts, checklists, guidelines Recordings of the use of a methodology, or explanations thereof, e.g., a webinar Practitioner roles, e.g., OR practitioner or facilitator, expert in particular methodology Practitioners, their knowledge and skills (Easton, 2010), or competences, (White et al., 2020) in relation to methodologies Physical aspects of memories, e.g., of past use, norms	Real (structures and entities) (Figure 5; Figure 6)	Cultural system ('intelligibilia', after Archer [1996], including rules, after Fleetwood [2021], and group/shared ideas) Cultural artefacts Structure (organizational). Roles are associated with practices. Agency, Persons Norms are 'always located in agents' cognitive systems' 'as memories of past actions' (Fleetwood, 2021, p. 632)
Methodologies in ***practitioner activities***	Methodologies ***in action***	Embodied actions of practitioners in intervention, and their interactions with other people, material resources and artefacts Artefacts in development/use	Practitioners' choosing, adapting, and using methods, building models, facilitating Software, physical representations of models (visualization), and checklists developed and used by practitioners	Actual (events) (Figure 5; Figure 7)	Agency Social interaction Socio-cultural interaction Group interaction (Archer, 1995) Alternatively, Bhaskar's four-planar social being (four dimensions of all social activity): '(a) material transactions with nature; (b) social interactions between people; (c) social structure; and (d) the stratification of the embodied personality' (Bhaskar, 2016 p. 53)
Methodologies in ***intervention designs***	Methodologies ***as used***	Methodological design is a characterization of methods *as used* by practitioners (Christie, 2023, after Maxwell & Loomis, 2003)	Records of previous interventions, e.g., project reports, case studies	Real (structures and entities) (Figure 5; Figure 6)	Subset of methodologies in pre-existing context of subsequent intervention (see above)

This conceptualization facilitates the consideration of methodologies in different ways and configurations, for example, an established version of a well-known methodology, such as SSM, or a particular practitioner's knowledge, experience and practical skills in SSM, or notions of what are appropriate methodologies for use in a particular organizational context. The conceptualization in Table 11 also allows consideration of the use and changing nature of methodologies over time within a processual analysis that is both relational *and* substantive, reflecting a realist rather than 'strong process' ontology (Cloutier & Langley, 2020, p. 14; see also Midgley, 2000; Yearworth, 2024). A particular version of a methodology or methodological design may then be seen as real where it is used instrumentally by a practitioner and causally implicated in material, psychological and social changes resulting from an intervention.

3.4.7 Mechanisms

> The basic idea of mechanistic explanation is quite simple: At its core, it implies that proper explanations should detail the 'cogs and wheels' of the causal process through which the outcome to be explained was brought about. (Hedström & Ylikoski, 2010, p. 2)

Explicating mechanisms

> … it is not enough to just label an aspect of reality a mechanism; for this to make sense, this label must refer to a postulated aspect of reality whose specific emergence is, in principle, explainable. (Ash, 2022, p. 118)

> … conditional influences are multiple and it is their confluence and combination which performs the overall process of moulding situations for people. (Archer, 1995, p. 213)

I consider an intervention an ongoing process with multiple outcomes resulting from multiple mechanisms. Methodologies will result from, or be implicated in, some of these mechanisms. Because of the open, complex systems in which OR interventions take place, there is a need to focus on areas of theoretical interest. The researcher cannot take into account all possible influences on intervention or project outcomes in one research study. We choose a level of analysis at which causal powers and liabilities are of interest, such as change at the organizational level or a lower level (Zachariadis et al., 2013).

We need to consider the 'context or field of operation' in which practitioners take action and 'explanatory or grounding structures' that influence behaviour, experiences, or, more generally, outcomes of interest, i.e., 'we need always to think of … the quartet composed of context, structure,

mechanism and outcome, CSMO' (Bhaskar, 2014, p. viii).[25] However, Hinds and Dickson (2021) warn that Pawson and Tilley's (1997) 'configuration C + M = O confuses researchers since it does not separate out the empirical, actual and real levels clearly enough so that they can engage in the iterative and retroductive theorizing that should take place between the different levels' (p. 9). My CMO conceptualization in Figure 6, in conjunction with Figure 5, instead reflects that 'human action is influenced and co-determined by social structures, mechanisms and situations, including of course the actions of other people' (Bhaskar, 2016, p. 73).

Therefore, as powers and liabilities of entities or structures in the real domain, mechanisms may or may not be observable or observed (Mingers & Standing, 2017; Westhorp, 2019), say, in behaviours in an intervention, or practitioners' explanations thereof.[26] Further, explanation of the causal effects of mechanisms – why things happen – requires consideration of the lower-level parts or sub-systems making up the entities or structures, and their necessary relations (Mingers & Standing, 2017; Westhorp, 2019). According to Westhorp (2019), to be explanatory, the description of a mechanism must include 'at least three things: the necessary components of the system, the necessary relationships between those components and the processes (or interactions) through which those components and relationships generate the outcomes that they do' (p. 53).

More specifically, explicating generative mechanisms in the real domain involves synchronic analysis (retroduction) in which we ask, 'What generic mechanisms existed in this phenomenon, with what properties and powers, and what do they cause to occur?', while explaining events in the actual domain involves diachronic analysis (retrodiction) in which we ask, 'How did the combination of mechanisms interact to generate a particular outcome in this context?' (Mingers & Standing, 2017, Table 2). We try to identify the mechanisms that lead to empirical events, conditions in which they

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[25] For applied research, Bhaskar et al. (2018) propose CA(I)MO – Context, Agent, social Intervention, Mechanism, Outcome.

[26] cf. Yearworth and White (2014, after Little, 2011), who, in deriving a generic constitutive definition for PSMs, include events and processes (series of events, procedures), i.e. behaviours, within their problem structuring behaviours mechanism. They conceptualize their mechanism as 'a process of generative causality' (p. 937; M) that links an appropriate context for PSM use (C) with a particular set of intervention activities, being the outcome (O) in Pawson & Tilley's (1997) CMO configuration. See also Tully et al.'s (2019, Table 6, Appendix C) translation mechanism that takes client and consultant from complex problem to intervention contract, while a PSM (or other intervention methodology) is conceptualized as a transformation mechanism that then leads to a unique intervention outcome in a particular context. I would suggest that the mechanisms in these two papers are examples of what Mingers and Standing (2017) describe as, 'an enduring mechanism spawning a variety of events' that result, in each case, from the researchers' particular interests (p. 177). Moreover, as Yearworth and White (2014) state, '… to understand why certain things happen, we need to see how they are produced by these mechanisms' (p. 943).

are triggered, and relations with other mechanisms and structures (Easton, 2010; Sayer, 1992).[27] Critical realism provides a suitable metatheory for exploring and adjudicating between causal explanations of an OR practitioner's purposive use of methodologies, and their impacts, where 'Metatheories are 'theories about the foundational assumptions and preconditions of science" (Danermark et al., 1997, p. 119, as cited in Ash, 2022).

Methodologies: purposes and properties

We saw in chapter 2 that different methodologies vary along different dimensions that may be considered by practitioners and other stakeholders in deciding whether they are more or less appropriate for a particular intervention. For Mingers (2003a), the practical utility of specific methodologies (or parts thereof) is captured in their assumptions about axiology,

> ... that is, what is valued or considered good within the modelling approach. This is manifest in what the purposes or uses of the model are, and who (e.g., analyst, facilitator, participant) develops and uses the model. (Mingers, 2006b, p. 221)

The purpose of a methodology is, 'the specific results that the method aims to bring about', which practitioners, when selecting methods according to the theoretical framework of multimethodology, can compare with 'what they need to achieve at a particular point within an intervention' (Mingers, 2003a, 2006b, p. 223). For example, the purpose of SSM is to, 'Learn about and improve a problematic situation by gaining agreement on feasible and desirable changes' (Mingers, 2006b, p. 225). For selecting methods for a multimethodology intervention, Mingers (2006b) suggests also considering the purposes of the 'component methods' of a methodology (p. 223). In language of critical realism, this purpose can be seen as an emergent property of the methodology itself, as a whole (Mingers & Standing, 2017). Other properties of a methodology may be reflected in a

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[27] Sayer (1992, pp. 111-112) writes,

> Besides identifying the immediate causes of events, explanations must include references to the necessary conditions for the existence of mechanisms, where we do not already know them. Unless this is done, a voluntaristic account of practice may be produced. Where a process, such as inflation, is co-determined by several distinct mechanisms, it is reasonable to speak of one having more effect than another, but the same does not apply to the existence of necessary conditions (e.g. the existence of exchange) for these are either necessary or they are not. While having a language is not what causes me to write now, it is a necessary condition of my being able to write. Reasons and other causes may be given for actions such as shopping, joining the army, signing a cheque, casting a vote, getting married, granting a loan, imposing tarifs or being polite. But all these actions presuppose conditions such as material resources and social structures, including the conventions, rules and systems of meaning in terms of which reasons are formulated.

methodology's constitutive definition or rules (Checkland & Scholes, 1999; Yearworth & White, 2014) and its methodological stages, methods and tools (see Table 7, chapter 2).

However, in practice, SSM and other OR methodologies are adapted (IFATE, 2020c; Midgley, 2000, 2023; Mingers, 1997b, 2006b; Mingers & Rosenhead, 2004), used obliquely (Flood & Romm, 1995, 1997; Mingers, 2003a), and allegedly misused, suggesting other uses, purposes, and properties.[28] Mingers (2006b) provides a number of examples of methodologies being used in ways other than originally intended, such as using subjective rather than objective data in mathematical programming (an ontological change), and qualitative (rather than quantitative) system dynamics modelling in group model building (an epistemological change). In those examples, the philosophical assumptions underlying the original methodologies 'do not apply' (p. 238) and could presumably be replaced (when using the theory of multimethodology) by assumptions underlying the methodologies actually used, where known.

Causal explanation of practitioners' use of particular methods and multimethodology (RQ2)

> Bhaskar (1998) argues that for the concept of agency to be saved, it is imperative for reasons, given by individuals, to be accepted as causes. The generative causality Bhaskar advances when talking about reasons agents give for action or non-action refers to 'that factor which, in the circumstances that actually prevailed, "so tipped the balance of events as to produce the known outcome"' (1998: 91). (De Souza 2013, p. 145)

Hence, for research question 2 (RQ2; section 2.10), and turning around Mingers' heuristic for selecting methods (the purpose of a methodology, or parts thereof), I sought to understand 'specific results that the' practitioner 'aims to bring about' by their use of a particular method (Mingers, 2006b, p. 223, after Checkland, 1990) in 'a particular situation' (Mingers, 2006b, p. 217).[29] This focus on results sought is similar to the 'purpose' of a model (or 'the problem'), which should be taken into account alongside the 'object' of the modelling (or 'the system') in selecting 'the most suitable methodology' in quantitative hybrid simulation, according to Lorenz and Jost (2006, as cited in J. S. Morgan et al. 2017, pp. 914-916), and upon which J. S. Morgan et al. built their theoretical framework for method selection (reproduced in Figure 45, Appendix F). The focus on results sought rather than the purpose of a methodology also arguably fits better with the focus in Midgley's (2000, 2023)

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[28] Bhaskar (1997) defines ideas to include 'category mistakes, logical contradictions, illusions, errors generally' (p. 143).

[29] Cf. the 'function' of 'items' in social positioning theory (Pratten, 2023). In short, compared with social positioning theory, my conceptualization takes into account the historicity of practitioners' methodological approaches, and is less (collectively) normative than social positioning theory.

systemic intervention on stakeholders' purposes guiding method choice, and the focus on problem structuring with stakeholders in recent theoretical and practical scholarship on method choice (see section 2.9). Further, in the pragmatic, practice-led transformation competence perspective, methods are selected for the contribution they could make to the *transformation* that the intervention is initiated to effect, with 'the transformation performed by the method' being an expansion of Mingers' (2003a) purpose of methodologies (Ormerod, 2005, p. 464).[30] Moreover, my focus on results sought by practitioners in using particular methods is consistent with evidence that OR practitioners are primarily concerned with practical intervention outcomes or seek 'what works' in a particular context, i.e., that practitioners adopt a pragmatic or instrumentalist attitude (section 2.8.4) that have been associated with theories of American pragmatists, especially William James (Ormerod, 2006a).

However, as set out in the previous chapter and captured in Mingers' (2006b) explication of the process of multimethodology (amongst others'), we know that many *other* dimensions influence method choice in an intervention, such as practitioner familiarity with certain methods, and practitioner 'views which alter their perception of the system and problem' (J.S. Morgan, 2013, pp. 914-915; J. S. Morgan et al., 2017). In this research, I sought to understand other reasons practitioners give for using the methods they do, for not using other methods, and for combining some methods and not others. In my critical realist approach, to identify plausible explanatory mechanisms, we start with individual (practitioner) beliefs and reasons for actions or non-action (choice of methods and use or non-use of multimethodology) and then look to make sense of those in context. I explain my methodological approach further in the following chapter on research design.

3.4.8 Realist evaluation

The approach in this chapter to OR interventions therefore builds on, but is different from, the conceptualization of social programmes in Pawson and Tilley's (1997) realist evaluation and CMO

[30] Ormerod (2005) writes,

> So, for instance, for SSM, the entry in Table 1, 'learn about and improve a problematic situation by gaining agreement on the feasible and desirable changes', could become:
> SSM transforms the views of a group of individuals about a problem situation into an agreed list of actions, which seem culturally feasible and systemically desirable, for further discussion and evaluation.
> Armed with such transformations for whole and part methods, it is relatively easy to consider how the outputs from one method can become inputs to another in the design of an intervention (which is undertaken to effect a desired transformation). (p. 464)

heuristic (Alderson, 2021; Mukumbang et al., 2023; Steenmans, 2017; Tully et al., 2019; Yearworth & White, 2014). First, we focus on evaluating one aspect of interventions – methodologies – in the context (C) of interventions. Second, though, we are not presupposing a particular social programme (M) or intervention methodology, nor postulating outcomes (O) as programme designers (though practitioners may do similar). In other words, a social programme is a set of activities designed to encourage a set of changes or outcomes (Danermark et al., 2019, p. 207), whereas we are focusing on method choice and intervention design, which may (or may not), in turn, have causal implications for overall intervention outcomes. For a discussion of differences between critical realism and realist evaluation more generally, see Alderson (2021) and Mukumbang et al. (2023).

3.4.9 Affordances

> affordance, n.
> ...
> *Psychology*. A property of an object or an aspect of the environment, esp. relating to its potential utility, which can be inferred from visual or other perceptual signals; (more generally) a quality or utility which is readily apparent or available. (Oxford University Press, n.d., Definition 2)

Gibson's (1979) account of the role of affordances (potential uses of objects) in visual perception of the environment is also relevant here. First, OR practitioners talk of affordances of different methodologies that make them more or less appropriate for a particular intervention. They use Gibson's term informally, particularly where they refer to methodologies as conceptual resources.

Second, in their action research study of the impact of a multimethodology intervention in Colombia, Henao and Franco (2016) show how the affordances of the models developed during the intervention led to personal, social and material change for the group of participants who were the authors' clients. The authors use data from the intervention (field notes) and subsequent interviews of participants to develop a grounded process model of multimethodology intervention impacts. The study builds on Franco's (2013, 2014) formal application of Gibson's theory to software and visualization of models used in participative OR interventions, and the influences of those material artefacts on participants' social behaviour. Henao and Franco (2016) develop the notion of the support capability of different methodologies for different stages of an OR intervention, after Mingers and Brocklesby's (1997) rationale for multimethodology. They propose consideration of 'the analytic and relational capabilities required for the intervention context' for choosing methodologies

for an intervention (Henao & Franco, 2016, p. 694).[31] According to their grounded process model, 'analytic' and 'relational capabilities' of different methodologies incentivise 'decision making effort' and 'integrative behaviour', respectively, amongst intervention stakeholders (p. 694). These lead to cognitive, social and task impacts/change for stakeholders associated with the use of the different, complementary methods over the course of the intervention.

We could incorporate affordances within our theoretical framework. Like a power in critical realism, 'An affordance is relational as it concerns the relation between the object and the other object or actor so an object or technology may have different affordances with different actors' (Mingers & Standing, 2017, p. 178). In research in information systems (IS), affordances of material artefacts such as management information systems have been conceptualized and reported in empirical studies as generative mechanisms, or parts thereof, within critical realist approaches (Bygstad & Bergquist, 2018; Bygstad et al., 2016; Essén & Värlander, 2019; Fromm et al., 2020; Lanamäki et al., 2016; Leidner et al., 2018; Mingers & Standing, 2017; Ostern & Rosemann, 2021; Stendal et al., 2016; Valbø, 2021; Volkoff & Strong, 2013; H. Wang et al., 2018; Winch, 2017; Wynn et al., 2013; Wynn & Williams, 2020). There are useful examples of the application of critical realist frameworks to organizational settings. IS technologies, like methodologies in OR interventions, form part of the pre-existing structural conditions that pre-date practitioner actions, having emerged from prior action (Essén & Värlander, 2019; Mutch, 2007; Volkoff et al., 2007; Winch, 2023). IS technologies, like OR methodologies, are used in ways that result from other pre-existing conditions and mechanisms within and beyond the particular organization (Mutch, 2007; Volkoff & Strong, 2013), with 'interactions leading to transformations leading to changed affordances' over time (Kempton, 2022, p. 9). However, as we are primarily interested in methodologies, which are more than material artefacts, our theoretical framework (ontology) is necessarily somewhat different.[32,33] Franco's (2013)

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[31] '*Analytic capability* is associated with the capacity of an intervention to effectively represent participants' differences and dependencies concerning a problem or task of mutual concern. *Relational capability*, on the other hand, is associated with the capacity of an intervention to enable interactional spaces conducive to integrative behaviours among those involved.' (Henao & Franco, 2016, p. 693, *emphasis in original*)

[32] Cf. Faulkner and Runde's (2013, 2019) conceptualizations of material, nonmaterial, and hybrid technological objects and their structure and social positions, after Lawson's (2022, 2023a, 2023b) critical realist social positioning theory.

[33] Cf. Egessa and Liyala's (2021) capability framework where material information and communication technology (ICT) artefacts, in addition to being material resources with affordances, are conceptualized as conversion factors (influencing the achievement or otherwise of agents' functionings), and as components of the structural context (influencing perceptions, preferences, choice, agency and actions).

affordance-based study has also been criticized for not adequately addressing issues of power and social learning (White et al., 2016, comparing affordance-based theorizing with activity theory).

In other words, if we are to explain how OR practitioners design their interventions, then we need to consider the range of methodologies they could and do or do not use, i.e., methodologies *as guidelines* in the pre-existing action context of an OR intervention, comprising aspects of culture, structure, agency, and cultural artefacts, i.e., including, but not exhausted by, material aspects (Table 11 above). We also need to consider the intervention context as it changes over time (Figure 5; Figure 6; Figure 7 above). A methodology *as used* is then conceptualized as a socially emergent, particular configuration of components that include material artefacts. The methodology *as used* may be considered a particular version of a particular methodology, such as SSM, with causal powers, and its material aspects may have affordances (Franco, 2014; Gibson, 1979).

3.4.10 Conclusion

In this section I presented a theory-informed, critical realist analysis of a generic OR intervention (summarized in Figure 5, Figure 6, and Table 11) that builds on findings from the literature review in the previous chapter and recent developments in philosophy and social science. I use and develop it further in my empirical research in subsequent chapters (Easton, 2010).

3.5 CONCLUSION

In summary, my employment of critical realism provides a systemic basis (Mingers, 2014) for understanding the complex social process of an OR intervention that: is theory-informed, building on a synthesis of existing empirical and theoretical understanding in OR; addresses the social and material, culture and agency, and their interrelations at different levels; facilitates comparison of and learning from OR interventions; and, facilitates the development of a mechanistic understanding of events in an OR intervention, and stakeholder's experiences thereof. It is an alternative to 'determinist and voluntarist extremes' for studying behavioural phenomena (Franco et al., 2021, p. 403). In short, we seek the 'potential benefits of a deeper view on causation and causal explanation to guide enquiry into the practice of OR' (Yearworth & White, 2014, p. 933). In the next chapter, I set out my methodological approach.

4 RESEARCH DESIGN

4.1 INTRODUCTION

Having introduced my philosophical assumptions and theoretical framework in the previous chapter, in this chapter I describe and justify my methodology for responding to the research questions in chapter 2. My methodology is the methodological approach I took to my empirical research (Friend, 2006; Mingers, 2001c), which I refer to as the research design. First in this chapter, I set out why I adopted multimethodology, and my position on paradigm incommensurability. I then provide an overview of the research design, building on my theoretical framework in the previous chapter and using Bhaskar's (2016) RRRIREI(C) model of exploratory investigation. In the remainder of the chapter, I describe and justify in more detail the following aspects of my research design: axiology (reflection, reflexivity and ethical review); integration of data across sources (participant de-identification, data coding and thematic analysis); the survey; the multiple case study; interviews; secondary data review; qualitative case analysis (coding, memo-ing, tabling, rich description of cases, and structural and causal analysis); merged analysis and interpretation of data in response to the research questions; and, corroboration and justification of research findings.

4.2 MULTIMETHODOLOGY

4.2.1 Adopting multimethodology

To respond to the research questions in chapter 2, and informed by my critical realist theoretical framework and assumptions in chapter 3, I adopted multimethodology. The OR interventions that I investigated, and the 'research situation' itself (Mingers, 2001a, p. 243), were complex and dynamic, with material, personal and social dimensions. In order to gain a rich understanding of phenomena in my research questions, I therefore needed to employ a number of different methodologies and methods from different paradigms (Hassan & Mingers, 2018; Mingers, 2003a, 2006b, 2015) – a multimethodology (Mingers & Brocklesby, 1997) or methodologically pluralist approach (Franco et al., 2021; Jackson, 2019; Midgley, 2023). Further, as Bhaskar (2016) argues, qualitative and quantitative research is required in order to understand social activity because social activity is both concept-dependent and material (embodied).

I selected and employed a number of previously defined methodologies, methods and tools, adapting them and comparing and integrating results in an iterative way to respond effectively to the research questions. I adopted different methods as required within and across iterative stages of my research, and corroborated tentative conclusions using multiple data sources (Mingers, 2014). Adopting multimethodology allowed me to learn about its use (Checkland & Holwell, 1998), which added to my research insights. However, using multimethodology raises questions of paradigm incommensurability that should be addressed (Jackson, 2019; Kotiadis & Mingers, 2006; Midgley, 2000; Mingers & Brocklesby, 1997).

4.2.2 Paradigm incommensurability

Paradigm has been defined in many different and sometimes inconsistent ways. However, broadly, a paradigm can be seen as representing accepted problems and ways of addressing them within a discipline or research area (Kuhn, 2012/1962; section 2.5.2 above). While Mingers and Brocklesby (1997) argued that methods could be used across paradigmatic logics, and that structuration theory and critical realism provided potential philosophical underpinnings for multiparadigm practice (see section 2.5.2, and the other philosophical justifications listed there), others considered that paradigm incommensurability could not be ignored (Jackson, 2003b) and/or that triangulation between methods assuming different views of reality or phenomena (such as functionalist and interpretive) was not logical or possible (Sale et al., 2002). However, this may be because methods are used to study different things, in which case triangulation is irrelevant, or to study the same thing but from a different perspective in pursuit of a different kind of conclusion (Mingers, 2001a).

More recently, Hassan and Mingers (2018) have argued that conflation of paradigm with philosophical aspects of research, such as epistemology and ontology, contributed to unnecessary paradigm wars. In the development of multimethodology and other methodological frameworks, this conflation took focus away from the selection of methods according to the contributions they make to the development of innovative, insightful theory focused on the object of study. In other words, 'By focusing less on its methods and more on the study's core concerns, the researcher is more likely to get to the heart of the matter' (Hassan & Mingers, 2018, p. 586).

In fact, emphasis in literature on mixed methods research in the social sciences on the importance of 'fit' between research questions and methods used to address them (Molina-Azorín et al., 2017, pp.

183-4; Onwuegbuzie & Hitchcock, 2019) is consistent with White's (2006) proposals for using pragmatic selection of methods for evaluating OR interventions in response to research questions. Hence, my research design was guided by my research questions rather than paradigmatic justification as a starting point. In taking a pluralist approach underpinned with critical realism as a metatheory, I assumed that,

> … it is quite possible to disconnect a particular method from its normal paradigm and use it, *consciously and critically*, within another setting. For example, the use of quantitative data need not imply the acceptance of a positivist, objectivist epistemology. Rather, such data can (and should) be interpreted in the light of relevant social meanings, and their [social] production … (Mingers, 2001a, p. 247, *emphasis in original*)

4.3 OVERVIEW OF RESEARCH DESIGN

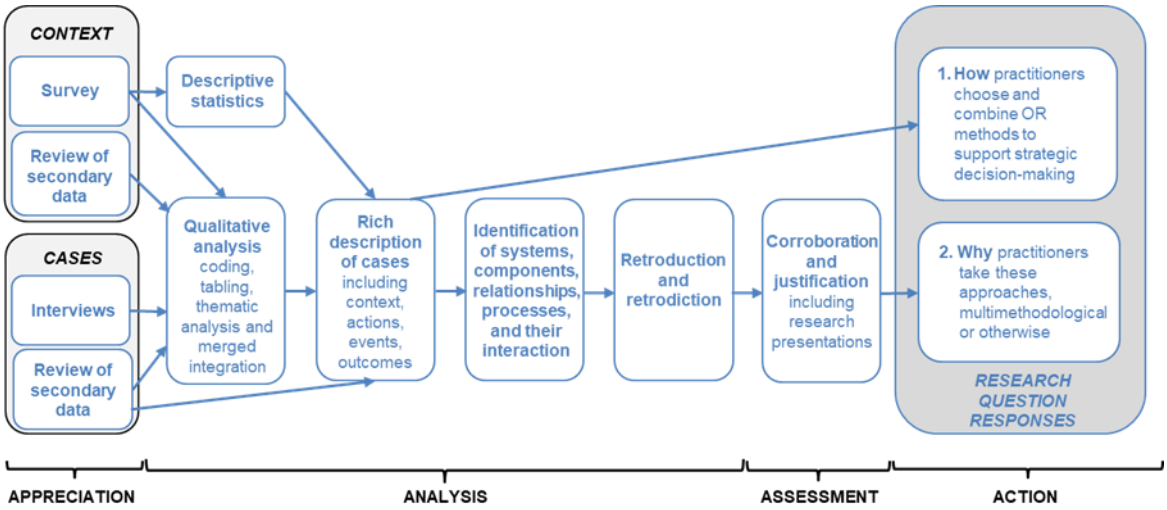
My research design is illustrated in Figure 8 below. The arrows indicate data sources and methods I planned to use to respond to each research question. Methods are organized by Mingers and Brocklesby's (1997) four overlapping and iterative stages of a typical OR intervention (the 4As) – Appreciation, Analysis, Assessment, Action (Mingers, 2014). In Figure 46 (Appendix G), data sources and methods of data collection, analysis and interpretation, as well as research outputs, and potential impacts, are further organized by the three interrelated and overlapping aspects of the world to be considered for a comprehensive research intervention (the 3Ws) – social, personal, and material (Mingers, 2014; Mingers & Brocklesby, 1997). I used the 4As-3Ws framework to organise and structure my methodological thinking in a theoretically sound way, consistent with critical realism, and to facilitate comparison with recent reporting of other research into multimethodological OR interventions (e.g., Henao & Franco, 2016), while familiarising myself with multimethodology itself. Alternative approaches I could have taken include using soft systems methodology (SSM) as an intervention framework (Checkland & Winter, 2006; e.g., A. Small & Wainwright, 2014), or one of the other theoretical frameworks described in chapter 2.

In the ***Appreciation*** stage, my empirical work included the collection, generation and review of data from a survey, interviews, and secondary data to gain an understanding of the research context and cases. In the ***Analysis*** stage, I described and analysed the data using descriptive statistics, deductive and inductive topic coding, tabling and memo-ing, thematic and comparative analysis, and rich description. I drew on my theoretical framework from chapter 3 and Bhaskar's RRRIREI(C) model of

exploratory investigation in applied critical realist research, which can be considered a methodology (Mingers, 2014):

> Resolution, abductive redescription, retroduction, (RRR)
> *Inference* to the best explanation – most plausible mechanism or complex (I)
> Retrodiction, elimination, identification of antecedents and correction (REI(C))
>
> (Bhaskar, 2016, p. 81, *emphasis in original*)

My description and analysis of the data facilitated iterative: *analytical resolution* of the cases and context into components and processes (entities, structures, conditions, actions, events, outcomes and their relations) relevant to the research questions (Elder-Vass, 2010; Sayer, 1992); *abductive or theoretical redescription* (Danermark et al., 2002, 2019); *retroduction* to potential explanatory mechanisms (generative causality); and, *retrodiction* to potential antecedent causal events (event causality; Mingers, 2014; Mingers & Standing, 2017).



Note: Critical realist research methodology stages (description, identification of components, retroduction and retrodiction, corroboration and justification) adapted from Mingers (2014, pp. 190-191) following Bhaskar's (2010) RRREIC and Wynn and Williams' (2012) critical realist case study research principles

Figure 8: Empirical research design for research questions

Assessment involved corroborating and justifying my provisional research findings. I compared and evaluated competing explanations I developed using multimethod empirical and theoretical corroboration, drawing on data and analysis from the Appreciation and Analysis stages as well as OR literature, and presenting preliminary results and inviting comments and challenge. ***Action*** included

responding to my research questions, and presenting my tentative conclusions in this dissertation, papers, at conferences, and to research funders. The potential ***Impact*** of my work comprised empirical evidence of OR practice, theoretical and methodological developments, and changes in OR practice and policy.

In addition to responses to my research questions, in establishing a critical dialogue between empirical data and extant theory (Alvesson & Ka, 2007), I anticipated there could be implications for existing theoretical frameworks for designing and evaluating OR interventions. This could present opportunities for new frameworks and methodologies (or elements thereof) for addressing complex real-world issues through the elaboration of existing theories using retroduction. It could involve challenging the logic of existing models, combining theoretical ideas, or introducing new concepts (Ketokivi & Choi, 2014).

While I did not directly test theoretical frameworks, some empirical data supported or challenged extant theory. I interpreted this within a critical realist framework. Accordingly, what may look like empirical evidence that confirms or falsifies a theory may in fact reflect an obscuring of interrelating factors, or a combination of events that is not addressed in extant theory. Great care was required in my interpretation of data and corroboration and justification of findings. My plausible conclusions are for further public debate.

I decided on the precise scheduling of data gathering, analysis and interpretation iteratively, in response to the research questions and data available (Creswell & Plano Clark, 2011), and in negotiation with people in the organizations with which I carried out my research. The research was to some extent participative in that there was ongoing dialogue between me, my academic supervisors (primarily John Mingers), and my industrial supervisor (primarily Martin Parr) and colleagues, who together were gatekeepers providing access to research participants and secondary data. We shared relevant literature and other insights, and undertook some joint discussions and planning regarding research questions, methods, research practicalities, and the communication of findings, as well as reflection on progress and findings (Eden & Huxham, 1996). While my approach to analysis was adaptive (Poth, 2018), guided by cycling between the research questions, data and literature, and in line with the flexibility afforded by a critical realist case study approach, for clarity I present my methodological approach in this chapter in discrete sections.

4.4 AXIOLOGY

4.4.1 Introduction

Axiology refers to practical, ethical and moral issues of research (Mingers, 2008), its outputs and their use (Stake, 2008). I do not believe that my research could be value-free as positivists claim. It is not possible to be wholly independent and objective as a researcher. In generating data, I carried out my 'field research' (Franco et al., 2021, p. 402) in the real-world context in which practitioners work. I was part of this context while conducting interviews, for example. I also intervened in the sense that the understanding I produced could be taken up by practitioners with a view to improving their practice (Mingers, 2006b). I acknowledged these aspects of intervention in my reflective and reflexive approach as an embodied and embedded researcher.

4.4.2 Reflection and reflexivity

I was reflexive about my research choices and impact on the cases, power effects in interviews (Wadham & Warren, 2014), and effects of organizational politics, commitments, resistance, and management ideology, as well as stakeholders' expectations and assumptions about the project and my own role and background. My reflexive approach included continuous reflection supported by field notes in order to learn from my study and provide transparency and recoverability in my reporting (Checkland & Holwell, 1998; Howick & Ackermann, 2011).

In case research, it is important to be open to surprise (Ketokivi & Choi, 2014); I sought not simply to reveal what I expected to find (Flyvbjerg, 2006). My research was questioning of the *status quo* in the organizations I studied (Mingers, 2000c) and reflexive and critical in the way I evaluated possible explanations for phenomena and compared them with empirical data and extant theory (P. H. Andersen & Kragh, 2011). In order to test my conclusions, I have been presenting my work and debating it with others within and outside the research context, across and beyond the OR community. As I aimed to contribute to the practice of my discipline and government policy, I reflected on how my research may be used in OR practice in future, and in positioning analysis with decision makers.

4.4.3 Ethical review

I undertook and continually reassessed an ethical review of my research plans. I commenced my empirical research once I had obtained ethical approval from the University of Kent Faculty of Social Sciences Research Ethics Advisory Group for Human Participants. Following piloting, I obtained further approval for changes to the questionnaire (Table 30, Appendix I) and a Participant Information Sheet (PIS). *Inter alia*, I continually reviewed, reflected on, and mitigated risks arising from the handling and storage of sensitive and confidential data, linking of data across methods (Hesse-Biber, 2010), potential conflicts of interest, access to people and data, the need for informed consent from (non-vulnerable) participants who were primarily employees (documented in Participant Consent Forms [PCFs]), and my responsibility not to have a negative impact on the activities of the organizations with which I carried out my research (Stake, 2008), including under the Collaborative Award Agreement for this doctorate.

4.5 INTEGRATION OF DATA ACROSS SOURCES

4.5.1 Introduction

I was interested in developing a consistent yet flexible approach to describing and analysing data across all sources. A consistent analysis approach would help me integrate findings in responding to the research questions, and approach the potentially daunting task of analysing large amounts of purposefully-sampled, rich textual data, including documents, transcripts and field notes (Crabtree & Miller, 1992) from the Appreciation stage (Figure 8 above). To this end, in the Analysis stage, I used participant numbers, a research codebook, topic coding, and thematic analysis.

4.5.2 De-identification, anonymization and participant numbers

As no participant requested to be identified (e.g., in response to the PCF), I removed participant names from questionnaire responses and interview transcripts and field notes. I assigned each participant a unique number between 1 and 200 using a random number generator, and included these in a log in Excel.

To de-identify data, I removed names of organizations and individuals, replaced or removed other identifying details, and ran a spellchecker to standardize spelling and punctuation across data

(Yeomans et al., 2023), including participant-generated survey responses. De-identification and anonymization were ongoing processes, and not fully achievable (Gummesson, 2017; The Qualitative Data Repository, n.d.). This was particularly true for individuals with some connection to one or more of the long, complex cases (whether being part of them, or aware of them because of their organizational role[s]). There was a need to balance the removal of identifying details (where obvious and possible) with the need to retain sufficient details for the cases to 'make sense' and provide credible objects of analysis (including for the Assessment stage), while telling a compelling story in research reports in the Action stage, and proceeding in an ethical manner, and in line with the ethical approval, and my commitments to participants (Pratt et al., 2020).

4.5.3 Research codebook and topic coding

In NVivo I set up an initial coding structure of nodes and sub-nodes, or research codebook, for coding data to topics. The initial topics nodes reflected: the research questions (as is typical in qualitative research, e.g., see Richards, 2014); my (provisional) conceptualization of common, relevant elements of OR interventions for my developing theoretical framework, based on extant literature (Berends & Deken, 2021; Crabtree & Miller, 1992); and, my data collection and analysis plans. I included sub-nodes for sub-topics, categories and other labels, for example the names of particular methods under the topic node 'Methods'. Table 28 (Appendix H) refers.

My approach was akin to Miller and Crabtree's (1992) template analytic style of analysis (being one of their four idealized strategies for analysing qualitative data) in that I used my pre-defined structure for coding, revised it in light of data, and took an interpretive, not statistical approach. As I hoped, and Crabtree and Miller (1992) anticipated, taking such an approach enabled me to: organise data by topics; focus my analysis and interpretation on key data extracts relevant to each research question; search for 'confirming/disconfirming evidence' of tentative conclusions; develop my analysis and interpretation iteratively; better understand the data and research context; and, save time compared with more comprehensive, inductive approaches to data, such as grounded theory (Glaser & Strauss, 1967; Strauss & Corbin, 1998). It enabled me to respond to my well-defined but broad-reaching research questions in a balanced way by thinking through what was relevant data in relation to my research questions (up front), but without restricting my analysis, and with awareness that there could be other issues 'beyond the codes'.

I added further nodes to capture other findings that were on-topic but did not fit specific research questions (reflecting a critical approach). As with all research, there was a need to be systematic and fair with the data (Yin, 2014). I was imposing discipline on how I treated data with a view to being fair and inclusive, while seeking to disregard data not relevant to particular questions. My approach provided an audit trail of my inclusion and exclusion of data in relation to the research questions. For example, I was always able to go back to all the data relating to each method used in a case as my understanding developed. This was helpful as different people referred to different methods in different ways. As I gradually compiled rich descriptions of each case, I could fill in gaps and reconcile data (or not) across interviews and secondary data.

To enhance completeness and consistency across data, and in the absence of a co-researcher working on the data generation and analysis, I built in ways of checking and re-checking my coding. For example, that topic codes overlapped, and that multiple topic codes – with very few exceptions – were relevant to each data extract, enhanced the completeness and consistency of my analysis across the data (from topic coding through to interpretation and corroboration of findings). I could look at cases from different perspectives with different groupings of data, while remaining focused on the research questions. Checking and re-checking was therefore built into the approach. This built robustness into the analysis. It was also a reason for coding to the nodes and sub-nodes with strict reference to the research questions (without over-broadening the scope).

There are many approaches to categorizing stakeholders that I could have used (e.g., see Ackermann & Eden, 2011b, 2020; Bourne & Walker, 2005; Cairns et al., 2015; Checkland & Poulter, 2020; De Gooyert et al., 2017; Eden, 1996; Eden & Ackermann, 1996, 2021; Friend & Hickling, 1987, 2005; A. J. Gregory et al., 2019; Hermans & Thissen, 2009; Hester, 2015; Lienert et al., 2013; Müller et al., 2012; M. S. Reed et al., 2018; W. Wang et al., 2015; Zheng et al., 2018). My use of the stakeholder categories that Ormerod (2001, 2008a, 2008b) proposed for selecting stakeholders for their evaluative views of interventions (doers, done for, done with, done to, and done without), fitted with my focus on practitioners' (doers') activities and my plan to capture views of a range of individuals with different intervention roles (Table 9, chapter 3). Decision makers are not specifically identified in this typology, but can be assumed, as a starting point for review with data and participants, to be included in the 'done for' (by definition if these are decision support interventions).

4.5.4 Thematic analysis

Thematic analysis is an accessible and flexible qualitative approach that can be adapted for use with different philosophical assumptions to develop clear, rich, nuanced understanding of complex data (Braun & Clarke, 2006; Fryer, 2022; Wiltshire & Ronkainen, 2021; Xu & Zammit, 2020). It has been used in research on multimethodological interventions (Howick et al., 2017), for analysis of responses to surveys (e.g., Munro & Mingers, 2002), interviews (e.g., Ackermann & Howick, 2022), and in systematic literature reviews (e.g., Howick & Ackermann, 2011), as well as for analysing interview transcripts using qualitative and quantitative OR within a critical realist framework (Shaw et al., 2019). Given my wider research plans and the time available, thematic analysis was a more suitable approach than, for example, discourse or conversation analysis, which require much more detailed, verbatim transcripts, and as result tend to focus on less data.

I adapted thematic analysis for use in the Analysis stage of my critical realist multimethodology (Figure 8 above) in an attempt to identify patterns (Braun & Clarke, 2006), tendencies (Danermark et al., 2002; Fletcher, 2017), and demi-regularities (Lawson, 1997; White, 2016b) across data. For example, following deductive and inductive topic coding of participants' statements in questionnaires, interviews, secondary data and in field notes about why practitioners combined methods (to the 'Why multimethodology' node), I analysed that data for themes, which, in turn, informed my exploration of generative and event causality (using retroduction and retrodiction), and, in the Action stage, my responses to research questions. Other approaches I considered, such as narrative analysis or phenomenology, would have been less summative and facilitative of comparative analysis across interventions.

4.6 SURVEY

4.6.1 Introduction

As the research context was new to me, and many years had passed since I had completed my MSc in OR, I conducted a survey in the Appreciation stage for understanding of the research context. Conducting the survey would increase my understanding of recent OR practice within the research context and thereby help me establish myself as a credible researcher in subsequent interviews (for the multiple case study) and presentations. The survey also provided early research results for

presentations to research funders, and at research workshops and international conferences (Christie, 2017a, 2017b) in the Assessment and Action stages.

The survey built – methodologically and topic-wise – on previous surveys of OR practitioners (Abdel-Malek et al., 1999; Bernroider & Schmöllerl, 2013; Clark & Scott, 1995, 1996; Fildes & Ranyard, 1997; Fildes et al., 1999; Ledington & Donaldson, 1997; Mingers & Taylor, 1992; Munro & Mingers, 2002, 2004; O'Brien, 2011; Ranyard et al., 2015; Stenfors et al., 2007), providing evidence of more recent practice within the context of this particular research project. I therefore undertook the survey cognizant of inherent limitations of surveys of OR practitioners, including in relation to their necessarily narrow scope, small samples, biases in sampling (e.g., in relation to geographical and sectoral representation, and self-selection of participants), self-reporting of practice, and overreporting of well-known methods (e.g., see Christie, 2023; O'Brien, 2011; Ranyard et al., 2015). However, as introduced in section 3.3.5 above, with this critical realist research, rather than to generate results that were statistically representative of a wider set of OR practice, I instead aimed to develop more plausible descriptions and explanations of the use of multimethodology in non-academic settings than previous research. In fact, the survey was a relatively quick way of producing data for responding to the research questions – in particular on the prevalence of multimethodology, methods that practitioners use and combine, and why practitioners use multimethodology (reported in chapter 5). Further, for the multiple case study, across the Analysis, Assessment and Action stages, survey responses enhanced my understanding and accounts of the cases, for example in providing context for practitioners' explanations as to their reasons for using particular methods (reported in chapter 6). Limitations with this particular survey, including the extent of information that participants could provide and could be reported, are discussed in more detail in the following subsections and reflected in my interpretation of the results in subsequent chapters.

4.6.2 Survey instrument (questionnaire)

The survey questions were derived using the research questions. They asked about practitioners' use of methods in their day-to-day work supporting strategic decision-making, methods they were familiar with and used, the frequency with which they combined methods, recent examples of multimethod projects, and why they combined methods, as well as project success. I used 'project'

(Pidd & Woolley, 1980) in the questionnaire rather than 'intervention', reflecting its common use in practice.

For reasons of practicality and given the sensitivity and confidentiality of data, I created the questionnaire in Excel and sent it by email, together with a PIS. Participants were asked to confirm they had read and understood the PIS and consented to participate in this research by selecting Yes or No from a drop-down box.

Question 1 asked participants to indicate their level of familiarity or usage for each of 47 clusters of OR and strategy methodologies, methods and tools, referred to as 'OR methods' in the questionnaire, and presented in alphabetical order with abbreviations and key names. Participants could select one response from a five-point itemized rating scale: Not heard of; Heard of; Familiar with, but not used; Use, but not regularly; Use regularly. For each method, a box for (optional) comments was provided next to the options buttons. I constructed the list of methods from my developing knowledge of OR and multimethodology practice, including in the research context and literature. I included a range of methods relevant to the area of concern (A) of the research (section 3.2) across quantitative OR (e.g., T. Williams, 2008), problem structuring methods (Rosenhead, 1989, 1996), systems thinking (Jackson, 2000; Midgley, 2003), qualitative/soft OR (Mingers & Rosenhead, 2011), management/strategy tools (O'Brien, 2011), OR methods that are less easily categorized, such as multi-criteria decision analysis (Christie, 2023), and other disciplines, as well as some domain-specific methods. In particular, I built on the lists of methods in O'Brien's (2011) questionnaire on the use of OR/MS and management/strategy tools in supporting the strategy process and Munro and Mingers' (2002) questionnaire on the use of multimethodology by OR and systems practitioners. Table 29 (Appendix I) refers. **Question 2** asked participants to list other methods that they (1) use regularly and (2) use, but not regularly. It was an open-ended question; free comment boxes were provided for responses.

Question 3 asked participants how frequently they combine methods (or parts thereof) within the same decision support project by indicating in how many of every ten projects they combine methods or part methods from zero (I never combine methods) to 10 (I always combine methods). These responses were listed in a drop-down box.

Question 4 asked participants to list examples of decision support they had provided recently where they used more than one method in a table with columns for brief descriptions of the subject matter (e.g., setting strategic goals, or operational planning), customer (client) and their organizational level, the time available (e.g., few hours, 6 months, 2 years) and each of up to ten methods used. **Question 5** asked participants why they used more than one method in their example projects. A free response box was provided.

Question 6 asked participants to rate average project success when they choose to combine more than one method on a scale of 0 to 10 in a drop-down box where 10 was successful in every respect, 5 partly successful partly unsuccessful, and 0 complete failure. **Question 7** asked participants to rate average project success on the same scale when they use one OR method (without other methods). **Question 8** asked participants to explain their rating(s) in questions 7 and 6 (if applicable). For example, what was successful or what was less successful? A free response box was provided.[34] Additional boxes were provided for participants to indicate if they had been practising OR for less than five years (**question 9**), to make any other comments (**question 10**), and to provide their name and/or email address if they would be happy to be contacted to discuss their responses.

4.6.3 Pilot

Two practitioners completed a pilot version of the questionnaire. I then shortened the questionnaire as practitioners felt that the length would adversely affect the response rate, and managers requested that the survey not require long answers. In particular, I removed questions on how participants chose, combined and adjusted or adapted methods in their examples of recent decision support projects, and I asked them why they used more than one method in their examples rather than asking for a reason for each example. Table 30 (Appendix I) refers. In the event, participants provided some data relating to removed questions, for example in response to question 10, and I included the topics in interviews on particular cases.

[34] Survey results on project success are in Appendix U.

4.6.4 Participant selection

In September 2016, my industrial supervisor and colleagues provided me with 63 email addresses as belonging to individuals who use or have used OR to support strategic decision-making for or on behalf of the UK government. Following further discussions, in May 2017, my industrial supervisor and colleagues provided email addresses of 196 other people who do or may do such work, enabling me to undertake a second wave of the survey.

4.6.5 Survey respondents and their project examples

I received completed questionnaires from 54 individuals. Table 12 below refers. The 40% response rate in Wave 1 was good for any survey (Anseel et al., 2010), and a small number of participants suggested to me that it was good compared with other surveys carried out in the same context. The lower response rate in Wave 2 reflects that the survey was sent to a broader group of invitees than in Wave 1, and when there was apparently more pressure on their time.

Table 12: Survey participants and their examples of recent multimethod projects

Survey wave	Participants					Examples of recent decision support projects with >1 method (question 4)		
	Invitees	**Responses**	**% Responded**	**Practising OR <5 years** (question 9)	**% Respondents practising OR <5 years**	**Respondents providing example(s)**	**% Respondents providing example(s)**	**Example projects (total number)**
Wave 1	63	25	40%	4	16%	21	84%	53
Wave 2	196	29	15%	4	14%	25	86%	51
Total	**259**	**54** *(note)*	**21%**	**8**	**15%**	**46**	**85%**	**104**

Note: Two other individuals emailed me to say they do not do OR.

4.6.6 Statistical analysis

After collating the Wave 1, and later Wave 2, responses in a single Excel file, I analysed the quantitative data in Excel and SPSS to produce descriptive statistics regarding methods practitioners are familiar with and use, the frequency with which they combine methods, and ratings of average project success for single and mixed methods projects.

4.6.7 Qualitative coding and thematic analysis

I generated qualitative data from the open-ended questions and other free comment boxes, including comments on specific methods used, descriptions of other methods not listed in the survey, descriptions and explanation of recent decision support projects, and reasons why methods were combined. My coding approach, informed by Saldaña (2015), was as follows. To facilitate organizing and making sense of the (quantitative and qualitative) survey data in Wave 1, and later Wave 2, I imported it into NVivo where I had set up my research codebook (section 4.5.3 above). I used the NVivo Survey Wizard to auto-code survey responses to question nodes, which I then brought within my initial coding structure (see Table 28, Appendix H).

In a first coding cycle, I closely reviewed the responses from each participant in relation to the research questions, coding fragments of sentences (to keep work manageable) to topic nodes and sub-nodes in the codebook, and new codes and sub-nodes that I added as required (e.g., for methods not listed in question 1). I used *in vivo* coding for capturing comments verbatim as sub-nodes. In a second cycle, I clustered and collapsed sub-nodes into thematic nodes, for example relating to reasons participants combined methods under the node 'Why multimethodology'.

As I went, I created memos and annotations on my interpretations of the research questions and data, and on node contents and overlaps between them. I kept a daily research journal to track and facilitate critical reflection on my coding, themes and interpretation, and reviewed all coding and thematic analysis at least twice to ensure completeness and consistency across participants.

4.7 MULTIPLE CASE STUDY

4.7.1 Introduction

> ... the inherent aim of conducting critical realist case studies provides leeway to discuss both the local and general nature of mechanisms and structures. (Frederiksen & Kringelum, 2021, p. 31)

> Comparative research helps to clarify both the nature of a mechanism and the range of variation in both process and outcome that can occur. By designing research programmes featuring a range of cases showing significant variation of key outcomes, there is the possibility of developing better-founded knowledge of the nature of mechanisms and their properties. (Ackroyd & Karlsson, 2014, p. 31)

In the study of the practice of multimethodology across OR, there is a lack of cross-case learning (Ackermann & Howick, 2022; Midgley et al., 2013; chapter 2). There is a pressing need to continue

the move from single-method evaluation of single interventions to multimethod comparison of multiple interventions (Brocklesby & Beall, 2018; Franco et al., 2021; Howick & Ackermann, 2011; Midgley et al., 2013; Mingers, 2003a; White, 2006). More specifically, in order to understand better method choice and development, Luoma (2016) and Yearworth and White (2014) call for examination of multiple cases within the same organization, while J. S. Morgan (2013, p. 255) proposes case studies for understanding the practicalities of practitioners' method decisions.

Case study is particularly suitable for this research as cases can provide rich information (Teddlie & Tashakkori, 2009) for addressing complex 'how' and 'why' research questions (Myers, 2013) about organizational practices where the context plays a key role (Yin, 2014). The approach is suited to the challenge of providing rigorous and contextually grounded research of practical use to managers (Pettigrew et al., 2001). Case studies also tend to appeal to sponsors; they are common in policy research (Bastow et al., 2014).

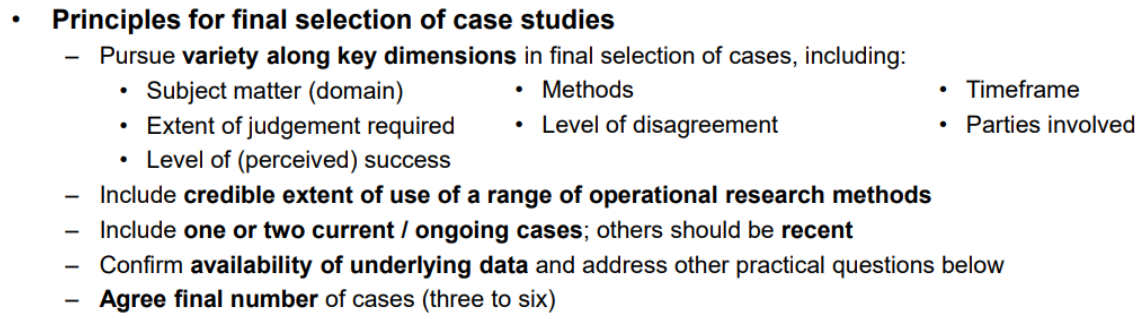
My critical realist case research was the sort of intensive research that Sayer (1992) argues is required to identify causal mechanisms, rather than the extensive research required to test them at scale (Easton, 2010; White, 2016b). My aim was to develop provisional, testable, data-driven middle-range theory developments from my comparative study of multiple cases (Easton, 2010; Eisenhardt, 1989; White, 2006) by 'qualifying the underlying mechanisms' in order to 'deepen existing theories' (Van Burg et al., 2020, p. 10). I sought transfactual generalization to more plausible explanations regarding the use and non-use of multimethodology.

4.7.2 Case selection

My industrial supervisor and colleagues agreed to suggest examples of 'typical problems to act as case studies' (Parr & Mingers, 2015, p. 7). These would be interventions in which OR methods were used to support strategic decision-making for or on behalf of the UK government. Cases would then be 'selected so as to include a variety of problems with different characteristics' (Parr & Mingers, 2015, p. 7) along a number of dimensions.

I developed the dimensions with reference to extant literature (e.g., Howick & Ackermann, 2011; Mingers, 2000b; Van De Water et al., 2007; White, 2016b; chapter 2). My expectation was that these dimensions may be associated with variability in intervention processes and outcomes, or in the

particular intervention context (Ackroyd & Karlsson, 2014, p. 31). Figure 9 below shows the principles agreed for selecting cases for the research, including proposed dimensions. An illustration of the format of the purposive case longlist used in selecting cases is at Appendix J (Table 31).



Source: Discussion Paper for Stakeholder Meeting, 10 March 2016

Figure 9: Principles for final selection of case studies

Key practical questions that had to be addressed before selecting a case included the extent to which documentation, other data sources, and intervention stakeholders would be available for the research. For the most promising potential cases, I was introduced to a practitioner so that I could introduce the research project and discuss features of the intervention and hence the intervention's suitability for the research project. Typically, before I could proceed, issues of sensitivity and confidentiality had to be resolved, and approvals obtained from organizations involved.

I sought to include current interventions to reveal differences between practitioners' espoused theories and methods-in-use (Cropper, 1990b; Midgley, 2000). As well as being contemporaneous with the doctoral research, their inclusion required willingness from intervention stakeholders and organizations to 'open' their intervention to ongoing observation. I also sought recent, past interventions, which might be recalled more accurately by participants (Eisenhardt & Graebner, 2007). Practitioners and other stakeholders would be more likely to be able to cast their mind back to when they were experiencing the intervention (Brönnimann, 2022). The inclusion of recent interventions allowed for post-intervention reflection and hindsight (from interviews and documents, and in relation to subsequent events), which could enhance my responses to the

research questions. Recent practice was also more likely to be comparable with current practice on which guidance was sought.

Much guidance is available in research literature on numbers of cases, but claims to a 'golden number' have been criticized in the context of qualitative and mixed research (Eisenhardt, 2021, p. 153). The aim in this research was to make contributions to theory and practice, and these might not be reliant on the number of cases or extent of data, except that trying to do too much would mean never finishing! Rather, academic and practical contributions required quality in interpretation, and responses to the research questions. In the end, my choice of number of cases was a pragmatic decision, based on what would be adequate for responding to the research questions, and acceptable for this doctoral research and its gatekeepers (Braun & Clarke, 2021).

By the time I started my empirical research, staff had proposed fifteen interventions for my purposive longlist based on their interests, knowledge and experience (Teddlie & Tashakkoki, 2009), with a view to selecting four to six for the research. Most of the interventions were historical; all but one occurred during the previous five years; some were contemporaneous. Two or three were current, although attending meetings and observing these interventions was in the end deemed impossible by organizations involved.

While I was carrying out the research, a second wave of longlisting was required in order to increase the final set of cases to five or six. The agreed intention was to capture more current interventions where the time available was hours or days, as well as past interventions considered to have been less successful, in order to match the interests expressed in the original research proposal, and broaden the final set of cases. The longlist I was discussing with staff grew to around 30 cases.

Although many interventions were proposed for the research over a period of some years (from when the research project was first conceived, before my involvement), most were either beyond the scope of the project (e.g., not supporting executive decision-making in strategy), or access to sufficient stakeholders or data sources and/or organizations was not in the end provided, whether for contractual constraints or other reasons. While many interventions were eventually ruled out, others, including at least three or four of the final five, were promoted to me as important to include in order to attract additional funding for the research. Thus, case selection was itself a process of

complex and dynamic decision-making that continued during the empirical research, and not the result of quantitative sampling of typical cases (Plakoyiannaki & Budhwar, 2021; Sim et al., 2018).

From the first wave of longlisting, I selected one intervention as a pilot case. It was more recent than others and relevant people were available and keen to learn from their experience of the intervention. The subject matter was not overly complex, not too far from my own practical experience of decision support, and a strategic decision had been made by a government minister following the intervention. I selected three further interventions for their recency or contemporaneous nature, the strategic nature of their subject matter, and because there appeared to be available access to relevant stakeholders and data, and some notable willingness amongst certain practitioners to (re-)consider the use of multimethodology in their intervention(s).

I was informed that the interventions were 'quite typical'. Due to restrictions arising from the sensitive nature of work in the research context, I could not verify this, however the interventions appeared – at first sight – to include a range of different types of stakeholders and methods, as well as similarities and differences in the suggested levels of judgement, disagreement and success. I ruled out other interventions because they were older and outside the intended scope of the research, for example, because there was apparently little recognizable OR.

In the second wave of longlisting, only one intervention fulfilled selection criteria and could be included in the research. I was informed that interventions lasting hours or days were rare, so that it was not surprising that these could not, in the event, be included in the research.

Once I had data on five interventions, I found it hard not to analyse them all – out of a sense of respect for and duty to research participants, and a feeling of obligation and pride in finishing what I had started. In the final set of five cases described in Figure 10 below, one was current, one was in a post-decision implementation phase at the time of the research, one had led to a decision that had been implemented, and the results of the other two cases were described by staff as having informed subsequent decisions and/or interventions. At least three of the five interventions involved practitioners' 're-working' previous interventions, which led to a need for me to understand – to at least some extent – years of practitioners' work.

1. Analysis for a business case for future investment in a national capability
2. Review of an approach to an organizational process to advise on its applicability to the enhancement of a national capability
3. Review of a national capability to inform its future strategy
4. Review of options for the future organizational model and governance of an organization comprising a number of national capabilities
5. Review and prioritization of options for the future technological configuration of a national capability

Figure 10: Brief indicative descriptions of cases (anonymized)

4.7.3 Case data

> ... combining evidence from multiple sources, such as interviews, archival data, and surveys frequently leads to the most successful case studies (Yearworth & White, 2014, p. 938)

In the Appreciation stage, case data comprised interview data, including field notes, and secondary data (Figure 8 above). Primary data from intervention stakeholders was required in order to understand what practitioners did (Yearworth & White, 2014).

In case study research, data collection may be programmed and/or opportunistic, subject to obtaining appropriate consent. I had intended to take a flexible, iterative approach, picking one intervention as a pilot, developing my approach and selecting further cases, interviewees and data sources based on lessons learned, and adapting my approach and requests for further access to respond better to the research questions and data as I proceeded.

However, while I found people were generally very willing to participate in the research, my experience was that the timing of data collection was governed by when gatekeepers (my industrial supervisor and colleagues) granted access to them, which meant that I collected most data on the interventions concurrently over an eleven-month period in 2016 and 2017 as and when it became available. This was frustrating and very time-consuming as it involved stopping and starting research into each intervention multiple times, re-briefing myself on the cases, including long reports, so as to

present as a credible researcher each time. I was generally not granted access to non-governmental practitioners, and where I was, a non-disclosure agreement was requested. Another key challenge in gaining access to interviewees and data sources was the frequency with which employees in UK government change roles.

4.8 INTERVIEWS

4.8.1 Introduction

In order to understand more specifically the process of choosing multiple methods (Howick & Ackermann, 2011), as well as 'the motivation, rationale and acceptance of mixing methods' (J. S. Morgan, 2013, p. 255), I interviewed intervention stakeholders. Interviews are commonly used in critical realist research to generate in-depth understanding of complex social phenomena (Brönnimann, 2022; Frederiksen & Kringelum, 2021; Wynn & Williams, 2012, 2020). In this study, interviews presented intervention stakeholders with opportunities to recount their experiences of cases (intervention 'events, situations and activities') from their perspectives, and facilitated my exploration of social and relational aspects of OR interventions (Danermark et al., 2019, pp. 43, 130).

4.8.2 Participant selection

I sought to reduce negative impact from retrospective sense-making and impression management by interviewing a range of diverse intervention stakeholders, and interviewing practitioners more than once over time (Eisenhardt & Graebner, 2007). I expected intervention stakeholders to view interventions from different perspectives due to their different intervention and job roles, seniority, functional areas/professions, geographies, organizations, other social groupings, and experiences (Eisenhardt & Graebner, 2007), in addition to their personal characteristics.

To identify potential interviewees, I took a snowball (M. S. Reed & Curzon, 2015), not quantitative sampling approach (Saunders & Townsend, 2016). During interviews, I asked interviewees to recommend people and documents that would be useful to enhance my understanding of the case, and my consideration of alternative approaches. I then requested that these interviewees be set up. I was sometimes then put in contact with interviewees or their assistants to make arrangements myself. I reviewed secondary data in order to identify other interviewees.

4.8.3 Interviewees

Over a period of ten months from September 2016, I conducted 50 in-depth, semi-structured interviews of 40 individuals who were intervention stakeholders across five cases. In two interviews, I asked questions about two different cases. Two participants each asked to bring a colleague to the interview, presenting the opportunity to interview them and their colleague together. One interviewee brought a colleague along to observe. Table 13 below refers.

Table 13: Numbers of interviews and interviewees by case

	No. of interviews	**No. of interviewees**	**Hours of interviews** *(Note 1)*	**Comments on numbers and types of participants** (compared with other cases)
Cases (one per row)	5	2	3	I was discouraged by interviewees from interviewing others about this, arguably smaller-bounded, case.
	8	7	7	-
	8	9	6.5	-
	11	12	10.5	I interviewed a broader range of clients in this case. Interviews included one long interview on intervention processes relevant to other cases.
	18	12	11.5	I interviewed a broader range of customers and more practitioners in relation to this pilot case.
Total transcribed	**50**	**40**	**38.5**	
Pilot case interview excluded from analysis following transcription.	(1)	(1)	(1)	
Total analysed	**49**	**39**	**37.5**	

Note 1: Time in hours is approximate and excludes discussions before start of interviewer's questions, including on informed consent, and after I stopped recording.

As far as possible, interviewees were across Ormerod's (2001, 2008a, 2008b) stakeholder categories (Table 9, chapter 3). They included practitioners, practitioner supervisors and managers (of the practitioners or areas of organizations under study), clients, decision makers, and individuals involved in the interventions, for example, as workshop participants, interviewees, or with technical and project/programme management roles, and/or subject matter experts. Like Ormerod, regrettably, I did not approach individuals in the 'done without' category, due to lack of time.

I interviewed the person described to me as the 'main practitioner' in each intervention at least twice in order to cover all the relevant parts of the interview guide, understand the case in more detail, ask questions about unclear or conflicting information, and secure other benefits of repeated interviewing over time (e.g., see Eisenhardt & Graebner, 2007). Overall, across the cases, I interviewed six of the practitioner interviewees more than once (up to four times). I interviewed

practitioners more than twice where the intervention was ongoing or being implemented, or because the practitioner had more they wanted to share (one participant).

In the event, on review of the transcript of one participant's interview about the pilot case, and having analysed all other data for that case, I decided not to use the data. Unfortunately, it was not practical for me to fulfil the participant's request 'to see any responses you use to ensure accuracy', and there was very little in the transcript that was not in other case data. The very few comments that were not in other case data were personal, and not directly related to the research questions, suggesting I had reached a point of saturation, at least in understanding the case from the perspective of a stakeholder from the same part of the same organization as this participant.

4.8.4 Pre-interview procedure

Around one week before each first interview with an interviewee, I sent an email to the interviewee with further information about the research project, a PIS and PCF, the name of the case I would like to interview them about, and what I would be interested in hearing about – their role and experience of the case, as well as their appraisal of it. I finished the email with some biographical details, including highlights of my academic and professional qualifications, work experience (as a consultant) and voluntary work.

I devised the interview guide (Figure 47, Appendix K) based on the research questions and related literature. I used it flexibly, as indicated, for different types of intervention stakeholders (practitioners, decision makers) in order to steer the discussion towards the research questions and understand the issues raised while letting respondents speak. In preparation for each interview, I reviewed secondary data received and interviews conducted to date on the case, including early findings from transcription and analysis of previous interviews where available. I annotated a copy of my interview guide with particular points for discussion and highlighted questions I expected to be more relevant to the particular interviewee, for example, because they had been described to me as a client rather than a practitioner.

4.8.5 Interview procedure, questions and field notes

At the outset of interviews, I communicated to each participant details I had been given of the level of security check I had been subjected to, and information that could – as a result – be shared with

me. As described in more detail in the interview guide (Figure 47, Appendix K), after dealing with consent issues (using the PIS and PCF), I started to record the audio of the discussion (in all but six instances, and only where interviewees agreed). After thanking the interviewee again, I highlighted what I was particularly interested in hearing about, for example, the interviewee's experiences of providing or appraising decision support in the case, and their experience of the decision support process, or, how they chose or appraised decision support methods.

Given the lack of methodological guidance then available for applied social research using critical realism (Alderson, 2021; Fletcher, 2017; Maisuria & Banfield, 2023; Nichol et al., 2023), like Brönnimann (2022, p. 17), I developed my interview questions in line with the ontological assumptions in my developing critical realist theoretical framework, and other more general guidance on conducting critical realist research (Danermark et al., 2002; Mingers, 2006a, 2014; Wynn & Williams, 2012). Brönnimann (2020) used experience from his research on successes and failures of business process management change projects to develop a model for critical realist interviewing in which the interviewer works backwards through time to trace causality. In contrast, I did not lead interviewees through my stratified ontology. Informed by my extensive professional experience interviewing graduate job candidates, as far as possible, I also avoided asking interviewees leading or hypothetical questions.

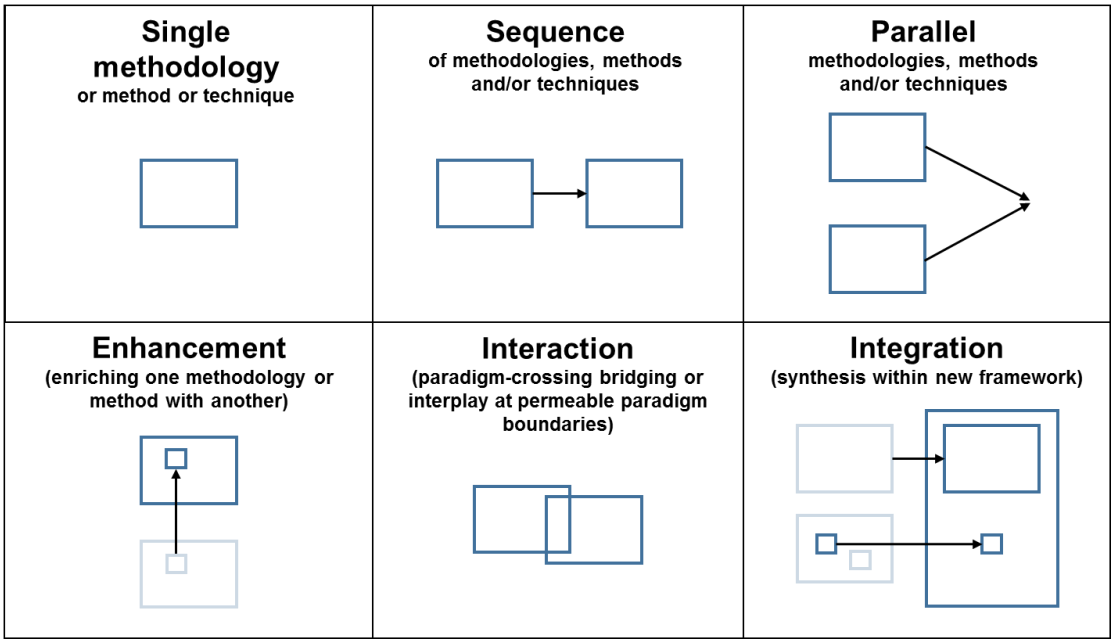
I started each interview by asking the interviewee to describe their role in relation to the case. The next questions were about when they were first involved and the case timeline. Following suggestions in Howick and Ackermann (2011), I asked what led practitioners to use or influenced their choice of particular methods or a multimethodological approach, and not others, and about benefits and challenges of methodological approaches (expected and experienced), notions of success, and dimensions and typicality of particular interventions. I also used interviews to explore, amongst other points, expectations of and commitments to other stakeholders (after Mingers, 2006b), alternatives considered and rejected and not considered, support available for using different methods, and the future of method choice. At the end of each interview, I asked the interviewee if they would like to add anything, and if they had any questions or comments on the interview or the research. I asked interviewees if I may return to them later in the research for more information, for help with understanding the data, or to review findings. Following the interviews, I wrote or spoke field notes of my experience of the interviews.

4.8.6 Interview activities and handouts for practitioners

During interviews with practitioners, I asked the interviewee to draw on a blank piece of paper a **timeline** of the case showing key stages, activities, decisions and outcomes. This was an example of a 'solicited document', created during research (Coffey, 2013).

I used two **handouts** with practitioners. The first, showing forms of multimethodology (Figure 11 below), was my own illustration of **J. S. Morgan, Howick and Belton's six linking designs** (J. S. Morgan, 2013; J. S. Morgan et al., 2011, 2017). I briefly explained the six forms to practitioners and asked them which resonated with them in terms of the methodological approach they took in the case. This was to prompt discussion of how they used elements of their methodological approach together (and any immediate comments they had on the typology of designs itself).

Forms of multi-methodology



Adapted from six linking designs in Morgan et al. (2011)

Figure adapted from 'Fig. 2. Mixed method designs.' in J. S. Morgan et al. (2017, p. 911), used under CC BY 4.0

Figure 11: Interview handout 1: Forms of multimethodology (licensed under CC BY 4.0)

The second was a **stakeholder grid** (Figure 48, Appendix K) I created for intervention stakeholder categories, adapted from Ormerod (2001, 2008a, 2008b; cf. Derakhshan et al., 2019) and with examples informed by the Defence Science and Technology Laboratory (DSTL, 2015a). I asked practitioners to write lists of intervention stakeholders in the grid, by category, which prompted their description and our discussion of particular stakeholders, roles and relations, and how they might be categorized. I expected Ormerod's categories (doers, done for, done with, done to, and done without) to be quick for practitioners to understand and respond to as part of interviews, as compared with other categorizations, for example, based on stakeholder power, legitimacy and urgency (R. K. Mitchell et al., 1997), or power and interest (Freeman, 1984), and which they were perhaps more likely to have used themselves in particular ways.

Where possible I took copies of secondary data for interviewees to refer to during our discussions, and to jog memories. A few interviewees brought a laptop and searched for relevant information while we spoke.

4.8.7 Follow up interviews with practitioners

In addition to using the handouts described in the previous section, I used follow-up interviews with practitioners to clarify particular issues, explore issues raised in further detail, check my understanding of intervention timelines, events and other case aspects, review information in secondary data related to the case, and address further questions from the interview guide. This was the form of member checking that was possible within the time constraints of the research project. For reasons of data sensitivity, confidentiality, and my other ethical commitments to participants, I did not share my rich case descriptions (section 4.10.5 below) with interviewees.

4.8.8 Location and duration of interviews

The interviews took place in interviewees' offices and meeting rooms in pre-arranged slots, typically one hour long, including pre- and post-discussion. I conducted one interview by telephone at the interviewee's request. That call was scheduled for 45 minutes, and the interviewee sent me their signed consent form by email. I also conducted one shorter (30-minute) follow up interview with a practitioner by telephone. A couple of interviews lasted an hour and a half.

4.8.9 Interview style

My interview style was supportive and encouraging of interviewees' responses, as opposed to a drier style of interviewing where questions are posed and then the interviewer is silent and unresponsive. I used lots of nods and yeses. My impression was that this helped where interviewees lacked confidence or were unsure about sharing details of cases viewed as less successful.

Interviews were exploratory and at times I was creative with my questions, particularly where individuals took roles in interventions that I had not anticipated when drafting the interview guide, and to follow up themes, or understand case-specific issues. Following Braun and Clarke (2021), writing about research using their reflective version of thematic analysis, this is not unexpected:

> For us, *quality* interview data, for instance, are typically 'messy', produced in a context where the interviewer is *responsive* to the participant's developing account, rather than adhering strictly to a pre-determined interview guide (Braun and Clarke 2013). (p. 208, *emphasis in original*)

I had decided not to take the approach of trying to conceal from interviewees the research subject, though I did not share the precise research questions (though wording of some interview questions came close). Overall topic and aims of the research were disclosed to participants through interview paperwork and discussions at the start and end of interviews. This open approach assumed that practitioners and other stakeholders were themselves best placed to provide understanding of the cases and reasons for their actions (Porpora, 2016). This was also a practical approach to generating sufficient data in meetings scheduled for one hour or less, so that I could actually analyse cases in some detail in response to the research questions.

Interviews therefore shared some features with 'unstructured interactive interviews' (Morse, 1997, p. 445) because I was learning about the cases and contexts as I went, and adapting my approach, as well as being both encouraging and probing. Where interviewees did not directly answer questions, there was limited time to probe further. I sought to balance not 'leading' interviewees' responses, while needing to direct them to the topics of interest *and* check the logic and consistency of what they were saying by using recaps to focus the discussion, as well as to confirm my understanding, and then move the discussion on.

4.8.10 Pilot

After the first pilot interview, I reflected that I thought it was important to listen and not jump in with answers or my own experience. On transcribing the first of the interviews, I wondered if I was interrupting the flow of interviews too much with back-channels such as, 'yeah', 'um', and 'OK'. I saw myself as reassuring interviewees that they could say what they were saying – that it was acceptable or 'normal'. I also reflected in the first two weeks of interviews on aspects of the research questions which I could seek more data on in future interviews, including reasons for method choices.

4.8.11 Transcription

I later transcribed all the audio recordings of interviews rigorously myself, due to the sensitive nature of the content. This was a way of familiarising myself with the data and starting to think about themes. I first transcribed into Word and then imported the transcriptions into NVivo. Once more familiar with NVivo, I transcribed (and coded) directly in NVivo using its transcription tools.

I started with verbatim transcribing in order to facilitate discourse analysis. However, it became clear the doctorate did not allow time for this approach, and adapting the output for inclusion in case summaries took time. I condensed verbatim accounts to produce gisted quotations (Evers, 2011; Paulus et al., 2015) for use in case summaries and reports of themes. I sought to ensure that all transcripts were appropriate for the analysis in terms of the level of detail required to respond to the research questions, and the epistemological positioning of the research. In other words, as I opted to pursue thematic analysis, I simplified and adapted my approach to match the requirements of my research design, and its theoretical underpinnings (Oliver et al., 2005).

I checked my accounts against the recordings a number of times, correcting them where necessary – when first transcribed, and later in case of any concern or doubt regarding understanding or meaning as I further coded and interpreted the data in compiling case descriptions and developing my thematic analyses. I sought to corroborate what interviewees said with other data and analysis 'to overcome the uncertainty associated with any single finding' (Shaw et al., 2019, p. 730).

Over an extended period of time, I developed a familiarity with the data through transcription and study. When I read the transcribed extracts and reviewed themes, I could 'hear' the interviews in my head. I became an expert on the data. Where I had doubt, I re-consulted recordings. All this

facilitated my reflexive approach. I actively reflected on the social nature of the interviews and factors that may have influenced what interviewees reported.

4.9 SECONDARY DATA

4.9.1 Introduction

I sought and analysed secondary data for contextual and case understanding (Figure 8 above). As recommended by Howick and Ackermann (2011), I reviewed written records of interventions. These documents provided accounts and representations showing how practitioners work (Coffey, 2013) that I could compare with interview and other data.

4.9.2 Secondary data selection

I took an opportunistic approach to obtaining secondary data, and a systematic approach to reviewing case data for other secondary data sources. Some of the data was made available to me during case selection; most information was made available during the interview period.

As is typical for organizations with 'systems of accountability' (Coffey, 2013, p. 373), reports tended to refer to other documents (previous reports, data sources, strategy and policy documents), which I searched for or requested. Documents revealed temporality and networks (Coffey, 2013, p. 374). Links between documents and shared language were informative, for example, of intervention timelines, while content such as distribution lists and intervention organization charts facilitated stakeholder identification. Given my critical approach, exclusions were also of interest.

The secondary data I reviewed included reports, memos, organizational charts, meeting minutes and practitioners' own notes relating to the cases (Checkland, 1981; Myers, 2013). Study plans included diagrams and explanations of practitioners' methods. I reviewed publicly available information where relevant.

Some documents were not made available to me for confidentiality or security reasons. Practitioners' reports to clients were made available for the research in four of the five cases. In case 5, access to other documentation, including scoping documentation, reports of outsourced analysis, and practitioners' modelling was provided instead. More generally, I was not given access to financial or

cost details of the interventions, nor other management information such as hours worked, budgets, other resources, or performance tracking or ratings. How I used some secondary data was subject to security restrictions.

4.9.3 Secondary data analysis

Where possible, I anonymized and imported secondary data, or at least key points relating to the research questions, into NVivo. I then coded and analysed data as described in the next section.

Analysing documents helped me 'make sense' of the cases, while considering their 'purpose or function' (Coffey, 2013, p. 371), different 'versions of reality' (Coffey, 2013, p. 369), and 'meaning-making' ('intended' and 'received'; Coffey, 2013, p. 371). Documents were 'imbued with cultural ways of telling' (Coffey, 2013, p. 371), being 'situated' accounts (Coffey, 2013, p. 375), written with particular audiences in mind. For understanding, some documents required many readings over time, and alongside review of other data due to their domain specificity.

4.10 QUALITATIVE CASE ANALYSIS

4.10.1 Introduction

> Qualitative data have particular strengths for understanding processes because of their capacity to capture temporally evolving phenomena in rich detail, something that is hard to do with methodologies based on quantitative surveys or archival databases that are coarse-grained and tend to "skim the surface of processes rather than plunging into them directly" (Langley, 1999: 705). (Langley & Abdallah, 2016, p. 137)

The small number of cases and the importance of context and meaning and interpretation to the research questions – in particular in understanding why particular methodological approaches are taken – lent themselves to in-depth, qualitative exploration (Myers, 2013) in the Analysis stage (Figure 8 above). Qualitative approaches facilitate rich understanding of the unfolding of the complex process of an OR intervention over time, including practitioners' choices, activities, events, ordering, sequences, and multiple outcomes (Franco et al., 2021; Gehman et al., 2018; Langley, 1999; Langley & Abdallah, 2016), and continual flux (Checkland & Scholes, 1990).

4.10.2 Overview of case analysis approach

In the Analysis stage (Figure 8 above), I developed my approach to analysing case data (interview data, including field notes, and secondary data) by cycling between the research questions, data and

literature, in line with the flexibility afforded by a critical realist case study approach. In the interests of transparency, and so that others can judge the quality of the research, I describe below my approach, which is summarized in Table 14 below.

My approach met well the need to aggregate and, where possible, corroborate multiple sources of data, building in checks of my analysis in the absence of co-researchers involved in detailed data analysis (see Morse, 1997). I reviewed all coding, tabling, thematic analysis and case descriptions at least twice to ensure completeness and consistency across the data. See also section 4.8.7 above regarding member checking.

4.10.3 Coding and memo-ing

For coding case data, I used a refined version of the research codebook (section 4.5.3 above), which I developed further, iteratively, as I transcribed and analysed case data. Table 28 (Appendix H) refers. As for the survey data (section 4.6.7 above), I closely reviewed case data in relation to the research questions, coding data fragments first to topic nodes and sub-nodes, and employing *in vivo* coding, for example, for capturing specific methods, activities, and outputs of practitioners. In order to balance having manageable amounts of data and remaining true to that data, coded extracts were one word to several sentences long. I undertook a second cycle of analytical coding using *in vivo* (analytical) coding within nodes, e.g., 'Subject matter', 'Issues and problems', 'Challenges'. I then clustered and collapsed sub-nodes into thematic nodes.

By constructing, reviewing and re-constructing themes within data coded, for example, to 'Subject matter' and 'Issues and problems' I had to reflect on consistency between data, overlaps and differences. This was perhaps particularly pronounced in one case where my key finding from the thematic analysis was that different stakeholders had very different views of what the intervention should deliver. I also considered using cognitive mapping, but found insufficient consensus across accounts presented to me (White & Bourne, 2007).

I created memos and annotations on my interpretations of the research questions and data, and on node contents and overlaps, and updated my research journal as I went (section 4.6.7 above). Later, as my confidence grew, and to save time, I memo-ed directly into research reports, like Yearworth and White (2014).

Table 14: Analysis of cases – summary of stages, aims, data, activities, and outputs

RESEARCH STAGES[0] WITHIN ANALYSIS STAGE (Figure 8)	**RESEARCH AIMS**	**CASE DATA**	**RESEARCH ACTIVITIES**	**RESEARCH OUTPUTS**	**DISSERTATION CHAPTERS**
Descriptions of 'events, situations and activities we intend to study and explain'[1] **Analytical resolution** into components and processes (entities, structures, conditions, actions, events, outcomes and their relations) relevant to the research questions[2]	To **identify 'the object** of the knowledge generated by the research'[3] – the cases To **explicate events** in the actual domain,[4] 'distinguishing the various components, aspects, dimensions and levels of analysis'[1]	Interview transcripts Field notes Secondary data (documents)	**Deductive and inductive topic coding** of data **and memo-ing** **Tabling and memo-ing** **Thematic and comparative analysis**	**Rich description of each case**, comprising: • Summary description (narrative) • Timeline (chronological account of events, activities, and outcomes) • Stakeholder diagram • Table of practitioner methods, activities and outputs	**Chapter 4** (summaries of research activities and outputs) **Chapters 5, 6, 7** (description of cases in response to research questions)
Abductive or theoretical redescription[1] **Retroduction** to potential explanatory mechanisms[5] **Retrodiction** to potential antecedent causal events[5]	To **explicate structure and context** in the real domain[4] To **identify generative mechanisms** in the real domain[5] To **identify antecedent causal events to explain events** in the actual domain[5] Overall, to **identify mechanisms** that lead to empirical events, **conditions** in which they are triggered, **and relations** with other mechanisms and structures[6]	As above, plus: Rich case descriptions	**Theoretical and explanatory interpretation and redescription** of case components and aspects relevant to the research questions[1] **Synchronic analysis (retroduction)** in which we ask, 'What generic mechanisms existed in this phenomenon, with what properties and powers, and what do they cause to occur?'[5] **Diachronic analysis (retrodiction)** in which we ask, 'How did the combination of mechanisms interact to generate a particular outcome in this context?'[5]	**Causal explanations of actions, events and outcomes in context** – configurations of mechanisms and the entities/structures they are emergent from[7]	**Chapter 3** (theoretical framework – a theory-informed, critical realist analysis of a generic OR intervention) **Chapters 5, 6, 7** (explanations of case elements in response to research questions)

Note: Differences between my mapping of critical realist research stages to the Analysis stage in the 4As (Mingers, 2006b, 2014; Mingers & Brocklesby, 1997) and that proposed by Wynn and Williams (2012, p. 810) are intentional. See also Figure 8 and Figure 46 (Appendix G).

[0] (Bhaskar, 2016, pp. 79-82)
[1] (Danermark et al., 2019, Table 5.4, p. 130)
[2] (Elder-Vass, 2010; Sayer, 1992)
[3] (Mingers, 2014)
[4] (Wynn & Williams, 2012, pp. 798, 810)
[5] (Mingers & Standing, 2017, Table 2)
[6] (Sayer, 1992)
[7] (Ash, 2022, p. 118)

4.10.4 Tabling for thematic and comparative analysis

Tabling, for ease of review and comparison of topic-coded data, proved to be a useful step in my thematic analysis, particularly in producing rich descriptions of the cases. Systematic tabling of data enabled me to compare and contrast accounts across participants, interviews, documents and other sources, for the identification of patterns and other insights (Cloutier & Ravasi, 2021). It enabled me to deepen my understanding of single cases as my analysis proceeded, reconciling data and differences in terminology used by different participants over time, and identifying points of disagreement. I also used tabling for cross-case comparative analysis.

4.10.5 Rich description of cases

I applied the transcribed, coded, and tabled data to constructing a rich, detailed description of each case (Keys & Midgley, 2002; Stake, 2008), comprising a:

1. Summary description (narrative);
2. Timeline;
3. Stakeholder diagram; and,
4. Table of practitioner methods, activities, and outputs.

The four elements are described in Appendix L. The rich, detailed descriptions included context, actions, events, and outcomes, as relevant to the research questions. Their compilation consolidated and deepened my understanding of single cases, and facilitated my identification of systems, components, relationships and processes and their relations and interaction (Figure 8 above).

In critical realist approaches to social science research, and case study research in management, there is a need to identify 'the object of the knowledge generated by the research' as a first step in the analysis (Mingers, 2014, p. 191). The case descriptions identify and describe the events to be understood 'to allow the researcher to describe and explicate in detail those events believed to have actually occurred' (Wynn & Williams, 2012, p. 797). As Wynn and Williams (2012) explain,

> The descriptions of the events include details of key actions and outcomes, and the specific structural components that were involved. The sequence of these events provides evidence of the effects of the causal chain that constitutes a change, or unexpected non-change, in the structure of the research setting. Developing a detailed, explicit sequence of events enables subsequent structural and causal analysis. In

> other words, the events are not part of the theory but tools by which the researcher can develop theories. Thus, by identifying and explicating the events, the foundation is established for identifying the elements of structure and context from which these events emerge, as well as the mechanisms that were enacted accordingly. (p. 798)

My descriptions of events for each case were based on the subjective experience of actors captured through their first-person accounts in interviews, and intervention documents. I focused on establishing 'main facts' (Ormerod, 2014a, p. 1249), or 'memories and interpretations' (Langley & Abdallah, 2016, p. 137), looking for experiences that were shared across participants, interviews and other data sources, while also capturing inconsistencies. There was a danger of over-tidying, and of making invalid assumptions. I was careful, for example, to leave loose ends and conflicting data where the data suggested it. As Vogl et al. (2019) note, 'The role of the researcher is to synthesize competing interpretations and present the 'least false' interpretation rather than 'the truth'' (p. 620). Further analysis of case descriptions, including quotations, was then required in order to bring out what was interesting about the cases.

4.10.6 Structural and causal analysis

As shown in Figure 8 above, I used the rich case descriptions, together with further structural and causal analysis (analytical resolution, abductive or theoretical redescription, retroduction and retrodiction; Table 14 above) in responding to the research questions in subsequent chapters. I acknowledged that case data were social products (Al-Amoudi & Willmott, 2011; Porpora, 2016), and in my critical realist analysis and interpretation sought to explain why these data appeared as they did (Mingers, 2014). As Easton (2010) states, 'The cutting edge of this method [retroduction] is to continue to ask the question why?' (p. 124).

4.11 MERGED ANALYSIS AND INTERPRETATION

My merged analysis and interpretation of the quantitative and qualitative questionnaire data in the Analysis stage involved side-by-side comparison, joint displays of results, and spiralling within and across data sources. Survey findings informed the multiple case study, for example in providing context for practitioners' explanations as to their reasons for using particular methods or approaches, and the multiple case study informed my interpretation of survey results.

4.12 CORROBORATION AND JUSTIFICATION

> The empirical evidence turns a possible mechanism to a plausible mechanism and may eventually lead to the identification of the actual mechanism. By presenting evidence in support of the assumptions of one mechanism and showing the absence of evidence for the assumptions of competing mechanisms, we increase the plausibility of the explanatory hypothesis. What separates proper mechanistic explanations from mere mechanistic storytelling is this kind of rigorous checking of the assumptions upon which the mechanism schemes rest. (Hedström & Ylikoski, 2010, pp. 6-7)

The challenge of this doctorate was to produce justifiable, credible research findings for academic audiences (satisfying peer reviewers) *and* practitioners (satisfying, for example, my research collaborators at Dstl). I did not seek validation of curated descriptions of particular OR interventions (this would not have been in keeping with my research philosophy), but rather I sought corroboration of my (thematic) research findings in the form of descriptive and causal, explanatory responses to the research questions in the Action stage (Figure 8 above). Accordingly, in the Assessment stage, I compared and evaluated competing explanations I developed using multimethod empirical and theoretical corroboration, my developing theoretical framework (chapter 3), and literature. I presented preliminary results at workshops, seminars and conferences, inviting comments and challenge from participants.

4.13 CONCLUSION

In this chapter, I described and justified in detail the methodological approach I took to my empirical research. I drew on the theoretical framework and philosophical assumptions in the previous chapter and Bhaskar's (2016) RRRIREI(C) model of exploratory investigation to show *how* I responded to the research questions in chapter 2. More specifically, I explained aspects of my adoption of multimethodology, axiology, integration of data across sources, the survey, the multiple case study, interviews, secondary data review, qualitative case analysis, structural and causal analysis, merged analysis and interpretation of data in response to the research questions, and corroboration and justification of the research findings. In the next chapter I present the first of my empirical results – from the survey of practitioners.

5 SURVEY OF PRACTITIONERS

5.1 INTRODUCTION

Having described and justified the design of my empirical research in the previous chapter, in this chapter I report results of my survey of 54 practitioners who had supported strategic decision-making for or on behalf of the UK government (as introduced in section 4.6 above). Using descriptive statistics and thematic analysis, I respond to the following research questions:

RQ1. How do OR practitioners choose and combine OR methods to support strategic decision-making?

RQ2. Why do practitioners take these approaches, multimethodological or otherwise?

The results increase our understanding of OR practice within the research context, and, compared with previous surveys, provide evidence of more recent practice in non-academic settings. The chapter is organized as follows. First, I introduce two aspects of my analysis of results – comparison with previous surveys, and clustering and categorization of methods. I then present the results and analysis by research question (RQ1 and RQ2).

5.2 RESULTS AND ANALYSIS

5.2.1 Comparison with previous surveys

In this chapter, I compare survey results with the following most recent peer-reviewed surveys of OR practitioners about methods practitioners use and combine (reviewed in chapter 2, and summarized in Table 32, Appendix M):

1. In supporting organizational strategy, primarily in the UK (O'Brien, 2011 [OB]);
2. Generally, across OR practice globally (Ranyard et al., 2015 [RFH]); and,
3. Generally, focusing on method choice and multimethodology, primarily in the UK (Munro & Mingers, 2002, 2004 [MM]).

As far as possible, I refer to comparative results from practitioners based outside academia (Ormerod, 2004), in the UK, in the public sector. Therefore, unless otherwise stated, comparative results relate to:

1. 51 mostly UK-based public sector respondents (PSRs) in OB (p. 909);
2. 245 global respondents in RFH (p. 5); and,
3. 22 mostly UK-based respondents 'not clearly based in academia' (NAPs) in MM (2004, p. 91).

5.2.2 Clustering and categorization of methods

Given interest in this research in how to choose and combine quantitative and qualitative OR analysis methods, thematic analysis of survey responses (section 4.6.7 above) involved clustering methods (e.g., to 'Scenarios' or 'Interviewing') and allocating clustered methods to provisional categories (e.g., 'Management/Strategy' or 'General Research'). Using categories to analyse method use data in OR is not new. Deductive approaches have been used, for example, OB (Appendices A-C) divided methods between three pre-determined categories (OR/MS tools, management/strategy tools, and soft OR/MS tools), while Howick and Ackermann (2011, Appendix B) designated methods as quantitative or qualitative. RFH took an inductive approach, using factor and cluster analysis to group methods and participants. In this study, my exploratory approach was both deductive and inductive, building on extant categories with the data, while seeking to avoid dichotomous division of OR into 'hard' and 'soft' (Dyson, 2022; Dyson et al., 2021; Yearworth, 2022a, 2022b).

Categories I adopted and developed first were **Quantitative OR**, **Management/Strategy, OR less easily categorized**, **Systems Thinking**, **PSMs** (Rosenhead, 1989, 1996), **Qualitative/Soft OR, Other Disciplines** and **Domain-Specific** (section 4.6.2). Close review and iterative analysis of the survey data, informed by my developing knowledge of OR practice and literature, led to my development of separate categories for **Workshops/Elicitation/Facilitation**, **General Research** methods, **Visualization**, **Stakeholder Analysis**, **Project Management**, **Historical Analysis**, and **Consulting Skills** (Table 37, Appendix N). No such methods were listed by respondents in previous surveys, except for project management (three listings amongst examples of combinations of methods from public and private sector OR/MS practitioners in OB [Table 6, chapter 2], and, in MM [Table 5, chapter 2], one listing of 'Project network' and possibly any of the 12 'Other' method listings

in NAPs' multimethodology examples). We shall return to this later. We now turn to responding to the research questions with the survey results.

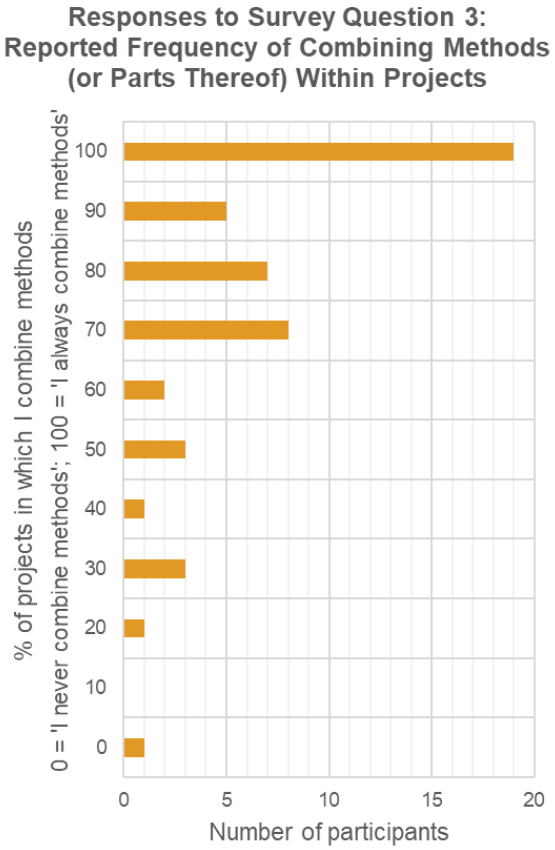
RQ1. HOW DO PRACTITIONERS CHOOSE AND COMBINE OR METHODS TO SUPPORT STRATEGIC DECISION-MAKING?

I respond to the first research question (RQ1) by presenting findings on the prevalence of multimethodology (section 5.2.3 below), methods practitioners use (section 5.2.4), methods practitioners combine (section 5.2.5), and forms of multimethodology practitioners use (section 5.2.6).

5.2.3 Prevalence of use of multimethodology by practitioners

I found a prevalence of use of multimethodology not seen in previous surveys (Figure 12 below). Most of 50 respondents to **question 3** reported that they combine methods (or parts thereof) within the same decision support project most of the time. The most common response was '10 (I always combine methods)', while the median was combining methods in 80% of projects (mean 78%; Table 39, Appendix O). I excluded one response of '5 (I combine methods in 50% of projects)' as it contradicted the participant's comment at question 8, 'This isn't applicable as I never use only one method'. That left only eight respondents (16%) who combined methods in 50% or fewer of projects. In addition, two of three participants who did not respond to question 3 provided comments at question 8 that suggested they use multiple methods in at least some projects, for example, 'Whether I combine multiple techniques in one project or not (or have contractors do this) will depend on whether it is appropriate for the project [...]'. In summary, in response to RQ1, these results suggest that practitioners commonly combine methods to support strategic decision-making.

Figure 12 might suggest that overall, on average, respondents combined methods in 77% of their projects, but that would be to make assumptions that have not been tested. For example, it would assume an equal number of projects of similar duration for each respondent, and that they never work together on projects.



Survey questions 5, 8, 10: Practitioners' reasons for using a single method
(% of projects in which participant combines methods)

QUICK TURNAROUND OR FOLLOW ON WORK

100: In the occasions where there were additional requirements or follow on questions, or in the event that we received "reachback" or quick turn-around questions then the project may have relied on a single OR method. However, the majority of these types of task relied on existing data or adapting/building on previous work (q8)
100: For [urgent projects] it may sometimes be appropriate to use a single established method but this is generally by exception as more often than not it is natural to use several even if in making the decision as to which to purse for the core analysis. (q5)
90: [...] I can only remember having used a single method in an emergency (not recently) […] (q8)
80: […] Single methods only typically work for small, constrained problems assessed over very rapid timescales. […] We don't attempt to use single methods for large/longer running problem areas - if we did I'm sure we would fail in a high proportion of cases. (q8)

OTHER EXPLANATIONS - SIMPLE QUESTIONS, CLIENT REQUEST, IF IT WORKS WHY NOT, TEAMWORK

90: [...] Simple questions (is A more accurate than B) lend themselves to simple approaches. However, even if A is more accurate, other factors might mean that B is the most cost effective solution [...] (q8)
80: [...] Customers sometimes request that only a single method should be used. [...] (q8)
50: [...] If a single method covers what is needed why use anything else? (q5)
0: When I have been involved in higher level modelling, while 1 OR method will be used, a lot of the data taken into that model may have been derived from other sources/methods (which I have not personally implemented). Being previously involved in the modelling domain, I tend to either be involved in enhancing particular models (i.e. the task is to develop a specific OR method...but that method will then be used to support other analysis which may be multi-method). (q8)

CHALLENGES TO CONCEPT OF COMBINING METHODS: DIFFERENT METHODS FOR DIFFERENT QUESTIONS

60: Despite having successfully been doing OR for 10 years, as an Engineer by degree I have not been trained in any of the techniques in Q1, and use a very limited selection of them. I use common sense to answer questions, backed up by Excel based calculations. Given the varied nature of the questions I answer, I just chose an appropriate technique to answer each element. Therefore I'm uncertain why the focus is on combining techniques. (q10)

Note: For descriptive statistics, see Table 39, Appendix O.

Bar chart adapted from Christie (2017a, p. 16; 2017b, p. 6)

Figure 12: Practitioners' frequencies of combining methods (N=50), and reasons for not combining methods

In Figure 12, prevalence results are compared with all of the few data on practitioners' reasons for using a single method. Only one participant (2%) reported never combining methods, however, from their comments, their work seemed part of multimethod projects when considered alongside work of their colleagues (Ackermann & Howick, 2022). Two further practitioners questioned use of the term 'combine methods' to describe what they did, noting their use of different methods for different project questions (or elements thereof). These practitioners appeared to use multiple methods within single projects, however they saw themselves using (perhaps series of) single method approaches.

Three practitioners who reported use of both multiple- and single method approaches provided the following further explanations for using a single method: (1) customers sometimes request a single methodology (question 8 [q8]); (2) simple questions lend themselves to simple approaches (q8); and, (3) 'If a single method covers what is needed why use anything else?' (q5). However, there was also a sense that practitioners only used single methods in exceptional circumstances. Four practitioners who reported using multiple methods in at least 80% of their projects linked single method use with rushed, very time-limited work on smaller projects, often related to previous work. Overall, the use of multimethodology seemed normal practice.

5.2.4 Methods practitioners use

Top OR methods practitioners use

The 15 most used of the **47 OR and strategy methods ('OR methods') in question 1** (Table 33, Appendix N) are compared with the top methods in previous surveys in Table 15 below. As explained in section 4.6.2 above, 'methods' is used to refer to the (clusters of) methodologies, methods and tools in question 1. Itemized rating scales, on which the rankings are based, are compared in Table 16 below. In RFH, MM, and this study, participants were asked about their use and awareness of methods along a four- or five-point scale (see Table 35, Table 36 and Table 38, Appendix N, for line-by-line comparisons of results across the surveys). In MM, 'If it [a method] had been used, respondents specified how many times' (2002, p. 371). In OB, participants were asked to score their use of each method along a seven-point differential semantic scale, or to indicate that they had not heard of the method (see Table 34 and Table 38, Appendix N). There are some interesting differences in the rankings.

Table 15: Top 15 OR methods, compared with previous surveys

Survey	This study *(question 1)*	Previous surveys		
		OB	**RFH**	**MM**
Year of survey	2016, 2017	Not reported (before 2011)	2008, 2009	Not reported (before 2002)
Rank	**% who used method** (cluster) (regularly or non-regularly)	**Median score for PSRs** who had heard of method (1=never use tool; 7=regularly use)	**% who used method** (more than once per year – regularly or occasionally)	**% who used method**
1	SWOT Analysis (93%; ≥2)	Project management (6)	*Spreadsheet modelling – basic (87%) (note 1)*	Statistical Analysis (95%)
2	Expert Workshops (91%; 7)	Statistical analysis (5.5)	Statistics – basic (86%)	Simulation (77%)
3	Project Management / Project Networks / Gantt Charts / Critical Path Analysis (83%; ≥2)	Cost benefit analysis (5)	Optimisation (72%)	Forecasting (73%)
4	Brainstorming (74%; ≥2)	Financial analysis/modelling (5)	*Spreadsheet modelling – advanced (72%) (note 1)*	Maths Modelling (59%)
5	Scenario Building/ Planning/ Analysis (72%; ≥2)	Brainstorming (5)	Strategic planning tools (Cost Benefit Analysis, *Performance Management*, *Balanced Scorecard*, Scenario Planning (70%)	Decision Analysis (59%)
6	Multi-Criteria Decision Analysis (MCDA) / Decision Analysis (DA) / Decision Tree (70%; ≥2)	Forecasting (5)	Simulation (69%)	Queuing Theory (55%)
7	Soft Systems Methodology (SSM) / Rich Pictures / CATWOE / Root Definitions / Conceptual Mapping / 3Es (Checkland) (65%; ≥2)	*Risk analysis (5)*	Forecasting (65%)	Heuristics/ Combinatorial (55%)
8	Gaming (62%; ≥2)	Scenario planning (4)	Statistics – advanced (62%)	SWOT/ PEST (55%)
9	Data Mining / Data Analytics / *Data Visualisation* (61%; ≥2)	Multivariate statistical analysis (4)	*Scheduling (53%)*	Project Network (50%)
10	Stakeholder Analysis/Mapping / Power-Interest Grids (59%; ≥2)	SWOT (4)	*DSS (52%)*	*Inventory Control (50%)*
Range for top ten methods	**93%-59% used** (regularly or non-regularly) (between 7 and 2, inclusive, using OB's median score method)	**6-4 median score** (1=never use tool; 7=regularly use)	**87%-52% used** (more than once per year – regularly or occasionally)	**95%-50% used**
11	Statistical Analysis (59%; ≥2)	Stakeholder analysis (4)	*Risk analysis ('noticeably less frequently used', so <50%)* *[other methods]*	Scenario planning (41%)
12	Cognitive Mapping / Causal mapping / Oval Mapping / Journey-Making / SODA (Eden) (56%; ≥2)	Balanced scorecard (4)		*Influence Diagrams (27%)*
13	Cost-Benefit Analysis / Net Present Value / Financial Modelling (54%, ≥2)	Simulation (4)		System Dynamics (23%)
14	PESTLE (53%; ≥2)	*Influence diagrams (4)*		Delphi (23%)
15	Historical Analysis (46%; ≥2)	*Resource-based planning (4)* *Benchmarking (4)* *Core competencies (4)*		DEA (18%)
Participants	**54** practitioners supporting strategic decision-making for or on behalf of the UK government	**51 PSRs** supporting the strategy process (87% UK)	**245** global respondents (32% UK; 29% USA)	**22 NAPs** (mostly UK)

Green = Results for method consistent with previous survey(s) *Yellow = Scored higher in this survey compared with previous survey(s)*
Orange = Not included in previous survey *Red = Scored higher in previous survey(s)*
Italics = Not included in this survey
Note 1: Like OB and MM, I did not include spreadsheet modelling as an OR method (in question 1), and only two respondents listed it at question 2 as another method they use. In question 4, the only listing of spreadsheet modelling as a specific method in a project example was 'pivot tables'. Two other participants referred to use of Excel within 'Bespoke modelling (usually in MS Excel VBA)' and 'Basic Excel tool constructed through systems thinking/engineering approach'. In OB, spreadsheet modelling was listed by respondents in 3 of 53 instances of combining tools to support the strategy process (6%). See also case 5 in chapter 6.
Note 2: Practitioners' reported use, knowledge, and awareness of all the OR and strategy methods in survey question 1 are in Figure 49 (Appendix N).
Note 3: For further details see Table 32 to Table 38 (Appendix M and Appendix N). For line-by-line comparisons with previous surveys, see Table 34, Table 35, Table 36, and Table 38 (Appendix N).

First, the most used method across previous surveys, statistical analysis, is in 11th place as only 59% of participants reported using it. Second, simulation and forecasting were used by 40% and 28% of respondents, again, notably less than all of OB, RFH, and MM. Results for the other highest-scoring methods in OB (scoring 6 or 5 – see Table 16 below), are: (1) consistent – for project management and

brainstorming; or, (2) slightly lower – for cost-benefit analysis/NPV/financial modelling (54%). Amongst other top methods from previous surveys, lower use of optimization (43%) compared with RFH is consistent with lower scores in OB (2 and 1). Overall, in this survey, SWOT analysis, expert workshops and the project management cluster were the three top methods, each being used by over 80% of participants. Use of the top method – SWOT analysis – by 93% of practitioners probably reflects higher use than in OB (where the median score was 4).

Table 16: Scale for method use, knowledge and awareness (question 1), compared with previous surveys

[REDACTED]

The third interesting difference is that the method that came a close second – expert workshops – was not included in previous surveys.[35] In fact, the methods that most participants reported using *regularly* were expert workshops, SWOT, scenarios, brainstorming, and the project management cluster (Figure 49, Appendix N). Further, other methods used by more than 70% of respondents in this survey – scenarios and MCDA/DA – were both used more than in previous surveys.

A fourth striking difference compared with previous surveys is that SSM and SODA/Journey-Making (SODA) were each used by more than half of participants, and used regularly (equivalent to a 7 on OB's scale) by 22% and 28%. In contrast, in OB, SSM and SODA scored 2 and 1.5, with only 18% and 12% of PSRs (who had heard of them) scoring their use as 4 or above, whereas amongst RFH's 81 UK respondents, SSM and SODA were used by 37% and 48%. Amongst other PSMs (Rosenhead, 1989, 1996), 25% of RFH's UK respondents used SCA, compared with 2% (one respondent) in this survey.

[35] Cf. Howick and Ackermann (2011), who categorize workshops, interviews and meetings as 'forms of intervention' (Table 7), and 'facilitated discussion' as a qualitative method (Appendix B) that was used with discrete event simulation in one of the journal articles they review (Table 1).

In OB, the only 'Soft OR/MS tools' with higher scores than SSM and SODA were influence diagrams, which was not included in this survey question, and stakeholder analysis (4), which was used by even more practitioners (59%) in this survey. A fifth difference is the extent of use of gaming (62% use, 29% regularly) and historical analysis (46% use, 23% regularly). This is notable as gaming and historical analysis were not included in previous surveys.

Finally, discrete event simulation (DES, discussed above) and viable systems model (VSM) were used regularly by a disproportionately high number of respondents (8, or 15%; Figure 49, Appendix N). 20% of respondents used VSM, compared with 5% in MM. All other methods outside the top 15 were used regularly by fewer than five participants (9%).

OR methods practitioners are aware of

Methods practitioners were aware of, but did not use, were broadly consistent with previous surveys (Table 34, Table 35, and Table 36, Appendix N). Compared with OB, there was more awareness of agent-based modelling (ABM; 85% of participants in this survey compared with 51% in OB), and less awareness of balanced scorecard and data envelopment analysis (DEA). Methods not included in previous surveys of which there was very high awareness were expert workshops, gaming, historical analysis, graph theory/network analysis, and Bayesian approaches.

Compared with OB, a similarly low proportion reported not having heard of SODA (9%), and even fewer SSM (4%; Table 38, Appendix N). Amongst methods not included in OB, and compared with MM, there was more awareness in this survey of VSM (56% heard of, compared with 27%), critical systems heuristics (CSH; 54%, 23%) and total systems intervention / system of systems methodologies (TSI/SOSM; 41%, 23%). Methods that over half of participants had not heard of were predominantly less well-known qualitative and systems methods that featured less in previous surveys, including boundary critique (70% not heard of). Compared with OB, there seemed to be less awareness of robustness analysis (65% not heard of) and SCA (62% not heard of). However, with OB, there is doubt as to whether greater awareness of robustness analysis was due to misinterpretation of its name. And separately, Steenmans has claimed that while SCA has had a persistent influence on the practice of policy analysis in the UK, it 'is often invisible when translated into the language of its clients' (I. Mitchell, 2021), i.e. not used explicitly. However, together with the use of SSM and SODA by more than half of respondents, and use of VSM by 20% of respondents, the awareness scores

suggest greater awareness and practice of systems thinking overall amongst OR practitioners compared with previous surveys.

Other methods practitioners use

In response to **question 2**, 40 participants reported over 160 **other methods** they used. The most frequently mentioned methods used regularly were: facilitated workshops; facilitation techniques/soft skills; interviews; and, mind mapping. Many responses were variants or elements of methods already listed in question 1, and most of the wide variety of other methods were reported by only one or two participants. Further details are in Table 37 (Appendix N), where comparisons can be made with methods in questions 1 and 4.

Project examples and methods

In **question 4**, 46 respondents provided 104 examples of recent decision support projects where they had used two or more methods. Clustering of the 456 method listings in the project examples resulted in 111 methods (Table 37, Appendix N) – more than four times the number of different methods reported in the examples in OB (26, across all MS/OR practitioner respondents) and MM (26 from NAPs; Table 40, Appendix O).

Top methods in project examples

The methods practitioners listed most frequently in their project examples were broadly consistent with the methods practitioners reported using regularly in question 1 (Table 17 below; Figure 49 and Table 35, Appendix N). The two key differences were the addition of facilitated workshops and interviewing, and that SODA/cognitive mapping was not a top method in the project examples. SODA/cognitive mapping was listed by only three participants (7%) in project examples (Table 68, Appendix T) – broadly consistent with only 2 examples (3%) in OB (Table 6, chapter 2). Where workshops were described as involving experts or specialists' judgement, I included them in the expert workshop cluster (Table 17 below). I added the facilitated workshops cluster to capture other descriptions of workshops not mentioning experts. Most were described as 'facilitated' or 'structured'. See the final column of Table 37, Appendix N for full details of the clustering of methods.

Table 17: Top methods in project examples, compared with previous surveys

This survey (survey question 4)							**OB**	**MM**
Rank	**Methods used in multimethod projects** (clusters)	Category	**Ppts**	**% of ppts** *(46 ppts)*	**Prjts**	**% of prjts** *(N=104)*	**% of examples of combining tools** *(N=53; <53 across all OR/MS ppts)*	**% of examples of multimethodology** *(N=31; 22 NAPs)*
1	Expert Workshop	Workshops/ elicitation/ facilitation	16	35%	27	26%		
2	Scenarios	Management/ Strategy	13	28%	21	20%	28%	9.7%
3	Brainstorming	Management/ Strategy	12	26%	21	20%	4%	
4	Stakeholder Analysis	Stakeholder analysis	11	24%	16	15%		
5	Visualization	Visualization	11	24%	14	13%		
6	Statistical Analysis	Quantitative OR	10	22%	15	14%	13%	42%
7	SWOT	Management/ Strategy	10	22%	14	13%	23%	6.5% (SWOT/PEST)
8	MCDA	OR less easily categorized	10	22%	12	12%	6%	9.7% (Decision analysis)
9	Historical Analysis	Historical Analysis	9	20%	17	16%		
10	Facilitated Workshop	Workshops/ elicitation/ facilitation	9	20%	13	13%		
11	Gaming	OR less easily categorized	9	20%	11	11%		
12	CBA	Quantitative OR	8	17%	13	13%	4%	
13	Project Management	Project Management	7	15%	15	14%	6%	3.2% (Project network)
14	PESTLE	Management/ Strategy	7	15%	9	9%	9%	6.5% (SWOT/PEST)
14	Interviewing	General research	7	15%	9	9%		
16	SSM	PSMs	7	15%	8	8%	4%	3.2%
17	VSM	Systems Thinking	6	13%	10	10%	4%	3.2%
18	DES	Quantitative OR	6	13%	7	7%	40% (Simulation)	52% (Simulation)
19	Simulation Modelling	Quantitative OR	5	11%	8	8%		
19	Subject Matter Expert (SME)/ Stakeholder/Team Judgement/Assessment	Qualitative/ Soft OR	5	11%	8	8%		
21	Graph/Network Theory/Analysis	Quantitative OR	5	11%	6	6%		
21	Benefits Modelling	OR less easily categorized	5	11%	6	6%		
23	NPV, Financial Modelling, Cost Analysis/Modelling	Quantitative OR	5	11%	5	5%	11%	
23	[Optimization/ Mathematical Programming/ LP]	Quantitative OR	5	11%	5	5%		32.3% (Maths modelling) 13% (Heuristics/ combinatorial)
				...				
-	Statistical Forecasting	Quantitative OR	3	6.52	4	4%	13% (Forecasting)	16.1% (Forecasting)
-	System dynamics	Systems Thinking	1	2%	1	1%	21%	

Green = Consistent results for method across surveys *Yellow = Scored higher in this survey compared with previous survey(s)*
Orange = Not listed in previous survey (new result) *Red = Scored higher in previous survey(s)*
Ppts = Number of participants including at least one method in at least one example of a recent, multimethod project in question 4
% of ppts = % of participants providing at least one project example *Prjts = Number of project examples with method*
This table only includes (clustered) methods used by 5 or more ppts (>10%), and methods listed in more than 10% of examples in OB and/or MM. See Table 37 (Appendix N) for full details of the clustering of methods. For further details of results in OB and MM, see Table 6 and Table 5, chapter 2, respectively.

Amongst methods included in previous surveys, we found greater use in multimethod projects of brainstorming, MCDA, cost-benefit analysis (CBA), project management, SSM, and VSM. There was proportionally much less use of simulation and system dynamics (only one project example, compared with 11 in OB, where system dynamics was the most listed amongst combinations of more

than two methods), and less use of forecasting. Unlike in OB, in this study there are also project examples that include optimisation, though proportionally far fewer than in MM's more general survey.

However, overall, compared with previous surveys, the examples in this study provide evidence of the use by practitioners of a broader range of quantitative and non-quantitative OR methods in multimethod projects, together with a much greater prevalence of use of methods beyond scenarios, statistics, SWOT, PESTLE (political, economic, social, technological, legal and environmental analysis), and financial modelling. New findings are the extent of use in multimethod projects of expert/stakeholder workshops and judgement, facilitation, stakeholder analysis, visualization, historical analysis, gaming, interviewing, graph/network theory/analysis and benefits modelling. These methods were each listed by 10-35% of practitioners who provided project examples (5 to 16 participants).

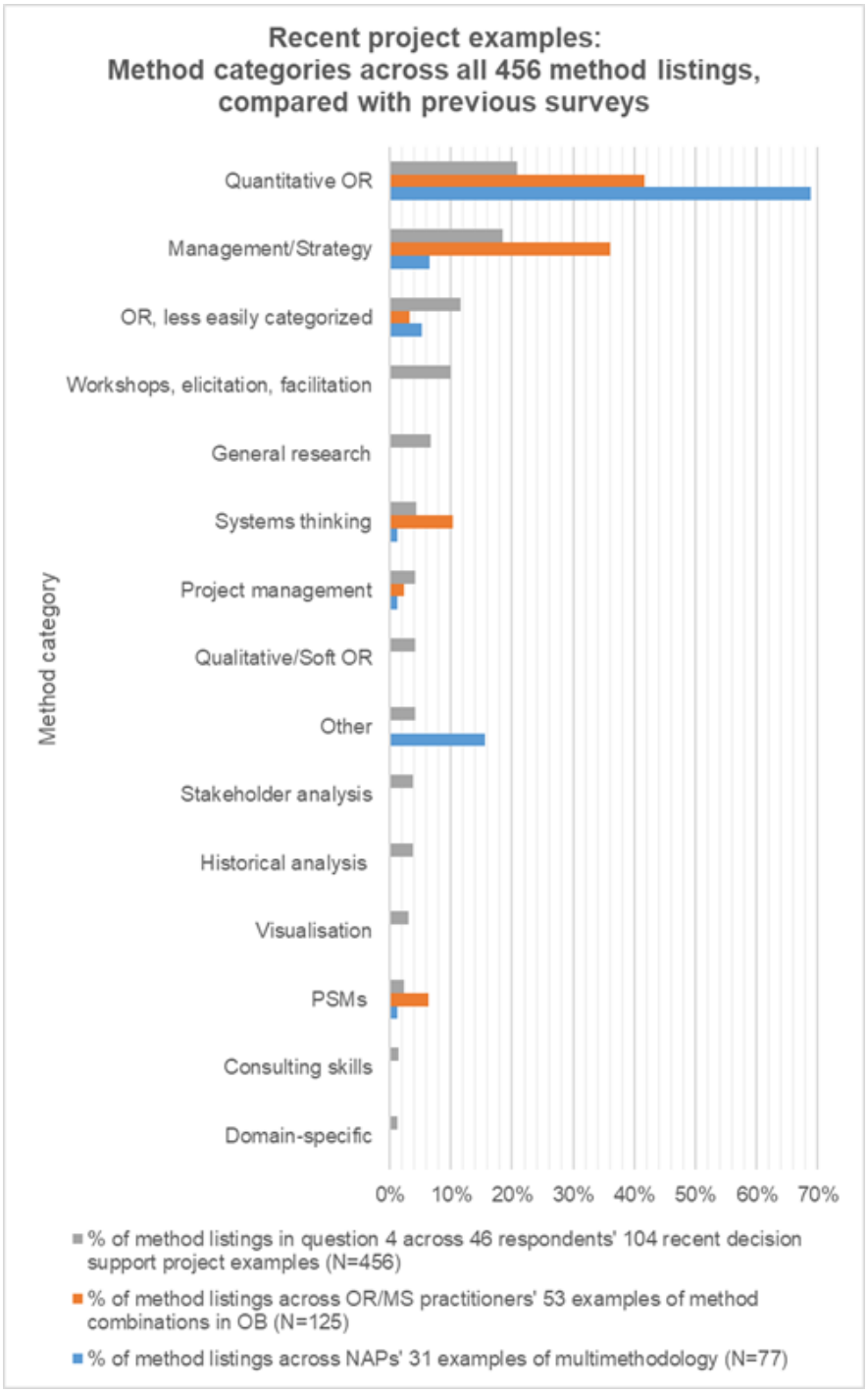
Top methods in project examples by category

To summarize by category, the Quantitative OR methods listed by most participants were statistics, CBA, and simulation; for OR methods less easily categorized, they were MCDA and gaming; and, for Management/Strategy methods they were scenarios, brainstorming, SWOT, and PESTLE. VSM and SSM were by far the most listed across PSMs, Systems Thinking, and Qualitative/Soft OR. The most used methods in other categories were expert workshop, stakeholder analysis, visualization, historical analysis, facilitated workshop, interviewing, and project management (Table 17 above).

All methods in project examples by category

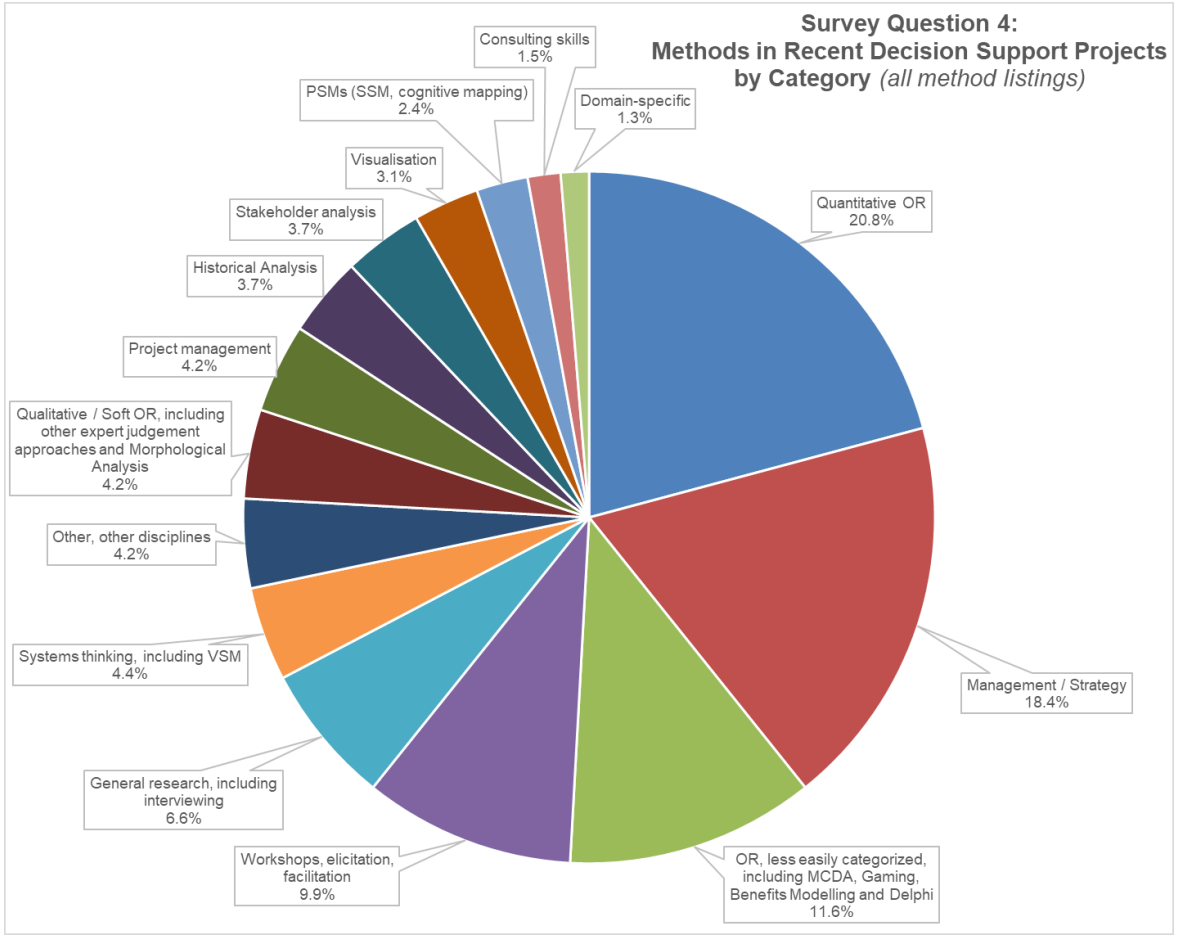
Over half of the 456 method listings were categorized as either **Quantitative OR** (20.8% of method listings made by 74% of respondents providing project examples), **Management/Strategy** (18.4% of methods; 70% of respondents), or **OR less easily categorized** (11.6% of methods; 59% of respondents; Figure 14 below and Figure 13 below; Table 45 and Table 46, Appendix Q). In this survey, the proportions of method listings in the Quantitative OR, Management/Strategy, Systems Thinking methods, and PSMs categories were all around half those in OB (Figure 13 below). However, the average numbers of methods from each category per project were the same or higher compared with OB (Table 45, Appendix Q), reflecting the higher number of methods per project in

this survey (Figure 18 below). Also of note is that proportionally, there were more than three and a half times more listings in OR less easily categorized (mostly MCDA/DA in previous surveys).



Note 1: Full details of method categories are in Table 37 (Appendix N).
Note 2: Percentages calculated for all 456 method listings across all 104 project examples (Table 45, Appendix Q, refers).
Note 3: For method categories by participant (rather than across all 456 method listings), see Table 46 and Figure 50(2), Appendix Q.

Figure 13: Methods in project examples, by category, compared with previous surveys (bar chart)



Note 1: Full details of method categories are in Table 37 (Appendix N).
Note 2: Percentages calculated for all 456 method listings across all 104 project examples (Table 45, Appendix Q, refers).
Note 3: The proportions of methods allocated to each category, and the ordering of categories are very similar with percentages calculated instead for the 321 first instances of each method (cluster) for each participant across the 104 project examples (Table 46, Appendix Q, refers). Key differences are for OR less easily categorized (11.6% of the 456; 13.1% of the 321), Historical Analysis (3.7%; 2.8%), and Project Management (4.2%; 2.8%). Figure 50 (Appendix Q) refers.

Figure 14: Methods in project examples, by category (pie chart)

5.2.5 Methods practitioners combine

Categorizing OR methods – pairs of method categories used regularly

I also allocated the 47 methods in question 1 to method categories and examined pairs of categories that individual practitioners were more (or less) likely to report they use regularly (Appendix P). Regular use of expert workshops (the most regularly used and most frequently combined method) was associated with regular use of six of the seven other top methods in Table 15 above (not SSM), as well as historical analysis. Regular users of Quantitative OR were as likely as regular users of PSMs to use expert workshops regularly. We can contrast this with RFH's distinguishing of PSM users as 'heavily client and stakeholder oriented with much of their work based on facilitation' (p. 9), while noting that expert workshops are only one way in which facilitation is used (cf. French, 2022) – a point we return to below.

54% of all respondents and 50% of regular PSM users used at least one Quantitative OR method regularly. These rates are lower than the two-thirds of RFH's 75 regular 'Decision Support/PSM' toolset users who also regularly used 'Traditional OR' and/or 'Business Analytics' methods (p. 9, Table 4; Christie, 2023). Although RFH included other methods in their Decision Support/PSM toolset, we found that the only other categories of methods that regular PSM users were more likely than all survey respondents to use regularly were: Systems Thinking (primarily VSM), PSMs (particularly SODA and SSM), Stakeholder Analysis, and Project Management. Regular PSM users were also *less* likely to report regular use of historical analysis and the other way around.

Regular users of Quantitative OR reported regular use of at least one PSM at about the same rate as all respondents (31% compared to 33%). But 79% of regular users of Quantitative OR reported regular use of at least one Management/Strategy method. This suggests that as compared with the 46% of regular users of Traditional OR that only used that toolset in RFH, a much lower proportion of respondents in this survey used only Quantitative OR. However, in interpreting these results, we note that Quantitative OR methods in question 1 included visualization (within the data mining/analytics/visualisation cluster), and visualization was one of the most listed methods in the project examples (Table 17 above). In fact, higher use of data mining in question 1 compared with previous surveys may be due to our inclusion of visualization in the same cluster.

Project examples – subject matters, customers, and time available

Unlike previous surveys, for each project example, we requested data on the subject matter, customer, and time available. **Subject matters** are summarized in Figure 15 below. The vast majority were clearly strategic in nature.

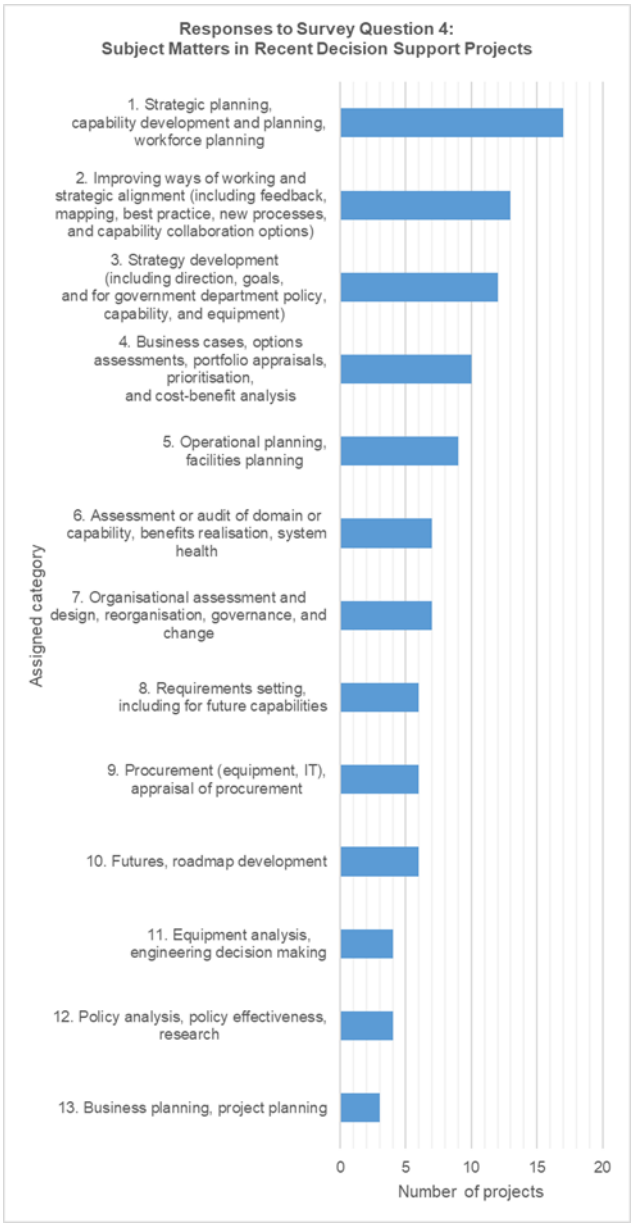
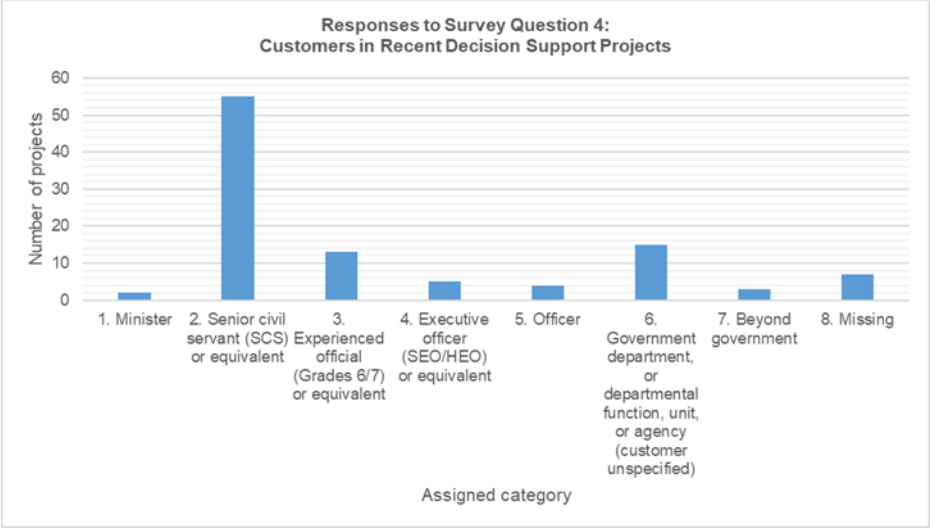


Figure 15: Subject matters in project examples

Project **customers** are summarized in Figure 16 below. Fifty-three per cent of projects had customers in senior civil servant or equivalent UK job grades (Clyne et al., 2023; Institute for Government, n.d.).



Note: '7. Beyond government' refers to intergovernmental and cross-organizational customers, and UK research councils

Figure 16: Customers in project examples

The **time available** for most projects was one month to one year (inclusive; Figure 17 below). For fifteen projects, it was up to 3 years (e.g., for an 'Implications of Policy Analysis' project). The shortest projects had a 'few hours' for 'Project planning' and '6 hours' for 'Requirements setting'. Both involved cognitive mapping (Table 68, Appendix T). The next shortest projects had '1 day' for 'workforce planning' and '2 days' for 'Policy insights'. Project duration was sometimes unclear (e.g., 'Multiple 1-2 week iterations', 'Intermittently over 9 months', 'Ongoing (repeated yearly)'), or changing (e.g., '3 months (which became 2 years)', '1 year (and ongoing for another 6+)', '8 months + 6 month follow on'). Longer projects sometimes involved many methods, but not always, and not

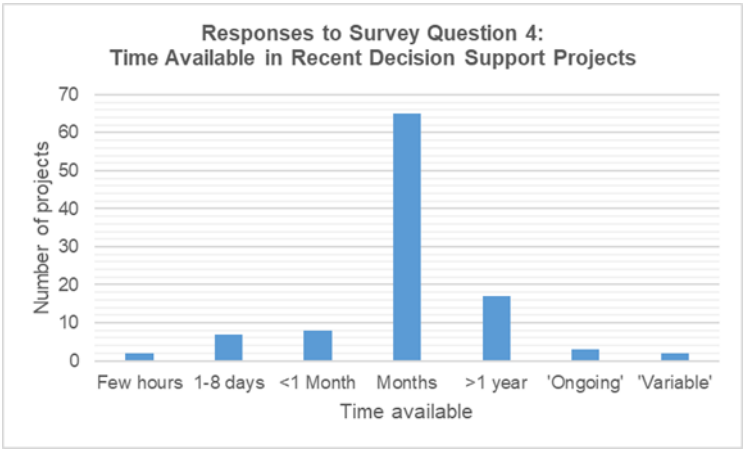
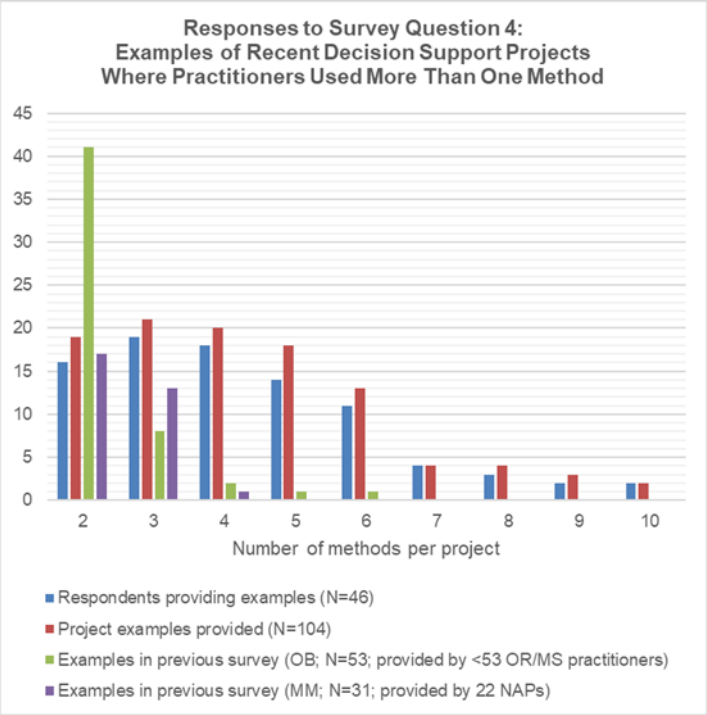


Figure 17: Time available in project examples

exclusively. There were also some concurrent work on multiple projects, part-time work, and secondments to projects.

Methods per project

The most frequent number of method listings per project was three, with a median of four. On average, there were nearly twice as many methods per project (4.4) compared with OB (2.4) and MM (2.5), where the median and mode were 2 (Figure 18 below). RFH did not collect data on single projects, so no results are included in Figure 18 for that survey.



Note: For descriptive statistics, see Table 40, Appendix O.

Figure 18: Methods per project, compared with previous surveys

Overview of projects, by method category and methods

Details of the 104 project examples (subject matters, customers, time available, methods used, and reasons for using more than one method) are included in tables in Appendix T by category and method(s). For an overview, see Table 18 below. Some data are anonymized, with details changed for

reasons of confidentiality. The examples together provide useful insight into a wide variety of interesting – and some potentially original – combinations of methods used by practitioners in supporting strategic decision-making for or on behalf of the UK government, which I analyse further below.

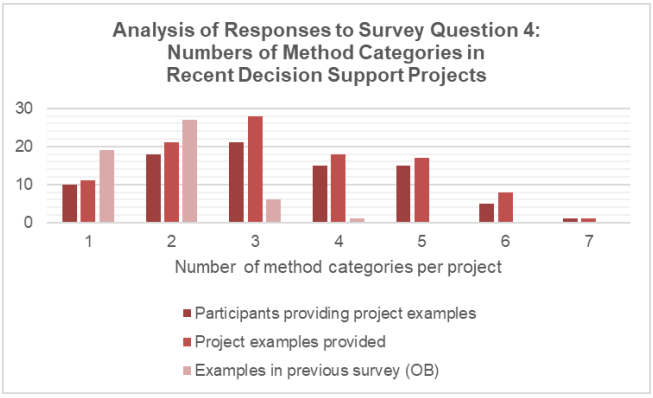
Table 18: Project examples in Appendix T by category and method

Category	Table	Title	Examples	Page
Quantitative OR	Table 55	Project examples with statistical analysis	15	383
	Table 56	Project examples with CBA (cost-benefit analysis)	13 [+ 1]	385
	Table 57	Project examples with DES (discrete event simulation)	7	387
	Table 58	Project examples with graph theory / network analysis	6	388
	Table 59	Project examples with simulation modelling	8	389
	Table 60	Project examples with NPV / financial / cost modelling / analysis	5	391
	Table 61	Project examples with data mining / analytics	8	392
	Table 62	Other project examples with Quantitative OR methods	14	393
OR methods less easily categorized	Table 63	Project examples with OR methods less easily categorized, including MCDA, benefits analysis/mapping/modelling, Delphi, and causal mapping	28	395
	Table 64	Project examples with gaming	11	398
Systems thinking	Table 65	Project examples with VSM (viable system model; including context mapping, ladder of abstraction, causal loop modelling, iceberg model and metaphors)	10	400
	Table 66	Project examples with other systems thinking methods (system dynamics and systems analysis)	3	402
PSMs	Table 67	Project examples with SSM (soft systems methodology)	8	403
	Table 68	Project examples with cognitive mapping (SODA)	3	404
Management/ Strategy	Table 69	Project examples with scenarios	21	405
	Table 70	Project examples with brainstorming, SWOT, PESTLE *[includes Morphological Analysis examples]*	32	408
	Table 71	Other project examples with Management/Strategy methods	12	413
Stakeholder Analysis	Table 72	Project examples with Stakeholder Analysis	16	415
Historical Analysis	Table 73	Project examples with Historical Analysis	17	417
Qualitative/ Soft OR	Table 74	Other project examples (not in other tables), including with other Qualitative/Soft OR methods	7	420

Note 1: The above tables together include all 104 project examples provided by 46 questionnaire respondents.
Note 2: The tables for each of the categories listed in the first column together include all method listings for that category across the 104 project examples, except for the Qualitative/Soft OR category.

Method categories per project

The number of method categories per project ranged from one to seven (inclusive), with a mode and median of three (Figure 19 below; Table 41, Appendix O). Most projects with three or four method listings included methods from three categories. The average number of method categories was nearly double that for the examples in OB, reflecting that in this study there was a wider range of methods (Figure 20 below) *and* more methods per project (Figure 18 above). MM did not report method combinations for NAPs, so no results are included in Figure 20 for that survey.



Note: For descriptive statistics, see Table 41, Appendix O.

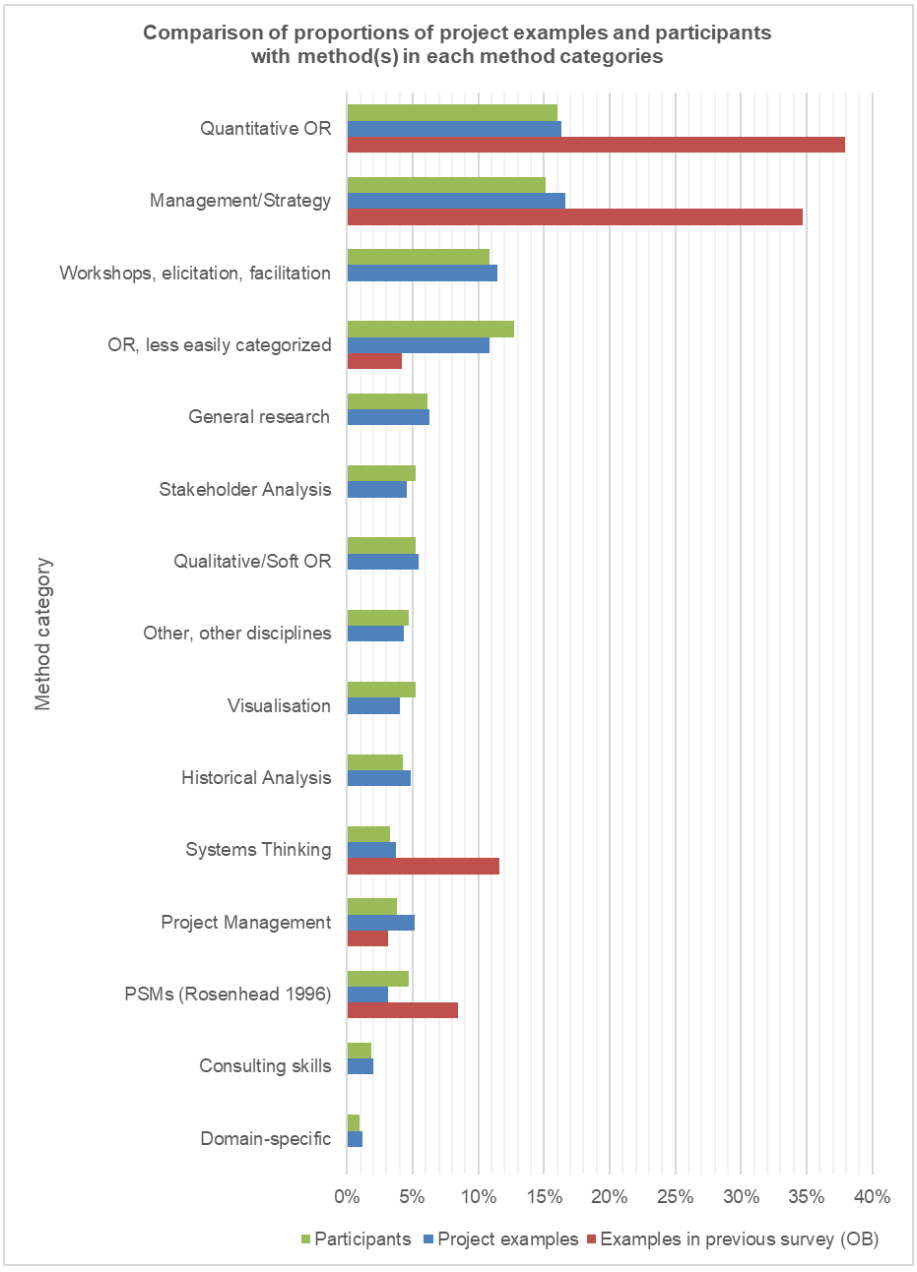
Figure 19: Method categories per project, compared with previous surveys

Method categories in projects with more than six methods

Survey respondents could list up to 10 methods per project. Thirteen projects (12.5%) had seven or more method listings (Figure 18 above). In contrast, in OB, only four examples were of four or more methods, and the maximum number of methods was 6.[36] In MM, only academic practitioners (not NAPs) reported use of more than four methods. Those academic practitioners reported up to nine or ten techniques per example, all so-called 'soft OR' (2002, p. 374). In contrast, the five projects in this survey with nine or ten methods (from three respondents) all included CBA and/or statistics and at least one other Quantitative OR method, and methods from five other categories. They all had senior civil servant or equivalent level customers (Table 55, Table 56, Appendix T). Of the four projects with eight methods (from three respondents), two involved VSM in overall systems/soft approaches (Table 65, Appendix T), and two (from the same practitioner) included analytical hierarchy process (AHP) and benefits modelling – one with historical analysis, and the other with Quantitative OR (stochastic computer modelling; Table 63, Appendix T). The four projects with seven method listings each included Quantitative OR methods and methods from four, three, or one other category (Table 55, Table 56, Table 57, Table 59, Appendix T). These examples are very different from the early examples of multiparadigm multimethodology that MM captured over twenty years ago, and much

[36] Three of the four example projects in OB with four or more methods combined Quantitative OR and Management/Strategy methods. Of those, two also included Project Management, and one also SSM (the combination being balanced scorecard, EFQM, financial modelling, risk management, SSM, and project management). The fourth project had no methods in the Quantitative OR category – the methods were system dynamics and VSM, cognitive mapping, value chain analysis, and Porter's five forces.

more varied than in OB. Overall, then, compared with previous surveys, the examples in this study provide evidence of the use by practitioners of higher numbers of methods per project, together with greater variety and a broader range of quantitative and non-quantitative OR methods in projects with the most methods.



Note: For further details, see Table 46, Appendix Q.

Figure 20: Method categories – proportions of project examples and participants providing them, compared with previous survey

Method combinations, by category

I now provide an overview of the projects in Appendix T, highlighting interesting findings about method combinations, by method category.

Workshops, facilitation, and judgement

We start with the category containing the most regularly used and most frequently combined method – expert workshops. Expert/stakeholder workshops and facilitation, including elicitation (i.e., methods in the **workshops/elicitation/facilitation (WEF)** category; Table 37, Appendix N) were combined with methods from all categories except Domain-Specific (Table 47, Appendix Q). Further, most of the 19 most used methods (listed by >12% of participants; Table 17 above) were listed with stakeholder workshops, facilitation, and/or expert/stakeholder/team judgement (categorized here as Qualitative/Soft OR) in more than half of projects. Only SSM and VSM were not listed with such methods in three or more projects.

VSM and SSM can be used with or without group facilitation techniques (M. Reynolds & Holwell, 2020; C. M. Smith & Shaw, 2019), so I investigated this further. Amongst 10 projects that included VSM, while two participants listed structured workshops or facilitation with VSM, one participant listed no workshops or facilitation in four projects with VSM, but commented elsewhere that in their practice they use facilitation with VSM and rich pictures. Amongst 8 projects with SSM, one included workshops, one included SME interviews, one included gaming and metagaming, and another was the VSM project from the participant that commented that they use group facilitation. In question 1, participants had seen expert workshops listed, but had not been primed with other methods that came to be categorized with it (facilitated workshop, elicitation, and related tools – see Table 37, Appendix N), unless they listed them at question 2. Overall, then, the extent of workshops and use of facilitation, stakeholder judgement, and elicitation in combination with other methods was high, and is likely understated across the project examples, with respondents not always considering or listing them as separate methods.

Visualization

Similarly, **Visualization** was listed in 14 projects by 11 participants alongside a wide variety of other methods (from all categories except Historical Analysis and Domain-Specific; Table 18 above).

Visualization was most frequently listed in the same project as facilitated and/or expert workshop(s) (6 projects, 6 participants; Table 47, Appendix Q), SSM (4 projects, 4 participants; Table 67, Appendix T), interviews (4 projects, 4 participants), and stakeholder analysis (3 projects, 3 participants; Table 72, Appendix T), so apparently mostly for engaging stakeholders.

Quantitative OR methods

We now turn to the methods that are the focus of the tables in Appendix T (Table 55 to Table 74, inclusive; see Table 18 above). Of the 58 project examples in this study that included at least one Quantitative OR method, 47% (by 37% of participants providing examples) included two or more Quantitative OR methods. Quantitative OR methods were then used most often with expert workshops, scenarios, and historical analysis.

I looked for evidence that supported or refuted Howick and Ackermann's conclusion from their (2011) literature review that, 'mixes of quantitative methods tend to address *operational problems*' (p. 507, *emphasis added*). Overall, we could claim in the context of this study (that only sought examples of practice supporting *strategic* decision-making) that the elicitation of *any* projects involving purely quantitative methods would challenge Howick and Ackermann's claim. However, it would seem more prudent to conclude that the evidence generated is inconclusive because: (1) in a few cases where quantitative methods were used together, the subject matter could plausibly be interpreted as more operational than strategic, or was unclear; and, (2) in other cases, we lack details of the nature of methods that may have been qualitative in nature (especially historical analysis and workshops/elicitation/facilitation; Figure 21 below).

Like Howick and Ackermann, we did, however, find a link between the use of **DES** (but not SD, nor simulation modelling more generally) and projects 'with an operational objective' (Howick & Ackermann, 2011 , p. 507), in that it was used in relatively more operational planning projects than other methods (Table 57, Appendix T). We found this was also the case for data mining/analytics (Table 61; Appendix T). More specifically, projects with **data mining/analytics** included relatively more operational planning (category 5, Figure 15 above) than other methods (4/8 projects; 3/4 participants). Like O'Brien (2011), we found a link between simulation and the assessment of options in that the seven projects from six participants with **DES** included relatively more operational planning and options assessments (categories 4 and 5, Figure 15 above) than other methods (4/7

projects; 4/6 participants). **DES** projects also had a more limited range of times available than across all projects – from months to 'A little over a year' (cf. Figure 17 above).

Findings relevant to Howick and Ackermann's (2011) claim that practitioners tend to use quantitative methods for operational issues

1) Two projects in which all methods were categorized as Quantitative OR.
   a) One was a two-year, three-method 'research' project combining machine learning, statistical analysis and statistical forecasting (Table 55, Appendix T).
   b) The second was a 'domain equipment' project for a government department over 'months/years' involving Monte Carlo and deterministic modelling (Table 62, Appendix T).

2) Four projects combining AHP and MCDA (both designated by Howick and Ackermann as quantitative), or Quantitative OR with Historical Analysis (which may be quantitative and/or qualitative), all for senior customers (category 2, Figure 16 above).
   a) One participant contributed two 'Portfolio appraisal' projects in which only AHP and MCDA were used – over two or three weeks (Table 63, Appendix T).
   b) Two 'Operational Planning' projects from another practitioner combined Quantitative OR with Historical Analysis (which may be quantitative and/or qualitative; Table 73, Appendix T). These were a one-week project, and a one-month project, that also involved Statistical Analysis and Project Management.

3) Ten projects in which Quantitative OR or MCDA or AHP was combined with one or two methods in the workshops/elicitation/facilitation (WEF) category, as well as other methods (set out below). These were suggestive of a participative approach to at least some of the modelling. Howick and Ackermann (2011) themselves categorized workshops, like interviews and meetings, as 'forms of intervention' (Table 7), but designated 'facilitated discussion' a qualitative method (Table 1; Appendix B). In this study, none of the ten projects was categorized as operational planning (category 5, Figure 15 above), although the subject matter for one was related to operations (being 'Operational assessment of national capability effectiveness'; category 6, Figure 15 above).
   a) Eight of these projects, with time available from weeks to one year, involved Quantitative OR (with or without historical analysis), or MCDA, or AHP, and WEF.
   b) The other two projects, with days or three months' available, combined Quantitative OR, data visualisation, and WEF.

Figure 21: Evidence on use of quantitative methods for operational issues

In OB, 40% of method combination examples included **simulation**, compared with fewer than 20% of projects and 25% of participants in this survey. In OB, simulation was almost always combined with one closely-related method – either Quantitative OR (especially spreadsheet modelling or CBA/financial modelling, also statistics, forecasting, and risk analysis), or scenario planning. Simulation was also combined in OB with system dynamics and/or influence diagrams, and, in one example, with cognitive mapping. In contrast, we found that across all projects, in addition to Quantitative OR (particularly statistics), **DES** tended to be used with expert workshops and/or gaming and/or Management/Strategy methods (particularly scenarios and/or brainstorming) and/or historical analysis, and with a much higher mean of 4.6 methods per project. Other Quantitative OR methods used with DES were ABM, CBA and linear programming. Similarly, **simulation modelling**

tended to be listed with scenarios and expert workshops and/or gaming, and with historical analysis or MCDA and CBA (Table 59, Appendix T).

The most combined Quantitative OR method in this survey was **statistical analysis** (Table 55, Appendix T). Projects that included statistical analysis were therefore perhaps unsurprisingly fairly typical overall in their ranges of subject matters, customers, time available, and numbers of methods. The proportion of examples involving statistics, and combining statistics with other Quantitative OR was consistent with OB, however the inclusion of data mining (in the methods it tended to be combined with) was new in this survey. Combinations of statistics with forecasting and simulation were also prevalent in MM – and, 'one might argue [they] were indistinguishable anyway' (2002, p. 374). In this survey, statistics was also listed with historical analysis, gaming, brainstorming, scenarios, and MCDA more than other methods. In OB, statistics was also combined with benchmarking, but, overall, only combined with Quantitative OR and/or Management/Strategy methods.

We now highlight two other Quantitative OR methods not included in previous surveys of multimethodology (OB and MM) – graph/network analysis, and data mining / analytics. The examples in this study show particular variety, including both quantitative *and* mixed projects. While the numbers of project examples may seem low, together these two method clusters were included in 13% of project examples provided by 20% of respondents providing examples. **Graph/network analysis** (6 projects, 5 participants; Table 58, Appendix T) was listed with quantitative methods (e.g., optimisation or statistics) and/or qualitative methods (e.g., a Management/Strategy method and/or CATWOE/conceptual or causal mapping), *and* with and without expert workshops, in combinations of three to five methods, with time available from two weeks to one year. **Data mining / analytics** (including machine learning and pattern recognition; 8 projects, 4 participants; Table 61, Appendix T) was used with statistics and/or historical analysis (for data gathering), and, in two projects combining 6 and 10 methods, with a very wide variety of other methods.

OR methods less easily categorized

The 28 project examples in Table 63 (Appendix T), which include **MCDA, benefits modelling/mapping/analysis, Delphi, AHP, causal mapping, fuzzy cognitive modelling, effectiveness analysis, game theory, and pathways analysis**, can be described in three broad

groups. First, in 11 projects, nine practitioners used two or three methods over two weeks to one year, combining these methods with a range of Quantitative OR methods (pattern recognition, DES, risk matrix, and graph/network analysis), expert judgement, balanced scorecard, and General Research methods. AHP and MCDA were used together in a couple of projects (one participant), as were MCDA and causal mapping (with graph/network analysis in one project). The projects in this group were most similar to the four two- or three-method projects in OB that included an OR method less easily categorized. In OB, MCDA was combined with simulation (two projects, one also with system dynamics), and with resource allocation and customer relationship management, and business case analysis was combined with forecasting.

Second, in four projects, from six hours to three years, three practitioners each listed one of Delphi (or elements thereof), pathways analysis, or benefits model, with another three methods, all qualitative and in some cases participative. The exception was 'graphs' in a benefits realisation project that combined 'quantitative management information' with 'more qualitative assessment of benefits' (using a survey and manual text analysis). Third, nine practitioners listed five to ten methods in 13 projects ranging from six months to three years, almost always for the most senior of customers (category 2, Figure 16 above, where specified). In these projects, practitioners stated they combined **MCDA or AHP and/or benefits modelling/mapping or causal mapping** primarily with Quantitative OR methods (CBA or financial/cost modelling, project and programme management methods, statistical analysis and forecasting, simulation modelling, DES, stochastic computer modelling, data mining/analytics, optimisation, mathematical programming, linear programming, and complex bespoke models) and Management/Strategy methods (scenarios, brainstorming, PESTLE, SWOT), expert workshops or expert/stakeholder judgement, historical analysis, and stakeholder analysis, as well as Delphi (in four projects). Overall, these results are consistent with Marttunen et al.'s (2017) literature review on applications of MCDA with problem structuring, in that SWOT/PESTLE, scenario planning and stakeholder analysis were used with MCDA (including AHP) more than other OR problem structuring methods.[37]

Gaming (Table 64, Appendix T) was used in both quantitative and mixed projects, typically (in 9 out of 11 projects) with historical analysis and/or simulation (simulation modelling, or DES with or

[37] We did not find any use of the DPSIR framework (used in environmental assessments).

without ABM), and in eight projects with expert workshops or stakeholder judgement and/or scenarios and/or SWOT. **Historical analysis** (Table 73, Appendix T) tended to be listed with Quantitative OR (simulation, data mining, statistical analysis, deterministic modelling) and/or gaming, MCDA or AHP, and scenarios.

Systems thinking

VSM (10 projects, 6 participants; Table 65, Appendix T) was listed with other systems methods (e.g., context mapping), including SSM (categorized in this study as a PSM), HPM (hierarchical process modelling), Management/Strategy methods (e.g., brainstorming), interviewing, stakeholder analysis, visualization, workshops/facilitation, and in one example with collaboration and problem solving. It was not listed with methods from other categories, including Quantitative OR, nor with MCDA. Half of the projects were concerned with organizational design, reorganization, governance, or change (category 7, Figure 15 above). In contrast, in OB, VSM was listed in two of the 11 projects that included system dynamics. One of these projects also included cognitive mapping, value chain analysis, and Porter's five forces.

The two projects (from one participant) for which the customer was listed as 'Minister' (category 1, Figure 16 above) – 'Policy Analysis' and major departmental change – both involved '**systems analysis**' (Table 66, Appendix T). This was listed alongside Quantitative OR (Data analytics or Risk Analysis), with Management/Strategy (Market analysis or SWOT and Brainstorm) plus psychological analysis, rich pictures (SSM) and data visualization, or policy analysis and stakeholder analysis, respectively.

PSMs

In total, 11 project examples from 10 participants included one PSM (Rosenhead, 1989, 1996); Table 67, Table 68, Appendix T), five of which included one or two Quantitative OR methods. In comparison, in OB, SSM was used in one three-method example with system dynamics and balanced scorecard, and in one six-method example with balanced scorecard, EFQM (business excellence), financial modelling, risk management and project management.

Compared with VSM, **SSM** (including rich picture[s] or CATWOE/concept mapping; 8 projects, 7 participants; Table 67, Appendix T) was arguably used with a broader variety of methods, as it was in

OB, including VSM, stakeholder analysis, and visualization. In OB, proportionally, SSM was used in half as many projects as this study. In this survey, SSM was listed in projects with the most senior customers (categories 1, 2, and 7, Figure 16 above); whether they participated in SSM activities is not known. In one example of methods used together to support decisions regarding the development of a national capability, a multi-disciplinary approach involved using SSM with stakeholder analysis, historical analysis / literature search, data analysis (data from training), simulation modelling, gaming and metagaming over periods from months to two years for senior customers. **Cognitive mapping** was used in one project with a spreadsheet and Gantt chart, while in OB it was used in two projects – one with simulation, and the other with VSM (see above). In this study, SSM and cognitive mapping were never listed in the same project.

5.2.6 Forms of multimethodology practitioners use

The survey questions on forms of multimethodology were removed following the pilot, however, 23 participants provided comments that suggested they used methods sequentially over time, or in different project stages or steps (Table 54, Appendix S). Often this involved the use of output from one method as input for another (Bennett, 1985; Schultz & Hatch, 1996), including the use of insights from one method to inform or scope subsequent modelling. This included examples of problem structuring followed by modelling using another method (Design 1 in Christie, 2023, after Woolley & Pidd, 1981). However, most participants referred to the need to use different methods in successive steps in order to deliver different and/or final project outputs and outcomes, with one adding,

> Methods are combined because there are usually multiple strands to the problem. This is not optional or to get synergies between methods, it's because it's essential to working through the problem. (question 10 [q10])

One practitioner used methods in sequence on more of a 'trial and error' basis to build understanding and reach a solution.

Other forms of multimethodology revealed in survey data included: parallel use of methods and tools with workshops, including in a 'mix and match' way, and 'as thinking tools to enquire of the group [when facilitating]' (q5; one practitioner), and of 'simpler decision tools' with scenario gaming (one practitioner); and, use of the eternal triangle from CSH when rich picturing and brainstorming, 'to think through why people are behaving in a particular way' (q1, CSH).

One participant noted they did *not* tend to use methods in sequence, but 'in combination according to need':

> I never use a single method. As a consultant, my primary focus is helping my client develop a better understanding of their problem and the routes to address it. Such problem spaces are complex or wicked, and require viewing from multiple angles, through multiple lenses, to understand them and potential responses. Single tools do not have the breadth, range or specificity necessary. [...] *I generally don't use them individually in series* **[...]** *but in combination according to need - for example, a combined context map and PESTLE to explore the external environment* [...] (q8, *emphasis added*)

For example, they explained their use of multiple methods in one project as:

> [...] capture of understanding of the system through *iterative stakeholder mapping and 1-1 engagement through interview*; system representation through VSM and RACI [responsible, accountable, consulted, and informed analysis]; health scoring through structured stakeholder workshops, Italian flag scoring, elicitation and capture of rationale for scoring. (q5; *emphasis added*)

Iterative use of methods was also noted by another practitioner:

> The methods can be complimentary and help you look at a problem through [...] different lenses to discover different aspects or cover different parts of the problem space e.g. as consultants we are seeking to understand the problem, structure it so that we can reflect it back to our customer in some sort of order and then identify a way forward. *Thus we use different tools in different parts of that process but often iterate. e.g. Laddering and SSM questions help you to identify whether you are studying the right problem to start off with.* [...] (q5; *emphasis added*)

RQ2. WHY DO PRACTITIONERS TAKE THESE APPROACHES, MULTIMETHODOLOGICAL OR OTHERWISE?

I respond to the second research question (RQ2) by presenting findings on reasons why practitioners use particular methods and why practitioners use multimethodology. First, I provide an overview of themes (section 5.2.7 below) and then review the themes in detail (section 5.2.8 below).

5.2.7 Overview of themes

Whereas Munro and Mingers (2002) asked their respondents how and why they used a particular set of methodologies in an intervention, we asked practitioners in question 5 why they used more than one method in their project examples. Responses to question 5 were provided by all 46 participants who provided project examples in question 4, and three other respondents. We then asked participants in question 8 to explain their ratings of average project success for (1) single method and

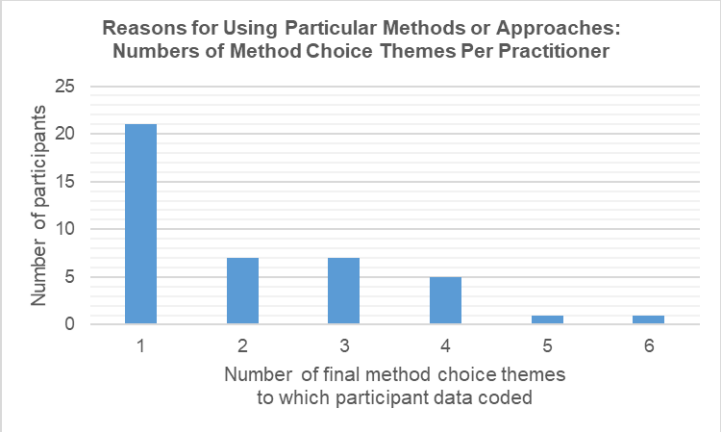
(2) multiple method projects. This led to insights into both their reasons for using particular methods, and their reasons for using multimethodology.

Following piloting, practitioners were not asked how or why they had chosen particular methods. However, in explaining their project examples, and elsewhere in the questionnaire, many participants included reasons. In the first coding cycle (see section 4.6.7 above), I coded these data to 'Method choice'.

One participant commented on what some methods in question 1 are more or less 'useful' for, and how the methods had been used in projects they had *observed*. This provided interesting contextual data. Other participants briefly stated functions of methods they named, probably to explain which method they were referring to (e.g., 'Q Method (Differing stakeholder issues analysis)'). I did not consider these data practitioners' reasons for choosing or using particular methods in their own projects.

As anticipated, there was some overlap between reasons for using particular methods and reasons for using multimethodology. Careful review of and across the data was required. For example, a need to undertake problem structuring could be considered a rationale for multimethodology, however, it may simply be a reason for using *a* method for problem structuring. Accordingly, I analysed themes across data fragments with a mind to context, participants, questions, and the sets of methods, approaches, and projects of which they were part. Maxwell (2022b) refers to these as 'virtual and actual relationships' between data (p. 151). I used the 'Dataset' view in NVivo, and referred to all data for particular participants as I analysed their data fragments. I reviewed and clustered themes to reduce overlap and ensure each one was distinctive.

From the thematic nodes constructed in the second coding cycle under 'Method choice', I generated and refined **eight themes** with data from 42 participants (Table 19 below; for illustrative data, see Table 48, Appendix R). There is considerable variety in the number of reasons each practitioner gave for using particular methods. Half of the 42 practitioners provided one method choice reason, while the other half provided up to 6 reasons (Figure 22 below). The mean number of themes per practitioner was 2 (median=1.5; Table 42, Appendix O).



Note 1: The total number of final method choice themes was 8.
Note 2: For descriptive statistics, see Table 42, Appendix O.

Figure 22: Method choice themes per practitioner (N=42)

From the thematic nodes constructed in the second coding cycle under 'Why multimethodology' (see section 4.6.7 above), I generated and refined **nine themes** across the different, interrelated rationales participants gave for using more than one method in their projects (Table 19 below; for illustrative coded and contextual data, and counts of participants, question responses, project examples, and data fragments, see Table 52, Appendix S). Percentages of participants whose data was used in building each theme, and percentages of project examples the data related to, are illustrated in Figure 23 below. Reasons are also listed by project example in the tables in Appendix T.

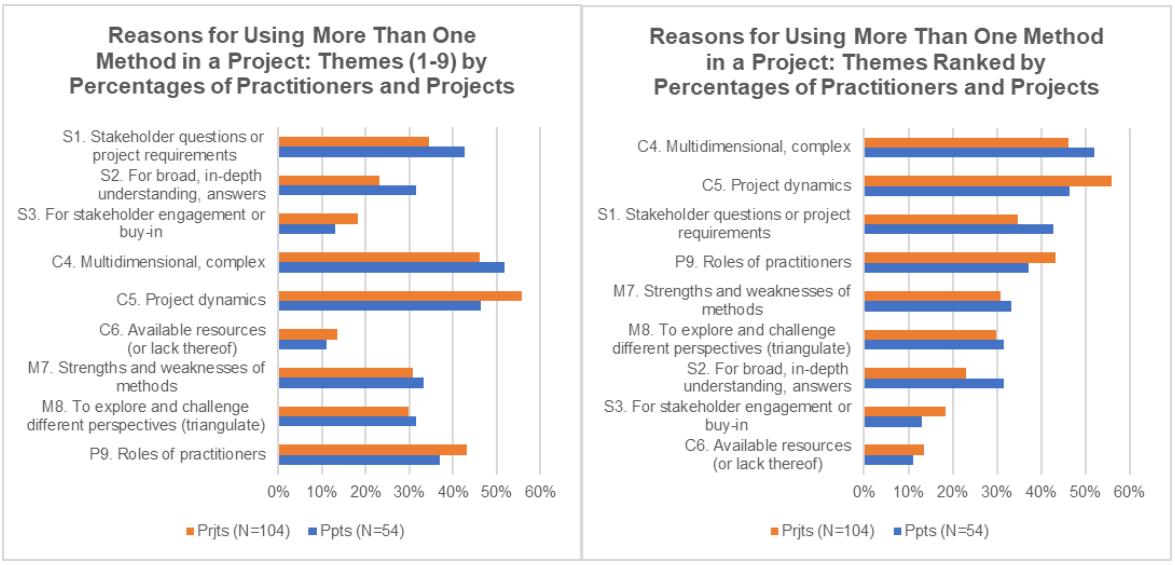


Figure 23: Practitioners' reasons for using multiple methods, by practitioners and projects

Practitioners' reasons for using particular methods (referred to as method choice themes), and for using multimethodology (referred to as multimethodology themes), are summarized by intervention element (defined in sections 3.4.3 to 3.4.6 above) in Table 19 below.

Table 19: Practitioners' reasons for using particular methods, and for using multimethodology

INTERVENTION ELEMENT	**THEMES**			
	Practitioners' reasons for using a particular method (method choice themes) *(Note 1)*	***Ppts*** *(N=42)*	**Practitioners' reasons for using multimethodology** (multimethodology themes) *(Note 2)*	***Ppts***
AVAILABLE METHODOLOGIES AND METHODS (M)	1. Particular method or multimethod or type of method in order to... ...understand or consider or define project scope and/or requirements, or issues for analysis and/or methods (at outset or during project) [5 ppts] ...identify, gather, and generate data needed for analysis [6 ppts] ...visualise and engage with stakeholders [4 ppts] ...analyse data [14 ppts] ...manage project progress or budget or risk [4 ppts] ...explore or structure a/the problem / problem space (with group of stakeholders, or otherwise) [7 ppts] ...develop understanding (with, without, amongst, and of project stakeholders) [9 ppts] ...elicit information / expertise / understanding / ideas from experts / stakeholders [6 ppts]	*26*	7. Strengths and weaknesses of different methods and tools	*18*
			8. To explore and challenge different perspectives (triangulate), and to test insights (for validity), for balance, sufficient representation, rigour and robustness	*17*
INTERVENTION CONTEXT (C)	2. Project or problem(s) or situation	*15*	4. Multidimensional, complex problem or problem space, project or analysis	*28*
			5. Intervention dynamics – project phases, or parts of analysis project, or iterative or emergent approach	*25*
	3. Resources, including available technology, time and funding, guidance and processes, knowledge, and data, or lack thereof	*13*	6. Available resources (or lack thereof), including technology, time, budget, and data	*6*
PRACTITIONERS (P)	4. I or we tend to use or most studies or I practice these methods	*9*	9. Roles of practitioners, including their ways of working, histories, tendencies, and specific methodological approaches	*20*
	5. History of use and familiarity of method (avoiding risk)	*9*		
	6. Appropriate for project/customer/problem/question	*6*		
	7. Name or source of method as unimportant	*3*		
STAKEHOLDERS (S)	8. Stakeholders	*6*	1. To respond to stakeholder questions or project requirements, or produce a range of outputs or activities	*23*
			2. For broad, in-depth understanding, and well-rounded, rich and complete answers	*17*
			3. For stakeholder engagement or interest or relevance or buy-in	*7*

Note 1: Illustrative data are in Table 48 (Appendix R).
Note 2: Illustrative data, and counts of participants, question responses, project examples, and data fragments, are in Table 52 (Appendix S).
Ppts=number of participants who provided data contributing to theme/sub-theme

5.2.8 Review of themes

I now describe the method choice and multimethodology themes, and interesting features of the data, by the following intervention elements from chapter 3: available methodologies and methods (M); intervention context (C); practitioners (P); and stakeholders (S).

Available methodologies and methods (M)

The most common theme by number of data fragments was '**Particular method or multimethod or type of method in order to…**'. These data, provided by 26 participants, and relating to 46 project examples (provided by 23 participants), described purposes or functions (e.g., 'Cognitive mapping [elements of] to develop goals and constituent activities', or 'Statistical Analysis for hypothesis testing'), or implied features of particular methods that explained why respondents had used them (e.g., 'Gaming was used to produce rapid results early'). Sub-themes are listed in Table 19 above; the methods they relate to are in Figure 53 (Appendix R). Some participants gave reasons relating to multimethods (e.g., two or three methods within a project that they used together) or types of method (e.g., soft OR, or PSMs, or their own repertoire of methods). However, methods are listed separately in Figure 53 (Appendix R) as the reasons practitioners gave were applicable to each method.

The only description – across all questionnaire responses – of **use of a theoretical framework for method choice** is within the sub-theme, 'to understand or consider or define […] methods (at outset or during project)'. Two participants reported using a particular method to consider which methods to use in their projects. The first used **brainstorming**, 'with other team members for longer-term studies to consider options and methods and potential case studies etc. […]' (q5). They used brainstorming with data mining, historical analysis, statistics, and project management in two of their four project examples – where the time available was three or four months, and the subject matter was 'Strategic Planning'. They did not use it in their one-month and one-week 'Operational Planning' projects. The second participant reported regular use of the **Cynefin** framework (French, 2013; Snowden & Boone, 2007) to assess how successful methods may be for particular projects or problems (q2i). However, in their project examples in question 4, no respondent listed Cynefin, nor any other theoretical framework (including those in question 1; Table 51, Appendix R).

Moving to reasons practitioners gave for using multiple methods, one third of participants (18/54), including 35% of those who provided project examples (16/46), made statements that suggested they used multiple methods, **'Because each individual method has strengths and weaknesses'** (q5), or that different methods were 'complementary'. This theme was related to 34% (32/104) of project examples, and some responses implicated strengths and weakness of specific methods within those, for example, 'Engineering models cannot model the complexity of all the interactions. The hi-fidelity models take too long to run. All models have to be validated against trials, operations and experiments' (q5). Some participants discussed strengths and weaknesses more generally. For example, one participant used multiple methods (a benefits model, graphs, a survey, and manual text analysis) because, 'Benefits realisation [the subject matter] needed to combine quantitative management information and more qualitative assessment of benefits' (q5).

Perhaps unsurprisingly, nearly all data fragments coded to this theme describe strengths and weaknesses of methods relating to other themes. Different methods had strengths and weaknesses in supporting different outputs or activities (as in the examples above), or for practicalities, such as time required to use them (as in the hi-fidelity models above), 'to discover different aspects or cover different parts of the problem space' (q5), 'to investigate multiple strands of inquiry' (q8), or in different intervention steps or phases. For example:

> We often go through several steps, such as generating ideas and then analysing or rating them in some way, before trying to come up with agreed ways forward. Different tools and methods have strengths in each of these steps. (q5)
>
> [...] when you are dealing with lots of uncertainty (especially) then one method might elicit understanding and knowledge that then allows you to redo the analysis with a better OR technique. [...] (q8)

There was considerable overlap with the triangulation theme, **to explore and challenge different perspectives (triangulate), and to test insights (for validity), for balance, sufficient representation, rigour and robustness**. The triangulation theme is based on responses from 31% of participants (17/54), including 24% (11/46) who provided project examples. It relates to 30% (31/104) of project examples. Additional methods, including statistics and experiments, were used by practitioners to validate or test models and insights from analysis, to explore or challenge different perspectives in building and analysing evidence, to balance quantitative and qualitative insights, provide sufficient representation (in models), and for robust, rigorous, or generalizable findings for

clients, given uncertainty and multiple angles. One participant suggested triangulation was necessary in all projects:

> [...] *there is always a need to 'triangulate' and hence to generate views from differently founded perspectives*, remembering that all models (was that methods in the detail of their application are in at least some senses) are wrong but some are useful. [...] (q5, *emphasis added*)

Intervention context (C)

Fifteen participants linked the choice of particular methods with the nature or requirements of the **project or problem(s) or situation**. This is a broader theme than Munro and Mingers' (2002) *unreflective* category, which mostly captured the use of 'hard OR/MS' methods 'required' to solve defined problems (p. 376).

Around half of all questionnaire participants (28/54; 52%), including 46% (21/46) of those who provided project examples, implicated a **multidimensional, complex problem or problem space, or project or analysis** as a reason for using multiple methods. These practitioners needed to use more than one method because of the 'complex' nature of the 'analysis project', 'problems' or 'problem spaces', or 'questions', or particular domain issues that they addressed, and/or they explained their use of multiple methods across multiple dimensions. Different methods were used for different parts of problems or project strands, different 'aspects of the problem space' or other factors, as 'lenses', and for different knowledge, and stakeholder understandings, agreement, or action. Multidimensional analysis involved multiple disciplines, levels, models, viewpoints, or understandings, or qualitative and quantitative analysis. Some participants described a need to structure and shape complex problems that may be solved with another method. Issues were described as complex, messy, wicked, strategic, systems level, conceptual, or subjective.

Nearly as many questionnaire participants (25/54; 46%), including 39% of those who provided project examples (18/46), implicated **intervention dynamics – project phases, or parts of analysis project, or an iterative or emergent approach** as a reason for using multiple methods. This theme brings together aspects of the *process* or *dynamics* of practitioners' projects. Different methods or tools were used in different intervention stages or phases, or steps, or layers, or parts, in moving towards solution or an end point or advice, and, for one participant, 'often iterate'. Practitioners referred to use of a range of methods as an understanding of the problem area emerges.

This may involve divergent and convergent phases - to build evidence or understanding or options and then later to reduce scope or options or move towards action, and/or review of issues and outputs by experts.

Like one or two participants quoted in OB who implicated 'resources available' and 'software' (p. 912) in method choice in the context of multimethodology, 13 participants in this study implicated **resources**, including available technology, time and funding, guidance and processes, knowledge, and data, or lack thereof, in their and their colleagues' method choice. Further, six participants, with reference to 14 project examples, implicated resources in choosing to use multiple methods. Participants reported constraints in terms of time, tools, or data available to them (e.g., 'To enable the most effective approach to the problem at hand, taking into account the data available' [q5], or, 'The hi-fidelity models take too long to run' [q5]). One participant combined methods in exploiting technology opportunities ('The move is of greater on-line real time analysis with live feeds for decision support' [q10]). One participant included project management in three of their four project examples 'to maintain personal oversight of budget allocated spend' (q5).

Practitioners (P)

Nine participants described **tendencies to use particular methods or types of methods** in their practice or most of their projects. These were methodological approaches – particularly, but not exclusively, non-quantitative OR – associated with their experience, the types and stages of projects they worked on, and their personal backgrounds, skills, and day-to-day roles or organizational membership. As in Ackermann and Howick (2022), the work of practitioners in this study tended to involve teamwork, as well as supervision, as captured in an email from one participant which stated, '[…] within the programme that I support [I am] simultaneously technically responsible for 20 tasks to the level that I am content that the philosophical and practical content of the work are being appropriately delivered […]'. One participant expressed concern that practitioners were 'methodologically entrenched' (q10). Relatedly, nine participants suggested they choose methods they are **familiar with from previous use**, with most suggesting 'the need for delivery often discourages risk taking in this regard' (q10).

Six participants suggested they use methods that are '**appropriate'**. This theme is somewhat similar to Munro and Mingers' (2002) *tacit* approach to method choice in that practitioners play a role in

judging the suitability of particular methods, drawing on their experience. However, the six practitioners in this study referred specifically to appropriateness for the question or project or customer and/or problem (or part thereof), and between them, four of the six participants also provided data supporting all the other themes, with, at most, two of these four participants providing data for any one of the other themes (Figure 52, Appendix R). Three participants made interesting comments about the **lack of importance of the names or source of methods**, reminiscent of, but different from, the comment from one participant in O'Brien's (2011) survey, " . . . I have absorbed so many different techniques that I cannot now remember their origins" (p. 912).

Roles of practitioners, including their ways of working, histories, tendencies, and specific methodological approaches were also implicated in responses from 37% (20/54) of participants as explanations for using multiple methods. Participants described always using multiple methods, or nearly always, given the type of work they did, or not trying or being able to do their job otherwise. One participant reported they 'Routinely use multiple methods' for 'complex problems', while another suggested 'more often than not it is natural [to] use several [methods] even if in making the decision as to which to purse for the core analysis'. Further, four participants, who together reported use of a broad range of methods, each reported a tendency themselves, or within their organization or team, to use a particular combination of methods. Four of them used the method combinations for particular types or parts of projects (problem structuring [q5], group facilitation [q5], questions about capabilities [q5], and projects involving historical analysis [q8]), while one, 'chose an appropriate technique to answer each element' from their short list (q10). (I identified further examples of tendencies to use similar combinations of method looking across projects from the same participants in their project examples in question 4.) Finally, within this theme, four participants implicated their experience of previous projects or problems, and what methods or tools or approaches 'work' and are 'more useful', in their decisions to use various, multiple methods.

Stakeholders (S)

Six participants implicated decision makers or customers in other ways in method choice, including access to them (Ormerod, 1997a), and their understanding, as well as expectations regarding future behaviour of decision makers and other **stakeholders**. All of these six participants also implicated the nature or requirements of the project or problem(s) or situation (method choice theme 2) and at

least one other theme (Figure 52, Appendix R). However, participants were much more likely to implicate project stakeholders (other than themselves) in using multiple methods, to the extent that I generated three multimethodology themes for the intervention element, stakeholders (S).

The first theme, **to respond to stakeholder questions or project requirements, or produce a range of outputs or activities**, built on responses from 23 participants (43%) and relating to 36 project examples (35%), highlights that single methods were insufficient to respond to intervention stakeholder questions or project requirements. Multiple methods were required in single projects because of 'customer' or 'client' or project 'requirements' or 'questions' (or 'problems'), or to produce or support a range of 'outputs and outcomes' or activities, across different disciplines, or organizational functions, or intervention phases. Activities included problem structuring, knowledge elicitation, communication, and stakeholder participation, engagement, understanding, options, and possible actions, many of which are captured separately within other themes below. However, while other themes capture reasons for having to address multiple questions or deliver multiple activities or outputs in a single project, this theme captures that practitioners needed to use multiple methods to respond to stakeholders' questions and/or requirements.

Participants associated some methods with particular outputs or activities, including where they listed different purposes or functions across the different methods in their project examples (Figure 53, Appendix R). For example, two participants, who together provided five project examples in question 4, referred in question 5 to the inclusion of a particular method (scenario building) or a specific method combination (cost-benefit analysis and effectiveness analysis) as required for policy compliance and quality assurance. Some methods did not correspond to outputs or activities on a one-to-one basis, for example where practitioners used methods together, 'To tailor the method to the [stakeholders' particular] problem' (q5), or because of a 'need to adopt a multi-disciplinary approach [...] to represent [... a particular] capability sufficiently' (q8).

The second theme, **for broad, in-depth understanding, and well-rounded, rich and complete answers**, built on responses from 17 (31%) participants and relating to 24 (23%) project examples, captures participants' concern with the *quality* of their answers to their customers' questions. Participants needed to use multiple methods to understand issues in detail, from multiple perspectives, and to provide balanced, thorough, actionable responses. By adding methods,

practitioners could explore whether there were other answers, generate additional insights and decision options, and (then) consider possible actions and plans, including with stakeholders. Practitioners used additional methods to generate additional evidence from multiple perspectives, for credibility, robust answers, and to support more robust decision-making or planning. Within this theme, three participants specifically referred to using qualitative *and* quantitative methods, or hard *and* soft techniques. Two practitioners explicitly mentioned uncertainty and/or risk analysis or mitigation across methods in their project examples. One participant working in soft OR noted a 'need to include soft ['facilitation and consultancy'] skills if you want well-rounded, rich and complete answers' (q10).

In the third theme, seven participants reported that they used multiple methods **to support or facilitate stakeholder engagement, achieve buy-in, or take into account stakeholder views**, for example, 'To access diversity of viewpoints, *keep audience interested/engaged*, challenge problem from different perspectives, *make outputs more relevant to customers*' (q5, *emphasis added*). These participants' related project examples mostly included workshops and/or visualization and/or stakeholder analysis. Two participants reported using multiple methods (or tools) to generate or analyse data for visualization (e.g., a sunray diagram [q5]) to engage stakeholders. One used PivotTables, then Tableau for data visualization, then stakeholder engagement tools in structured workshops, explaining their use of multiple methods as, '[…] A range of tools to analyse data, visualise it in a way accessible to stakeholders, and allow them to engage with it to develop option spaces […]' (q5). One practitioner considered the need for an approach to stakeholder engagement in addition to the tools they used:

> Tools in and of themselves rarely in my experience 'work', and definitely not in isolation. *It is important to use an approach that will work in the circumstances and achieves buy-in from customers/end users. This I would class as a soft systems approach.* (q5, *emphasis added*)

One practitioner implicated stakeholder views in another slightly different way – taking them into account when they chose to use multiple methods, 'To enable the most effective approach to the problem at hand, *taking into account* the data available and *the stakeholder views*' (q5, *emphasis added*).

5.3 CONCLUSION

The survey was a response to the need to explore in more detail, across OR practice, the issues that practitioners' address in multimethod projects, and dimensions such as who their clients are, and time available, as well as particular method combinations (Ackermann & Howick, 2022; Hopes, 2021; Howick & Ackermann, 2011; Ranyard et al., 2015). Like Ackermann and Howick (2022), though in a different way,

> ... the work described in this paper sought to understand mixed methods through the lens of the practitioner – teasing out and appreciating not only the 'what' (methods to be mixed), but 'how' (the nature of their combining), 'where' (the problem situation), and 'who' (clients, stakeholders, modellers) to gain generalised insights that could be of benefit to those seeking to undertake mixed methods OR interventions. (p. 1907)

For this doctorate, the findings in this chapter also provide a useful first indication of knowledge and experience of methods amongst practitioners who support strategic decision-making for or on behalf of the UK government.

Practice in non-academic settings has long been underreported (Christie, 2023; Ranyard et al., 2015), and in the absence of a more recent IFORS survey, this chapter has provided new evidence of the prevalence of multimethodology, methods used, the extent of their use in multimethodology, methodological approaches, and practitioners' explanations thereof. This included key dimensions of 104 of practitioners' multimethod projects (Table 18 above), reflecting a wide variety of combinations of methods. This chapter is therefore a first step in narrowing 'the gap between academic research and practice' (Ranyard et al., 2015, p. 12, following Ackoff, 1979; Corbett & Van Wassenhove, 1993; G. C. Jones, 1993), specifically in relation to OR practice supporting strategic decision-making in government. This study has also provided empirical justification for theories of method choice and multimethodology that foreground the selection of methods according to what practitioners seek to achieve, and that highlight numerous other influences of the intervention context.

Howick and Ackermann (2011) suggest that in-depth, semi-structured interviews with practitioners should reveal more regarding the *process* of choosing combinations of methods. We shall follow this up in the next chapter with in-depth study of a small number of projects. As in this chapter, we shall explore practitioners' stated reasons for using particular methods, and for using more than one method in an intervention, and then go further by seeking to explain why with causal analysis. This

will also present the opportunity to explore in more detail some of the results in this chapter, including why practitioners did not use PSMs more extensively, despite their association in OR literature with addressing strategic issues.

6 MULTIPLE CASE STUDY

6.1 INTRODUCTION

In this chapter, I report results of my multiple case study from interviews, field notes, and secondary data (as introduced in sections 4.7 to 4.12). I respond to the following research questions using the results of in-depth, comparative study of five interventions:

RQ1. How do OR practitioners choose and combine OR methods to support strategic decision-making?

RQ2. Why do practitioners take these approaches, multimethodological or otherwise?

Like the survey in the previous chapter, this multiple case study was a response to the need to explore in more detail, across OR practice, and particularly in non-academic settings, issues that practitioners' address in multimethod projects, and dimensions such as who their clients are, as well as methods used and method combinations (Ackermann & Howick, 2022; Hopes, 2021; Howick & Ackermann, 2011; Ranyard et al., 2015). This study also presented an opportunity to explore in more detail some of the survey results, including a lack of use of problem structuring methods. Moreover, I sought to go further than the survey by adopting a multimethod approach that included insights from a range of intervention stakeholders and documents, and by seeking to explain the *process* of practitioners' methodological decisions using structural and causal analysis of the cases. I aim towards a more theory-informed, causal understanding of why practitioners use the methods they do, and why they use (or do not use) multimethodology. The chapter is organized as follows. First, I introduce the cases and their key dimensions (subject matters, time available, stakeholder roles, and phases). I then respond to the research questions (RQ1 and RQ2).

6.2 RESULTS AND ANALYSIS

6.2.1 Introduction to the cases

> While the planning and design of case studies are important before the field is entered into, the data is often somewhat unwieldy and full of generous surprises. In this situation, it is important to be able to rethink *of what* one's work is a case as part of the research process (Lund, 2014, p. 224, *emphasis in original*)

The cases were current or past interventions in which practitioners used methods to support strategic decision-making for or on behalf of the UK government.

6.2.2 Subject matters

All five cases involved review of one or more pre-existing national capability (Figure 10, chapter 4). In the context of organizational strategy, a capability is defined as, 'the combination of processes, tools, skills and behaviors, and organization that delivers a specified outcome' (PwC, n.d.). National capabilities include UK Government organizations and groups (UK Government, n.d.), and parts and subsets thereof. Cases 1 and 4 were about organizational design and governance of a capability (category 7, Figure 15, chapter 5), while case 1 also involved supporting a business case for future investment in a capability (category 4). Case 2 was about investigating ways of working (organizational processes) within a capability (category 2). In cases 3 and 5, practitioners supported strategy development (category 3). In at least three of the cases, past projects had addressed similar issues, albeit in different circumstances (see section 4.7.2 above). In four cases, practitioners were to provide analysis as part of a wider project (for the compilation of a wider project report or body of evidence that also addressed other aspects) and/or practitioners' analysis was to be considered as part of making decisions on wider strategy of a government organization or programme.

6.2.3 Time available

The time available was in all cases within the range for most projects in the survey (Figure 17, chapter 5). At the outset of each of the five interventions, at least some months were available to practitioners for their work. In the event, in all cases, project duration appeared to change, with practitioner interviewees tending to work on each of the interventions and/or wider projects for around 18 months.

6.2.4 Stakeholder roles

> In concrete circumstances it is, of course, only the person who acts, though we will normally have to explain what they do in terms of the various social roles they are participating in and/or transforming. (Bhaskar, 2016, p. 68)

Stakeholder roles from across the cases, grouped by organizations they relate to, are listed in Figure 24 below, which is a consolidation of stakeholder roles from across the five case stakeholder

diagrams (Appendix L). In each case there was a subset of the roles shown in Figure 24. For examples of UK Government organizations, see UK Government (n.d.). ***Intervention roles*** included clients, decision makers, and practitioners (or interveners), as well as quality assurers, managers and organizational leaders with responsibility for overseeing practitioners' work. For analysis projects, UK Government guidance distinguishes between the related responsibilities of 'commissioners, analysts and analytical assurers' (HM Treasury, 2015, pp. 7-8), which are broadly equivalent to clients, practitioners, and assurers ('Reviewers' and 'Assurance specialists') in this dissertation. As well as having interrelated intervention (and/or wider project) roles, individuals had ***employment roles***, i.e. they were employees, with employers.

In each case, one or more ***practitioners*** were tasked with delivering analysis to clients. Typically, practitioners worked as part of a team of practitioners, each with different knowledge, skills and experience. For each intervention, one practitioner was described to me as the 'main practitioner' and took a leading role in providing analysis for the vast majority, if not all, of the intervention phases I analysed. In two cases, practitioners worked closely with non-practitioner colleagues (specialists in other fields) within the same intervention team. In case 4, practitioners worked as part of a government policy team delivering the intervention. For reasons of confidentiality, I refer to practitioners plural in the cases. Five practitioners across four of the cases also participated in the survey (Table 76, Appendix V).

Like the majority of project examples in the survey (Figure 16, chapter 5), the practitioners in all cases reported to ***clients*** in senior civil servant or equivalent UK job grades (Clyne et al., 2023; Institute for Government, n.d.). Clients were leaders, sponsors, and/or funders or procurers of the national capability in each case (Figure 24 below). For reasons of confidentiality, I refer to clients plural for each case. Interventions came about to provide support to decisions to be made by clients and/or senior level government boards and/or government ministers, referred to in Figure 24 as ***decision makers***.

UK Government Partner Organizations
- National government representatives (non-UK)
- Industry representatives
- Academics
- Trade union representatives
- Other partners

UK Government Organizations
- **MINISTERS**
- Board members
- Senior civil servants/equivalents
- Staff

UK Government Functions
- Assurance specialists
- Commercial/Legal specialists
- Finance specialists
- Procurement specialists
- Strategy specialists

UK Capability Organizations
- ***SPONSORS/OWNERS***
- ***FUNDERS/PROCURERS***
- ***LEADERS***
- ***BOARD MEMBERS***
- Leaders/managers
- Staff/secondees

UK Government Programme/Project Organizations
- ***PROJECT SPONSORS***
- Steering committees
- Governance committees
- Red teams
- Working committees
- Programme and project managers
- Project teams (practitioners and other project team members/secondees)

Practitioner Organizations
- Leaders/managers
- Project and programme managers
- Reviewers (assurance)
- Practitioners/Consultants
- Specialists and subject matter experts

BOLD CAPS = DECISION MAKER
ITALIC BOLD CAPS = CLIENT
Yellow = UK Government role *Pink = Programme/project organization role*
Green = UK Government and/or Partner (non-UK Government) role *Blue = Partner (non-UK Government) role*

Figure 24: Stakeholder roles, by organizations

For simplicity, overlaps between programme/project roles and other organizational roles are not fully specified in Figure 24. For example, a UK Government senior civil servant may have a role as a UK capability leader, or a capability stakeholder may be involved in an intervention as a workshop participant, or one UK capability organization may be a customer/user of another capability organization. Such interrelations are explicated in case analysis below as required. However, due to the small numbers of cases and (categories of) participants per case, in order to preserve some anonymity, quotations in this chapter are not attributed.

6.2.5 Intervention phases

> A case is an edited chunk of empirical reality where certain features are marked out, emphasized, and privileged while others recede into the background. As such, a case is not "natural," but a mental, or analytical, construct aimed at organizing knowledge about reality in a manageable way. (Lund, 2014, p. 224)

In my multiple case analysis, I sought to understand practitioners' work across different intervention phases, as captured in the rich case descriptions. To keep the research manageable within the constraints of this doctorate, for responding to the research questions in this chapter I focus on one intervention phase per case. The selected intervention phase was generally the first (after initiation of the intervention), but for one particularly long, multi-phase intervention, practitioners identified a different phase as of particular interest. Each selected intervention phase presented in this chapter started with practitioners being tasked with providing analysis, and ended with practitioners delivering their findings to clients in the form of a written report. In subsequent intervention phases, beyond the scope of this dissertation, practitioners responded to or implemented decisions made.

RQ1. HOW DO PRACTITIONERS CHOOSE AND COMBINE OR METHODS TO SUPPORT STRATEGIC DECISION-MAKING?

I now respond to the first research question (RQ1) by reporting multiple case study findings on methods practitioners use and combine (section 6.2.6 below), the prevalence of use multimethodology by practitioners (section 6.2.7), and forms of multimethodology practitioners use (section 6.2.8).

6.2.6 Methods practitioners use and combine

Activities at the outset of interventions, in the *Initiation* stage (NATO, 2012a, pp. 5-6), included background reading, literature searches, and discussions with colleagues, with clients, with other project stakeholders (including in one case, a customer engagement committee), and with people in other organizations (to gather information), as well as intervention planning. Broadly, practitioners were seeking to identify and understand issues, stakeholders and stakeholder views, scope their work, and in most cases starting to consider which (further) methods they could use. An overview of how the interventions came about, what practitioners reported as their initial activities, reasons for those activities, and what practitioners did next, with illustrative data, are in Table 77 (Appendix V).

In response to RQ1, methods practitioners then used and combined in the phase of their interventions focused on in this chapter are in Table 20 below. As in the previous chapter, 'methods' is used in this chapter to refer to methodologies, methods and tools (Table 7, chapter 2). Defining what constituted a method in the context of the cases was challenging, so I sought to describe methods in terms that were meaningful in light of the clustering and categorization of methods in survey data generated in the same research context (see section 5.2.2 in the previous chapter), while following practitioners' own descriptions, and highlighting, for example, versions of existing methods that practitioners used, and how they used them.

The categorization of methods highlights that methods *not* used included problem structuring methods (PSMs; as defined by Rosenhead, 1989, 1996) and historical analysis. However, all interventions were to some extent participative. All included facilitated stakeholder/expert workshops. One case included stakeholder analysis using a modified version of G. Morgan's (1997) pig diagram.[38] In all cases, practitioners reviewed stakeholder lists (including with clients) before

[38] Pig diagram refers to G. Morgan's (1997) drawing of stakeholders around a pig ('WHAT IS THE PIG?' [p. 3]) for prompting consideration of the 'meaning and significance' of the pig to each stakeholder, e.g., a wolf is considered to view the pig as food, and a veterinarian to consider its health (p. 2). The drawing is presented alongside G. Morgan's well-known metaphor approach of 'seeing' and understanding something in different ways. Later in his book, in a diagram illustrating an organizational case study, and this time without pictures, G. Morgan quotes different stakeholder groups' 'perspectives' or 'readings' in separate boxes that surround a short description of the problems addressed in the case, with arrows from the stakeholder boxes to the problems in the centre (Exhibit 5.4, p. 120). For example, one box contains the words, 'SENIOR MANAGEMENT "We don't need this problem. We have to restore normal levels of control and efficiency, based on measured results."' The illustration, part of Morgan's process as 'change agent' in the case, is to prompt insights that help interpret, understand and change the situation creatively (p. 122). For example, it is used to prompt an understanding of threats perceived by different stakeholders (what they may lose) from organizational change designed to resolve problems, and ideas of other ways of changing the situation.

deciding who to invite to participate, particularly in workshops. Interviews were common. Practitioners tended to talk about stakeholder engagement (including with clients) as an intervention activity and/or as a rationale for using particular methods, especially workshops and interviews. In at least two cases, stakeholder consultation as a separate activity (outside workshops) was a major part of practitioners' approach. Visualization, in the form of diagrams in practitioners' reports, was also common.

As is traditional in OR (Rosenhead & Mingers, 2001a) and in UK government analysis (HM Treasury, 2003, 2015, 2022), all cases involved the development or construction of decision options. This is not included as a method in Table 20 below. In most cases, practitioners outsourced the costing of options.

In four of the five cases (not case 2), practitioners made scoping documentation available for the research. This included milestones or deadlines for completing work. In two of the scoping documents, time-based project plans were summarized, and for another case, practitioners made their project plan available separately. As these documents were compiled for the purposes of the interventions themselves, they are not included in Table 20 below, neither are practitioners' activities at the outset of interventions (see Table 77, Appendix V).

6.2.7 Prevalence of use of multimethodology by practitioners

As shown in Table 20, in all five cases, practitioners used more than one method, and across multiple categories. Numbers of methods and categories by case, adopting the clustering approach in the previous chapter (section 5.2.2), are in Figure 25 below. Case practitioners also reported using multiple methods commonly in their day-to-day work on complex or multi-disciplinary projects. In response to RQ1, we can therefore conclude that multimethodology was prevalent.

Table 20: Methods used by practitioners, by category and case

METHOD CATEGORY	Case 1 Analysis for a business case for future investment in a national capability	Case 2 Review of an approach to an organizational process to advise on its applicability to the enhancement of a national capability	Case 3 Review of a national capability to inform its future strategy	Case 4 Review of options for the future organizational model and governance of an organization comprising a number of national capabilities	Case 5 Review and prioritization of options for the future technological configuration of a national capability
QUANTITATIVE OR	Statistical analysis Costings of options (o/s) Cost-effectiveness calculations	-	Funding and costs analyses	Costings of options (o/s)	Spreadsheet modelling – combinatorial, including costing tool Discrete event simulation
MANAGEMENT/ STRATEGY	Brainstorming	-	-	[see reference to SWOT below]	-
OR LESS EASILY CATEGORIZED	Participative MCDA (multi-criteria decision analysis)	-	-	-	-
WORKSHOPS/ ELICITATION/ FACILITATION	Facilitated workshops	Facilitated workshop	Facilitated workshops	Facilitated workshops	Facilitated workshops
GENERAL RESEARCH	Structured interviews Analysis of qualitative data	Talking with stakeholders	Review of policy documents Structured and unstructured interviews and emailing Taxonomies, Grids, Dependency mapping, Activity mapping	Documentation and literature review Structured interviews and evidence requests Thematic analysis	Qualitative reporting of issues and risks
SYSTEMS THINKING	-	-	-	Systems analysis *[VSM used in later intervention phase]*	-
STAKEHOLDER ANALYSIS	-	-	Pig diagram	*[Used in earlier intervention phase]*	-
CONSULTING SKILLS	Stakeholder consultation	-	Red teaming	Stakeholder consultation	*[Red teaming by client]*
OTHER DISCIPLINES	-	-	-	Policy analysis of options – benefits and risks (akin to SWOT [strengths, weaknesses, opportunities, threats analysis])	-
VISUALIZATION	Visualization (diagrams in reports)	*[Used in later intervention phase]*	Visualization (diagrams in final report)	-	Visualization (diagrams in final report)
PSMS	-	*[Soft systems methodology (SSM) used in later intervention phase, as part of wider project]*	-	-	-

o/s = outsourced by practitioners

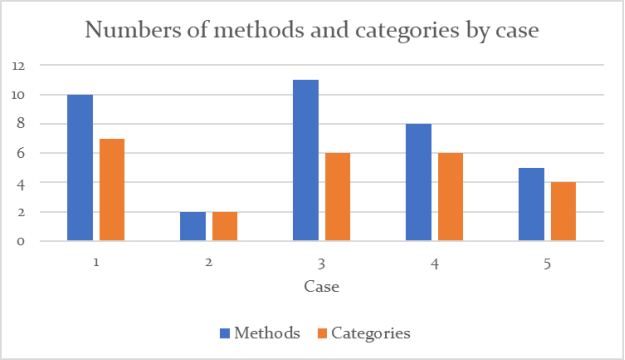


Figure 25: Number of methods and categories by case

6.2.8 Forms of multimethodology practitioners use

In this section, I describe views from practitioners on which of the six forms of multimethodology in J. S. Morgan et al.'s (2017) linking designs for OR/MS interventions (single methodology, sequence, parallel, enhancement, interaction, integration; Figure 11, chapter 4) resonated with their methodological approach. I then present illustrations of the methodological designs (forms of multimethodology) compiled using the rich case descriptions. In response to RQ1, the illustrations show how the methods in Table 20 above were used together in each case.

In the illustrations, practitioner methods, activities and outputs are shown in boxes joined with arrows indicating how one led to another over time. Methods, activities and outputs are categorized according to Mingers and Brocklesby's (1997) four overlapping and iterative stages of a typical OR intervention (the 4As) – Appreciation, Analysis, Assessment, Action (Mingers, 2014). Where relevant, activities are also categorized to the Initiation stage (NATO, 2012a; Table 77, Appendix V). As in Table 20 above, practitioners' work on scoping documents and project plans is excluded. In deciding what to include in the methodological design illustrations, and how to link and categorize methods by intervention stage, I sought a justifiable accommodation of underlying case data across all sources.

Case 1: Analysis for a business case for future investment in a national capability

In case 1, practitioners described their methodological design (Figure 26 below) as 'towards the integration'. Practitioners explained that their methodological approach was that they sought to

answer, 'the questions we need to answer, to satisfy those who are judging' using 'the appropriate toolsets to do that, that are already available', and only looking to 'develop [...] a totally new method if there isn't something there that which adequately delivers it safely'.

In fact, we see in Figure 26 that MCDA (Table 20 above) provided a framework for most of the methods in the methodological design (Christie, 2023; Mingers & Rosenhead, 2001; see also Belton & Stewart's, 2010, characterization of MCDA as providing 'in effect a *pro forma* structuring template' akin to a PSM [p. 234, *emphasis in original*]). Interestingly, within the MCDA framework, practitioners included generation of comparative evidence of benefits and challenges of options, and analysis of qualitative data from weighting and scoring workshops. We shall return to this below. Practitioners then combined their analysis of the effectiveness of options from the MCDA with costings of options to produce cost-effectiveness calculations for the business case they were asked to support.

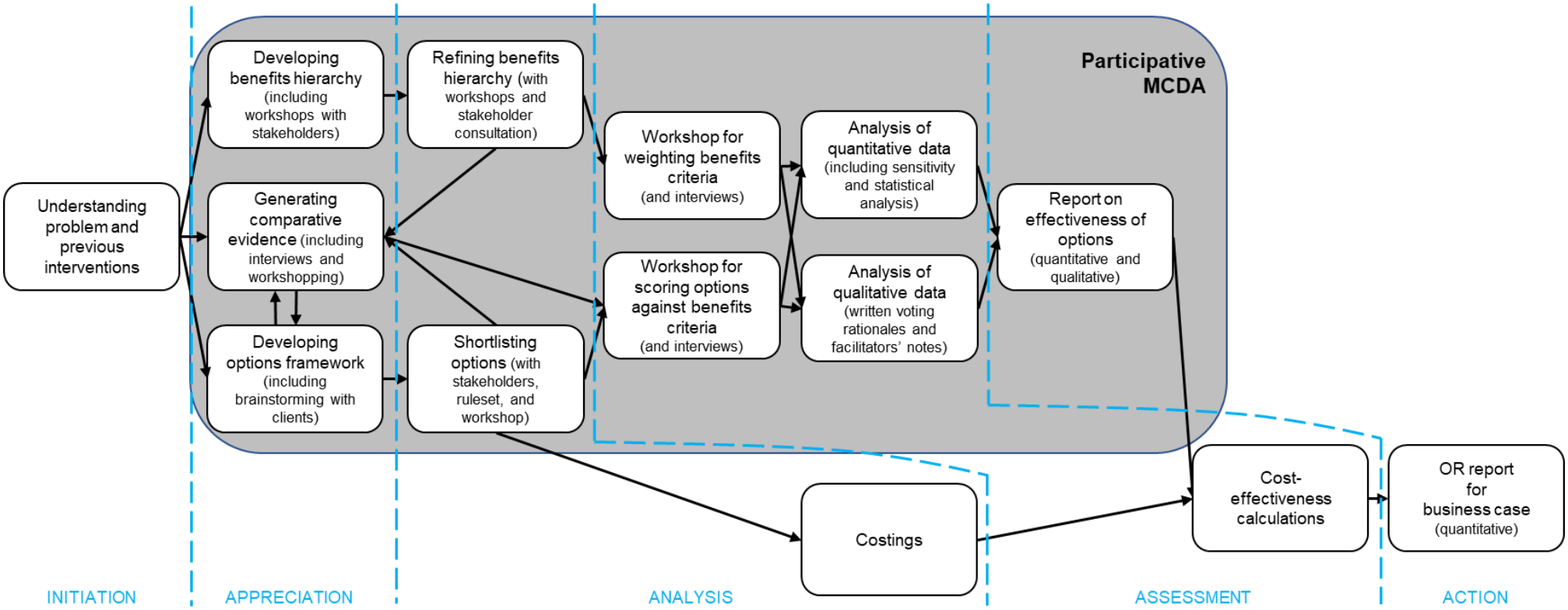


Figure 26: Case 1 – illustration of methodological design (simplified)

Case 2: Review of an approach to an organizational process to advise on its applicability to the enhancement of a national capability

In case 2, practitioners' methodological design (Figure 27 below) included talking with a third party, then talking with government stakeholders, and then involving both third party and government stakeholders in a workshop (Table 20 above). Practitioners described it as,

> [...] very sequential, this was very this and then this and then this and OK now I need to do this now I need to do that. There wasn't much overlap certainly in the very beginning [in this intervention phase] there wasn't time for overlap. There was simply this is all the time we've got, to do something.

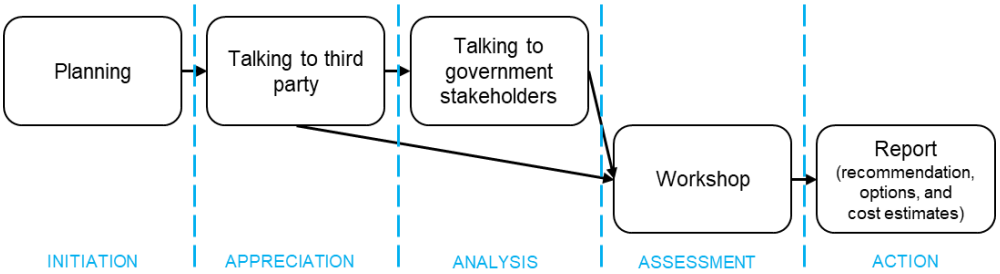


Figure 27: Case 2 – illustration of methodological design (simplified)

Case 3: Review of a national capability to inform its future strategy

In case 3, practitioners described their methodological design (Figure 28 below) as 'integration' in that they applied 'all sorts of bits' of different methods (Table 20 above) to analyse different aspects of the situation, rather than using 'one method throughout the whole thing'. Practitioners considered that they had 'tried lots and lots of methods', which also suggested some sequential use, as follows:

> Because that tends to be the approach of, well I'll try this and then I'll try that and then, actually which tells me more what I want to know and sometimes you do just end up choosing one of them. And, sometimes you actually find that one of them has an answer that you have to combine what you did, to be able to understand, properly. [...] it's very much all aimed at there is a question I need to get to for each part. Which [method] gives me the closest to that answer. So I'm quite happy to scrap methods as I go along.

However, practitioners also saw their integration of different methods as starting with parallel use of methods, and, in the end, involving enhancement of one method with another. They reported,

> [...] but that's probably not unusual for a lot of, projects that you end up doing that kind of thing. [...] you start with a parallel but actually what you find is that, when you've done one it actually a bit of that [method] would fit into that and [method] make it better.

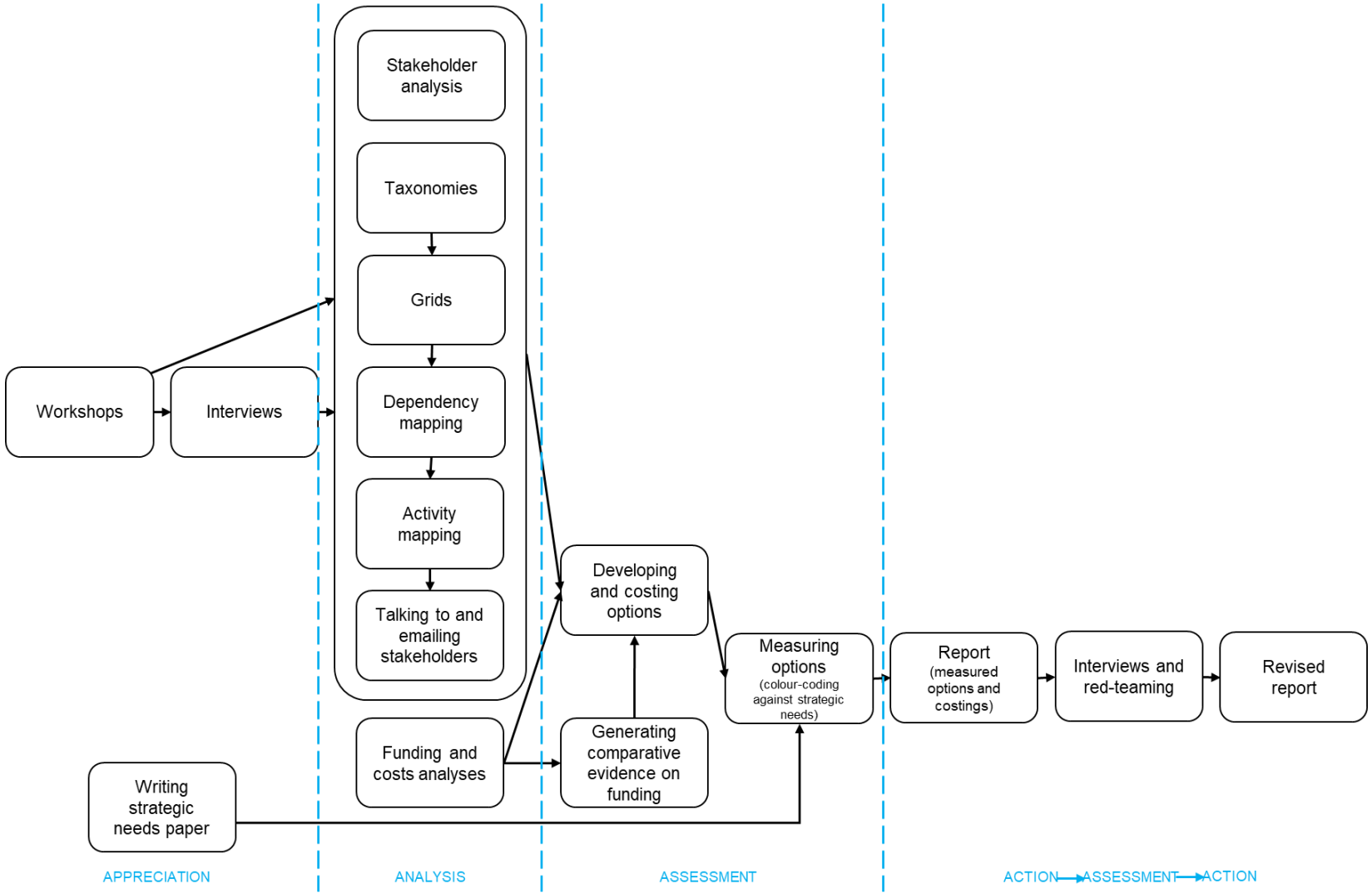


Figure 28: Case 3 – illustration of methodological design (simplified)

Case 4: Review of options for the future organizational model and governance of an organization comprising a number of national capabilities

In case 4, intervention team members (including practitioners) saw their methodological design as involving sequential use of methods (e.g., with costing of options 'at the end'), as well as parallel use of methods (explaining, 'we kind of had to, because of time constraints'), and possibly enhancement of organizational modelling with interviews, as part of the team's stakeholder consultation process (Table 20 above; Figure 29 below). Practitioners described their stakeholder consultation process as 'very iterative', involving both the seeking of new insights for their analysis (e.g., in interviews), and of confirmation of what other stakeholders were telling them to strengthen their evidence base. There were then different views as to whether practitioners' development and policy analysis of options constituted a new framework, and therefore reflected integration, for example:

> [...] you could argue that, [...] when we were looking at [our shortlist of] candidate options, and our set of success criteria, that that was a new framework, because we created it ourselves [...] We didn't take it from another [intervention] or anything like that, and it was bespoke, to [the organization's] needs. [...] and the needs of the [intervention] team itself.
>
> [...] It probably wasn't, really a <u>new</u> framework, it was just a couple of, pre-existing techniques [...]

Practitioners' systems analysis was described as parallel to the policy analysis, with some 'read across' or 'interaction' in relation to 'the <u>risk</u> side of things'. Practitioners drew a comparison between this and how, in interventions more generally, costing of options tended to be carried out in parallel and then compared with the measurement of benefits or effectiveness of options (e.g., as in case 1 above).

In addition to the methods listed in Table 20 above and Figure 29 below, practitioners in this case produced a stakeholder engagement plan. Practitioners also had a communications workstream for updating organization stakeholders on the project, based on a communications plan.

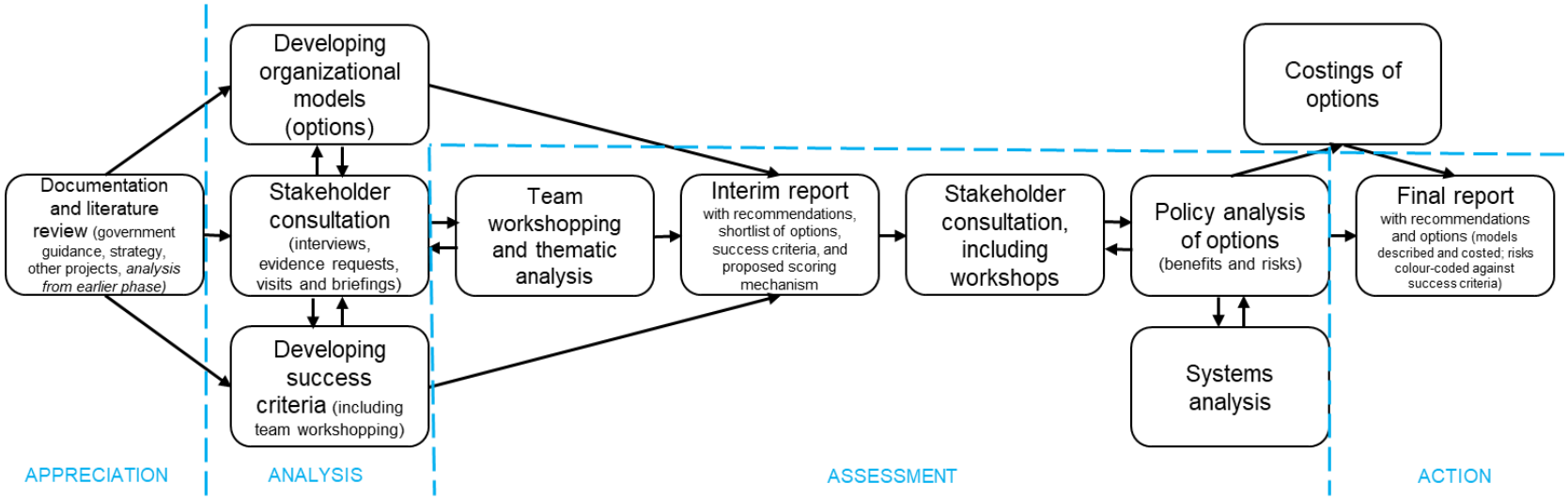


Figure 29: Case 4 – illustration of methodological design (simplified)

Case 5: Review and prioritization of options for the future technological configuration of a national capability

In case 5, practitioners saw their modelling as sequential. They commented, 'The one I think we eventually used most of the time was sequence. It was very much, do that then that then that. [...]'. Practitioners also questioned whether their use of a linear programming (LP) spreadsheet from an earlier phase – in building their spreadsheet model in this intervention phase (Table 20 above) – constituted enhancement of the LP, or perhaps integration. They concluded that,

> Effectively we are enhancing the [LP] tool [from an earlier phase and previous projects] by having data generators. So, what we tend to have is, here's an output from some method, here [is] something we'd like to bring it in, so we then bring another method to translate it into it, so, in theory it's enhancement but it's, sort of between the two [enhancement and integration]. But in practice in strict terms I think it's all sequence. So I think that's our primary one that we ended up using.

Another view was that the design (Figure 30 below) involved enhancement of spreadsheet modelling with expert/stakeholder judgement from workshops, and that some of the judgement may 'form an output in its own right', so that workshops are in parallel with modelling, with outputs 'then brought together'. In other words, '[...] it was [spreadsheet] modelling, informed strongly by, or enhanced by, the judgement activity'.

At the time of the research, practitioners had reported on their lessons learned from this and other multi-phase interventions with similar subject matters, including with input from a systems thinking consultant. They had concluded that practitioners,

> [...] end up doing a double loop. So you end up with an initial loop [in an earlier intervention phase] where you try it [a methodological design], [...] You do it once quickly, and everyone goes, 'Well, that's good but I don't like that bit'. And you end up doing it again [in a later intervention phase like this one], properly. (practitioner)

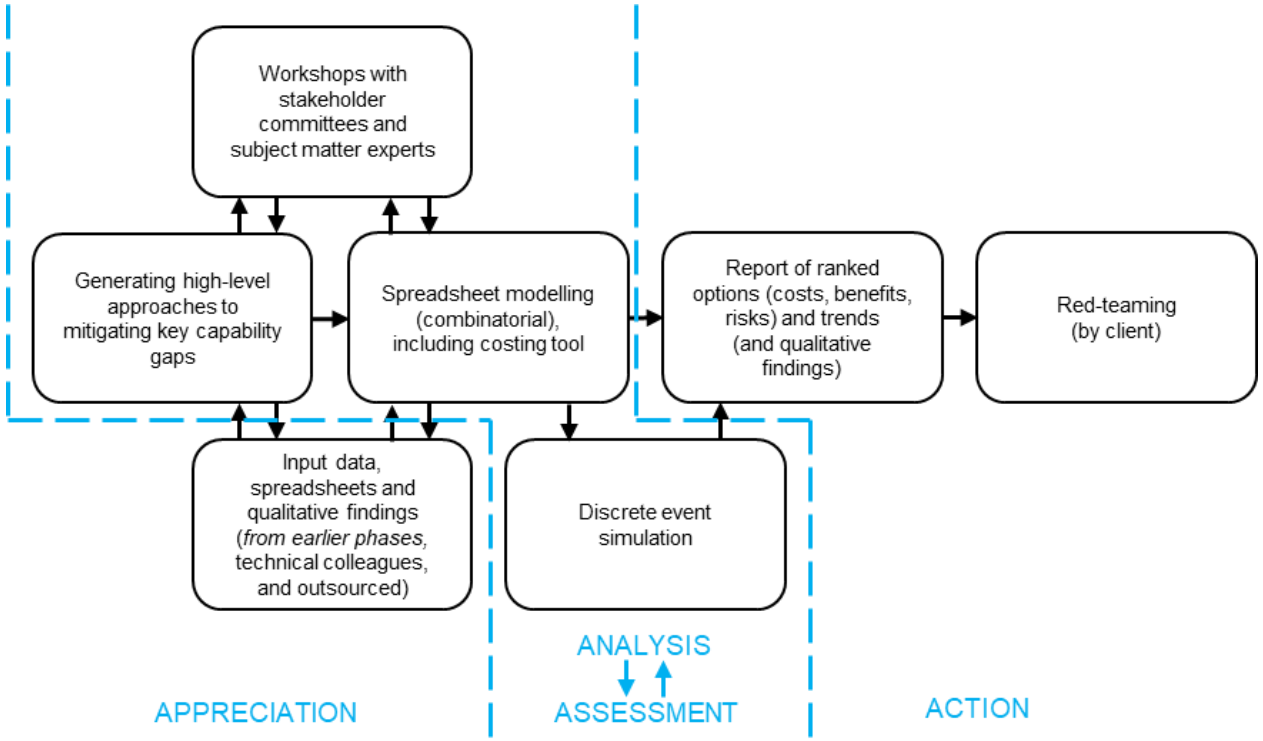


Figure 30: Case 5 – illustration of methodological design (simplified)

RQ2. WHY DO PRACTITIONERS TAKE THESE APPROACHES, MULTIMETHODOLOGICAL OR OTHERWISE?

Next, I respond to the second research question (RQ2) by presenting multiple case study findings on reasons why practitioners use particular methods (section 6.2.9 below), and why practitioners use multimethodology (section 6.2.10). I show how I employed the theoretical framework in chapter 3 (summarized in Figure 31 below) in analysing the methodological approach used by practitioners in each case as emergent from the pre-existing intervention context.

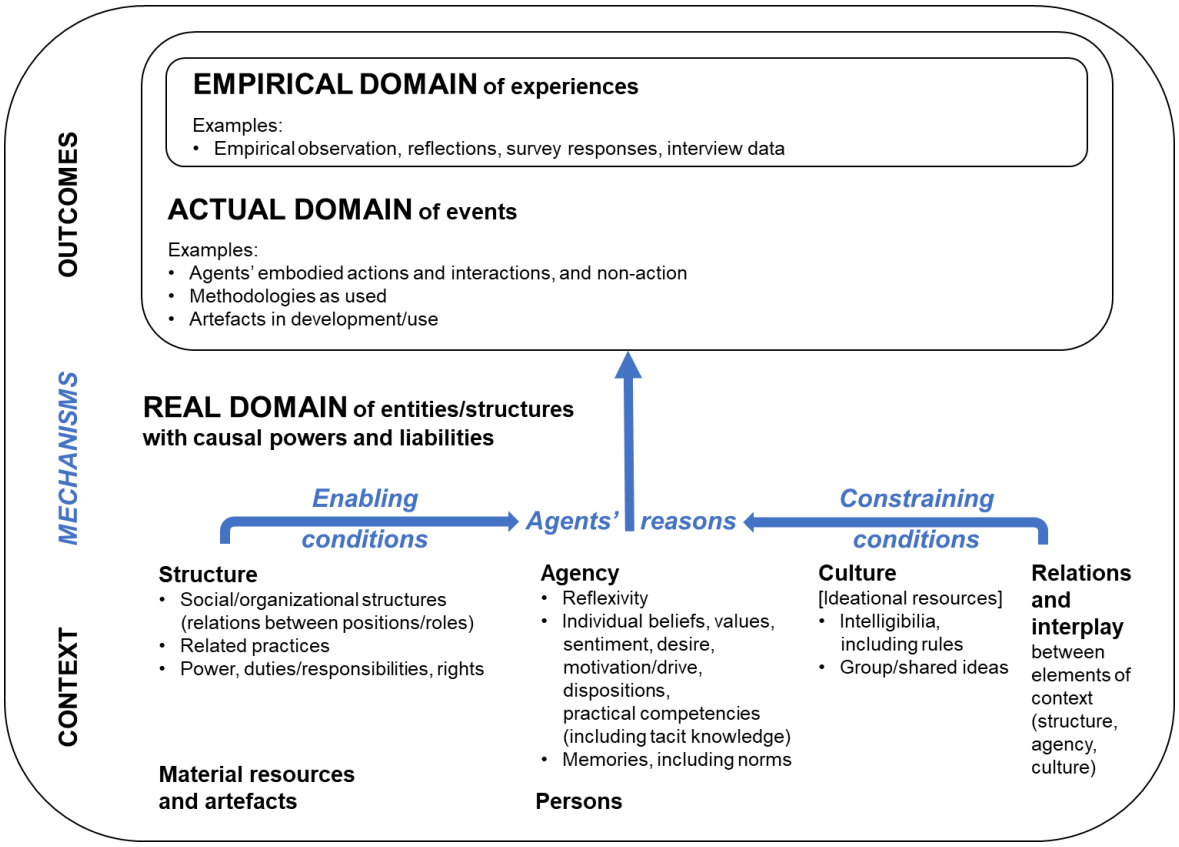


Figure 31: Ontology of a multimethodological OR intervention and conceptualization of mechanisms in agents' actions

6.2.9 Why practitioners use particular methods

In this subsection, I present results on why practitioners use particular methods. After a summary of my structural and causal analysis, and the resulting mechanisms of method choice across the cases, I present the results for each case. I then present further analysis as to why practitioners did not use

PSMs, and the extent to which practitioners used other methods as PSMs. In a final subsection, I summarize findings on causal complexity.

Structural analysis

To recap, I analysed pre-existing intervention contexts as comprising aspects of social structure, culture, and agency, and relations between them (after De Souza, 2013, 2022; chapter 3). So structural analysis (or abductive or theoretical description; Table 14, chapter 4) involved my identification of entities or structures from which mechanisms of method choice emerged – across social structure, cultural resources, and stakeholder agency (Figure 31 above; Table 11, chapter 3). From this structural analysis, I concluded that social structure included stakeholders and their roles, relations between roles, and related practices. As reported in section 6.2.4 above, practitioners and other stakeholders had intervention (and/or wider project) and employment roles. Evidence for the systemic and enduring nature of intervention roles (e.g., the tasking of practitioners by clients to deliver analysis), i.e., that relations between them could be considered to exist in the realist ontology (Figure 5, chapter 3), albeit for less time than in relation to individuals' employment roles, came from changes in individuals allocated to particular roles over time (recorded in interview and secondary data). Practitioners took actions to deliver analysis. The delivery of analysis was a 'goal countenanced by' practitioners (Archer, 1995, p. 198), itself conditioned by practitioners' intervention and employment roles (amongst other influences). Archer (1995) terms such goals, 'projects' (p. 198), noting that,

> ... one of the most important conditional influences of structures (SEPs [structural emergent properties, such as roles] and CEPs [cultural emergent properties, such as rules]) is their effect upon the projects to be conceived, entertained and sustained within a given social environment ... Therefore, the morphogenetic task is to supply an account of how the powers of the 'parts' condition the projects of 'people' - involuntaristically but also non-deterministically, yet none the less with directionality. (pp. 200-201)

Cultural resources included rules (e.g., in policy documents) and shared ideas (e.g., in discourses on past projects). Aspects of stakeholder agency included practitioner reflexivity, values, beliefs, motivation, dispositions, practical competences, and norms. As the sample of practitioners was small, and there were issues of confidentiality, I did not analyse personal characteristics of interviewees (e.g., social and personal history).

Causal analysis

In my causal analysis (or retroduction and redescription; Table 14, chapter 4), to identify plausible explanatory mechanisms, I started with individual (practitioner) beliefs and reasons for actions or non-action (their choice or use of particular methods and method combinations) in case data in the rich case descriptions (Table 14, chapter 4) and then looked to make sense of those in context. Like De Souza (2013, 2022) in her systemic analysis of the emergence of a social programme, in order to explain practitioners' social practice, I built on Sayer's (1992) proposals for realist research. I sought practitioners' reasons and analysed data for 'formal and informal rules [cf. Fleetwood, 2021] existing in the context of social action within which the reasons given make sense' and 'structures (or the aspects) that generate these rules, influencing the perceptions and actions of agents' (De Souza, 2013, p. 145, after Sayer, 1992). These implicated pre-existing mechanisms (conditions) in the intervention context that influenced method choice and intervention design, which I analysed by aspects of structure, culture and agency, and their relations and interplay (after De Souza, after Archer, as discussed above).

As explicated in chapter 3, as powers and liabilities of entities or structures in the real domain, mechanisms of method choice may or may not be observable or observed (Mingers & Standing, 2017; Westhorp, 2019) in practitioners' or other stakeholders' explanations of method choice in the empirical domain (Figure 4, chapter 3). In isolating causal mechanisms from case and survey data and analysis, I sought, 'that factor which, in the circumstances that actually prevailed [in the case], "so tipped the balance of events as to produce the known outcome"' (De Souza, 2013, p. 145, after Bhaskar, 1998), i.e., the use of the particular methods, and use of multimethodology (reported in the next subsection). In identifying enabling and constraining conditions, I considered what *else* must have led to the existence or triggering of the mechanisms (Sayer, 1992, p. 113). For this, I employed counterfactual reasoning because,

> A mechanistic explanation describes the causal process selectively. It does not aim at an exhaustive account of all details but seeks to capture the crucial elements of the process by abstracting away the irrelevant details. The relevance of entities, their properties and their interactions is determined by their ability to make a relevant difference to the outcome of interest. If the presence of an entity or changes in its properties or activities truly does not make any difference to the effect to be explained, it can be ignored. (Hedström & Ylikoski, 2010, p. 7)

Summary of method choice mechanisms across the cases

Structural and causal analysis thus resulted in my identification of causal mechanisms of method choice, and enabling and constraining conditions, which are consolidated and summarized across the cases by aspects of context (structure, culture, agency, and relations), in Table 21 below in response to RQ2.

In terms of social structure, relations between roles, and associated responsibilities and power, together with effects of practitioner agency (including practitioners' reflexive deliberation, values, and norms) led to practitioners' specific aims regarding what they would deliver in each case. These various method choice mechanisms (practitioners' aims in delivering their analysis) reflected practitioner interpretations of the specific intervention/organization/employment role relations, as well as practitioners' prioritization of aspects of what they were tasked to do. For example, in case 1, practitioners aimed to be seen as trustworthy, fair, and independent, in line with established practices of practitioner employees in their organization in relation to clients, and reflecting practitioners' own beliefs and values. This, in conjunction with other method choice mechanisms, led to practitioners' use of qualitative analysis of workshop and interview data in order to explain different stakeholders' issues with different decision options (see also Figure 32 further below). Another example is that, in case 2, as captured in the interview data in subsection 6.2.8 above, given their roles, practitioners prioritized delivering analysis quickly, which led to their use of a workshop (see also Figure 33 further below). In most cases, practitioners and other stakeholders also noted limited resources (time and/or money) for interventions and for practitioners to try new methods. Generally, using new or different methods was considered risky in the context of these resource-constrained interventions, in that it may not give an answer or be understood by stakeholders. Across the cases, these mechanisms, emergent from social structure, were variously enabled or constrained by other stakeholders' expectations, rules in policy documents, national political priorities, time constraints, the availability of practitioners specializing in particular methods, and learning from previous work (Table 21 below). For example, in case 1, practitioners' aim to be seen as trustworthy, fair, and independent was enabled by their employer's expectations of their work. In case 2, practitioners' aim to deliver quickly was enabled by a lack of time.

Table 21: Summary of cross-case mechanisms of method choice

Aspect of context	Context	Mechanisms of method choice	Case					Enabling / constraining conditions	Case				
			1	2	3	4	5		1	2	3	4	5
Structure	Relations between intervention, organization and employment roles, and associated responsibilities and power	Practitioners' aims regarding - what they would deliver (given roles)	✓	✓	✓	✓	✓	Other stakeholders' expectations, including scope of practitioners' work	✓		✓	✓	✓
		- how other stakeholders would understand and audit their analysis	✓		✓		✓	Intervention within scope of rules in policy documents / national political focus on affordability/risk			✓	✓	✓
		- how practitioners would be seen by other stakeholders	✓					Time constraints		✓		✓	✓
								Availability of systems practitioners / Learning from previous work				✓	✓
	Lack of resources	Absence of time for certain methods			✓			Reduction in number of practitioners working on intervention			✓		
Culture	Rules in policy documents	Rules requiring cost-effectiveness measure and risks commentary	✓				✓	Intervention/work within scope of rules	✓	✓	✓	✓	✓
		Rules requiring option appraisal		✓				Stakeholder expectations/direction					✓
		Rules specifying limited range of options, requirement for wide stakeholder engagement, and lack of guidance specifying methods				✓		Resistance of stakeholders to particular methods	✓				
								Time and resource constraints					✓
	Discourses and documents on past projects, and the appropriateness of certain methods and not others / Ideas from colleagues	Practitioners' knowledge of particular methods suggested by colleagues	✓		✓			Lack of knowledge of alternative methods / Expectations of those responsible for policy documents	✓			✓	
		Practitioners' confidence that using particular methods was feasible and would result in acceptable answer / knowledge that methods were appropriate in the context	✓			✓		Tendency amongst practitioners to ask colleagues for ideas and views on methods			✓		
		Practitioners' aim to show they had used suggested methods			✓								
Agency	Practitioners' dispositions	Practitioners' tendency to: - adapt and use existing methods and tools (not novel methods)	✓				✓	Limited resources (time, money) and data	✓				✓
								Risk aversion amongst practitioners and assurers	✓				✓
								Trust in existing tools and in practitioners					✓
								Practitioners' expertise in particular methods					✓
		- use particular methods and method combinations for particular types of problem (that they have used in the past)				✓	✓	Practitioners' and other stakeholders' experiences, learning from past work				✓	✓
								Relative lack of experience in other methods					✓
								Availability of tools					✓
								Visibility of project					✓
								Other stakeholders' expectations				✓	
		Practitioners' tendency to use workshops and/or structured interviews		✓	✓		✓	Tendency to use workshops and structured interviews amongst colleagues	✓	✓	✓		
								Lack of time		✓			
								Senior backing of project facilitating stakeholder participation					✓
		Practitioners' tendency to use lots of methods / elements of soft systems approach, and take informal approach to methods			✓			Concept amongst practitioners of methods as aids to thinking			✓		
								Lack of available methods to deal with complex, interdependent issues			✓		
Relations	Lack of agreement between stakeholders and politics playing	Practitioners' aims to capture different stakeholders' views and stakeholders' acceptance of recommendations	✓			✓		Other stakeholders' expectations	✓			✓	✓
								Internal KM system considered inadequate for purpose		✓			
		Practitioners' aim for consensus amongst stakeholders		✓		✓		Overall capability processes undefined/able		✓			
								Lack of trust and gaming between stakeholders					✓
		Practitioners' aims to agree scope, gather data/evidence, and agree assumptions with stakeholders throughout intervention					✓	Pressures from stakeholders to change scope					✓
								Broad, changing, 'difficult' scope					✓
								Scoping document as best practice for practitioners					✓
								Existence of stakeholder committees facilitating agreement					✓
								Practitioners' experience of past intervention phases					✓
								Other stakeholders' expectations					
	Relations between intervention roles	Practitioners' aim to engage stakeholders in future capability		✓	✓	✓				✓	✓	✓	
		Practitioners' aim to analyse stakeholder needs and dependencies to justify ongoing capability activities			✓			Different preferences amongst clients as to practitioner outputs			✓		

Beyond structural mechanisms, method choice seemed to be largely governed by (1) practitioners' dispositions, i.e., agency, in that method choice mechanisms included practitioner tendencies (given their past experience and skills) *and those of their colleagues* (particularly to use workshops and/or structured interviews), and (2) collective views of similar past projects, and/or rules that restricted the range of acceptable methods, i.e., cultural resources. The other key influence on method choice across the cases was disagreement between stakeholders and politics playing, i.e., relations. This led to practitioners' aims to capture different stakeholder views and consensus or stakeholders' acceptance of practitioners' recommendations and/or engage stakeholders in the future capability they were investigating, with implications for the methods they chose (particularly participative methods, especially workshops and interviewing), and enabled especially by other stakeholders' expectations.

Method choice mechanisms by case

Next in response to RQ2, I present results for each of the cases. I illustrate the method choice mechanisms, enabling and constraining conditions, and aspects of context (from my causal and structural analysis) for each of the cases in Figure 32, Figure 33, Figure 34, Figure 35, and Figure 36 below. After Sayer's (1992, pp. 112-113) conceptualization for realist research methodology, in the illustrations, lines represent the 'necessary relations' linking aspects of the context with the method choice mechanisms (being causal powers and liabilities of the entities and structures in the pre-existing context). 'Contingent relations' are illustrated by listing enabling and constraining conditions (other mechanisms in the pre-existing context) along arrows linking the mechanisms with outcomes, being practitioner actions, i.e., use of particular methods, in practitioners' overall methodological designs illustrated in section 6.2.8 above.

I precede each of the illustrations of the method choice mechanisms with a case report. The case report serves to introduce and describe the case, focusing on the intervention context and methods used, including practitioners' stated reasons for using them. The case reports and the method choice mechanisms are based on within- and cross-case analysis, and in particular, summary descriptions of cases and tables of methods and activities (Appendix L). In other words, the case reports summarize key – but not all – case data that I used to identify the method choice mechanisms and enabling and constraining conditions in the structural and causal analysis. Further detail and illustrative

underlying data for one of the cases for the mechanisms identified are then in Table 78 (Appendix V). Other relevant case data was reported in section 6.2.8 above alongside the methodological designs.

To provide a trail of how I developed the analysis of mechanisms in each case, I provisionally allocated parts of the case reports below to aspects of the intervention context (structure, agency, culture, relations) using subheadings. However, I also conceptualized that the mechanisms of method choice all included effects of practitioners' reflexive deliberation and values (and other aspects of agency, including norms [after Fleetwood, 2021]), i.e., *as well as* practitioners' circumstances, and social structural conditioning (Bhaskar, 2016, p. 66). It was therefore not surprising that I found that mechanisms often related to more than one aspect of the context (structure, agency, culture, relations), also due to the complexity of the cases. Another aspect (that Table 21 above brings out) is that some similar mechanisms (e.g., lack of time) appear in different places in different cases, for example, as a mechanism of method choice in one case, and as an enabling or constraining condition in relation to another mechanism in other cases, depending on the particular case data. As with the methodological design illustrations in section 6.2.8 above, in deciding how to describe the causal mechanisms for each case, I sought a justifiable accommodation of underlying case data across all sources. Now, having explained my approach to deriving causal method choice mechanisms from case data, I present the case reports and method choice mechanisms that respond to RQ2.

Case 1: Analysis for a business case for future investment in a national capability

Case report

Structure: Practitioners were tasked with providing analysis required for a business case for a decision regarding future funding for a national capability, and what its organizational model should be. This business case was the subject of organizational procedures (a specified process), according to which assurers would review the business case, including practitioners' analysis, and explain and provide advice on the business case and analysis to decision makers.

Culture: 'A set of formal rules' for business case approvals were prescribed in policy documents, including analysis required at different stages, and assurance of the analysis. An evidence-based

appraisal of the cost-effectiveness of a set of recommended options was required, focusing on user need (to be justified in the business case), as well as political and practical factors, and current policy and planning. Policy documents required robust and, where possible, quantitative (not qualitative) evidence in the form of measures of the cost-effectiveness of a set of options.

Practitioners decided to use MCDA (The Department for Communities and Local Government, 2009) with stakeholders to develop a benefits hierarchy and then assess benefits of options using quantitative and qualitative evidence, and stakeholder judgement (the assurance team having stated that stakeholder judgement alone would provide insufficient evidence). For specifying options for the inter-organizational model for delivery of the future capability, practitioners developed a framework (of roles and possible role incumbents) for generating options, and a plan for reducing them with stakeholders to a shortlist of viable options. To check robustness of their findings, they used sensitivity analysis and statistical analysis. They combined results with costings to measure cost-effectiveness of options, as set out in the policy documents.

Practitioners had tried to come up with a method for measuring option benefits objectively. However, like in other projects assessing enabling functions such as IT systems, this proved very difficult. Practitioners considered cost-benefit analysis (CBA), but applying CBA to the options was challenging, and there was disagreement (including resistance from other stakeholders), and CBA was not accepted. It was challenging to connect – directly – any single past project undertaken by the capability to realized financial benefits, and difficult to differentiate options for the capability (organizational models and assignment of organizations to roles) on that basis. There was also debate about how the existing capability might have performed differently compared with other options under consideration. For other business cases, numerical, physics-based, computer modelling had been used to compare options using data from trials, training, operations, and/or expert judgement, however that approach was unsuitable in this case. Practitioners saw the use of judgement (where objective measurement was impossible) as necessary and ‘a constraint on the process, that we couldn't necessarily find robust quantitative analysis on option A versus option B’. In using MCDA (including with sensitivity and statistical analysis), practitioners sought to capture capability benefits not easily quantified, to ‘get a handle on’ ‘a very complex set of potential benefits’, including ‘non-financial benefits’, bringing together qualitative and quantitative evidence in a robust way.

In choosing MCDA, practitioners drew on knowledge and experience of previous and current projects and advice from practitioner colleagues, including methodological experts. MCDA had been used to support the previous business case for the capability, including participative weighting and scoring of options, and the involvement of a range of participants. There was a lack of knowledge of apparent alternatives and a general feeling that MCDA was an 'appropriate' technique for this activity or purpose.

Agency: Practitioners sought to provide sufficient evidence for the business case, acceptable to the assurers (who would advise decision makers). Practitioners were motivated to follow the rules to facilitate approval of the business case for their project clients, and in fulfilling their duties and responsibilities as the practitioners on the project, and as government OR analysts. There was a tendency amongst practitioners to use, and from the assurers, given their role as 'owner' of the approval process, to accept and advise use of the same (known) methods used in the past, that stakeholders understand, given limited resources (time and money) for OR projects, and risk aversion in the client organization.

Practitioners' inclusion of qualitative analysis with their recommendations was viewed by stakeholders as an attempt to provide additional commentary on the quantitative cost-effectiveness results relating to risks and risk mitigations, as suggested in policy documents. However, practitioners described it as an attempt to explain stakeholder perspectives on 'how palatable options are to different communities', to reflect 'the richness' behind the 'fairly sterile' numerical [MCDA] scores, and to highlight and provide 'useful' recommendations for thinking about and addressing stakeholder 'concerns' and 'issues between different communities'.

Relations: Practitioners pro-actively collaborated with clients and other capability stakeholders, as well as assurers, in order to produce work that would be satisfactory. During the project, there were working group meetings with assurers in which a client was, 'brokering the discussions between the people who were responsible for generating the evidence, [...], writing the business case [...] and the [assurance] teams who were requiring a particular level a particular standard a particular approach to the solution' (client).

Practitioners found a lack of agreement amongst stakeholders as to the purpose and value of the capability, and plenty of politics playing. In adopting a participative approach in workshops (and

interviews), including for the weighting of benefits, and the scoring of options against those benefits, practitioners sought to capture different stakeholder views on viable options, while seeking stakeholder acceptance of recommendations.

Mechanisms of method choice

Method choice mechanisms for case 1 are illustrated in Figure 32 below.

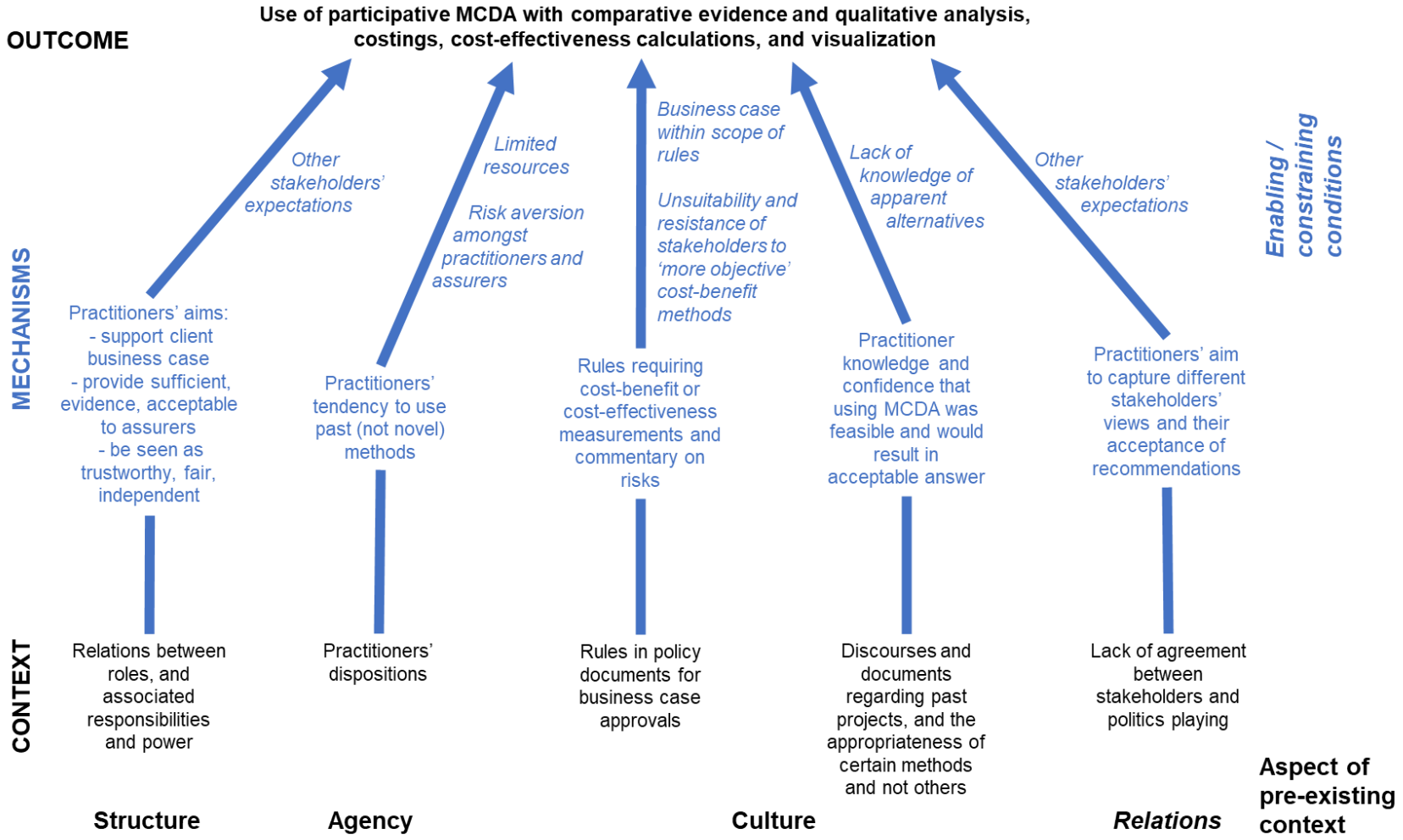


Figure 32: Mechanisms of method choice - case 1

Case 2: Review of an approach to an organizational process to advise on its applicability to the enhancement of a national capability

Case report

Structure: As part of a wider strategic initiative to enhance a national capability through a number of projects, practitioners were tasked with talking with a named third-party commercial organization identified by the project client as of interest, to understand its approach to a particular organizational process. Practitioners were to investigate and understand the applicability of the approach 'as a possible way of doing [a particular organizational process] differently' (practitioner), and how it differed from current practice within government, and its value, benefits and challenges.

Culture: Following planning over two weeks, practitioners had a meeting with representatives of the third-party commercial organization. Then, in order to understand existing practice within government they spoke with colleagues, gathering examples of current practice: 'coming back into the [...] organization and saying this is what [a company doing these processes] can offer', asking 'where's the baseline good practice in [government]'. Practitioners found 'there were a lot of [...] 'But we already do that' type responses'. Practitioners needed more information. They considered: (1) review of an internal knowledge management system – considered inadequate; (2) review of a definition of the subject of the overall initiative (capability) domain (overall process[es]) – considered undefinable because 'everyone thinks it's a bit something different'.

Relations: Practitioners therefore decided to conduct a workshop to bring together third party and government stakeholders. They sought to 'work out [...] whether we're doing this stuff or not and who's doing it and when', seeking consensus on an organization-wide view (rather than examples of 'pockets' of practice).

Practitioners designed and delivered the workshop to understand existing practice better and compare it with the processes of the commercial organization, and to understand benefits and challenges. They gathered a group of between 10 and 15 participants with relevant experience and knowledge, mainly from the relevant government organization. In the workshop, managers from the third-party organization explained one part of their way of working (not all of it, as it was proprietary). The workshop, which lasted several hours, was divided into two sessions. In the first

session, participants were asked whether certain process steps in the third party's approach were used in government, when, and which were the most important. They were first asked to consider the steps individually and then to discuss their views to develop consensus. In a second session they were asked to categorize criteria forming part of the third party's way of working according to whether they were needed or not, or would be difficult to implement, and their consistency with policy, and to discuss and vote on the most important criteria for the government organization. An example government project was presented for participants' consideration alongside the criteria. The workshop was also used to engage participants who may have a project to recommend to which the approach could be applied. Practitioners delivered a report on their findings to the project client, in which they recommended a pilot of the approach, and included two other costed options.

Mechanisms of method choice

Method choice mechanisms for case 2 are illustrated in Figure 33 below.

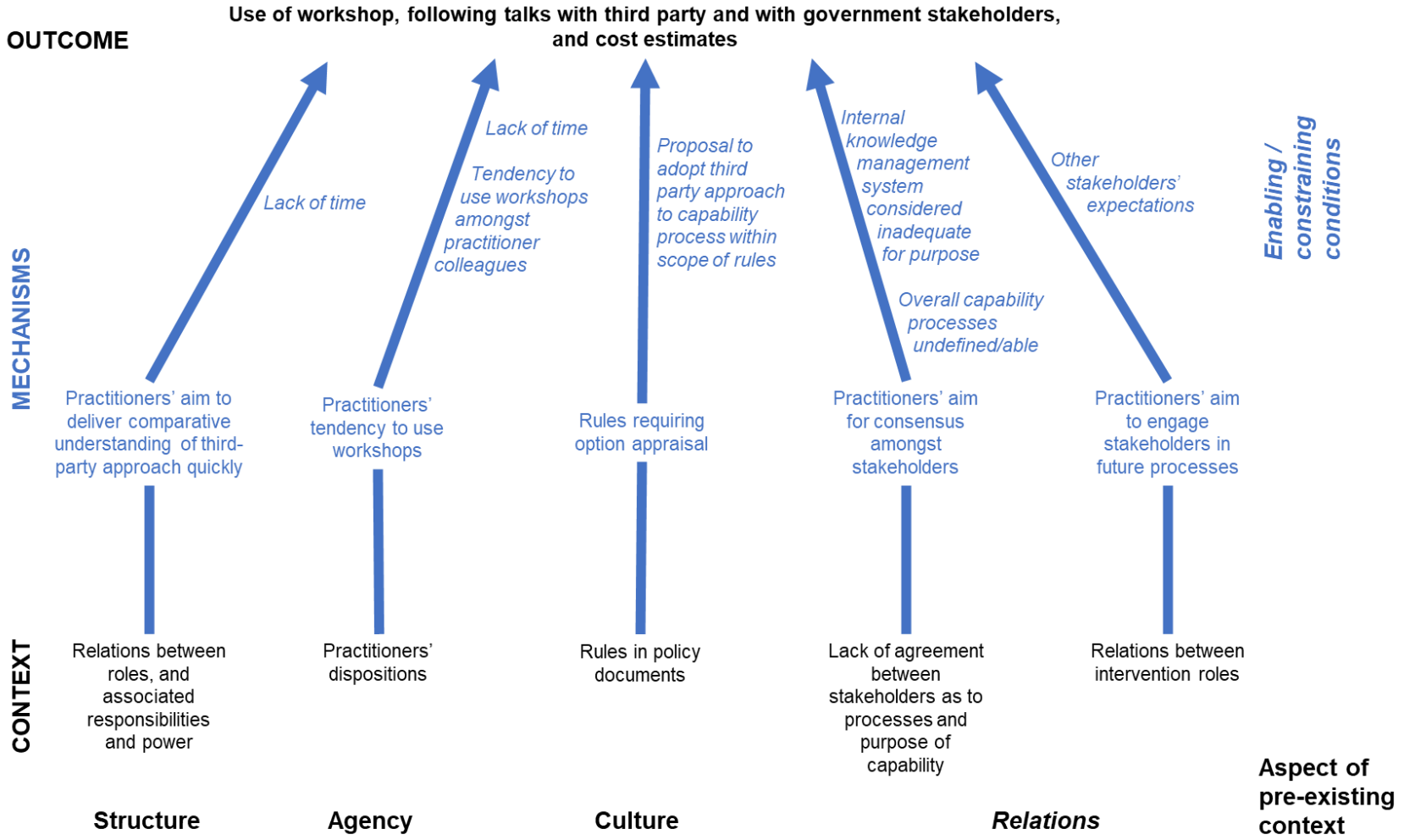


Figure 33: Mechanisms of method choice - case 2

Case 3: Review of a national capability to inform its future strategy

Case report

Structure: According to the agreed scoping document, this intervention was to: explore, identify and understand the current and future funding, costs, and benefits of a national capability (valuing benefits where possible), and in particular the extent to which national strategic and policy needs were and would continue to be met; make recommendations regarding any changes required to the balance of activities, as well as options for improving the return on investment and the cost-effectiveness of assets; and, support decision-making (by a client board) and implementation. Practitioners would use 'structured conversations' to engage widely with capability stakeholders and gather evidence (scoping document).

The description of the project in the scoping document made it sound like an economic appraisal as described in government guidance (HM Treasury, 2003), requiring the analysis of costs and benefits of different options for achieving government objectives. However, neither the future requirements for the capability nor the amount of future funding were specified by the client, and a 'more flexible' methodological approach was taken, looking to identify options for the future strategy for the capability.

Practitioners produced a paper of high-level assumptions about strategic needs, derived from a review of extant strategy and policy documents. The assumptions provided a means of 'measuring' the extent to which capability activities – and, later, options – mitigated strategic risks, by mapping them to strategic needs, and colour-coding needs according to the extent they were met. The paper had been specified as an intervention output in the scoping document. It was later approved by 'senior stakeholders' and the capability board.

Practitioners facilitated a series of workshops with senior capability employees to gather information and understand different areas and aspects of the capability, and participants' views of why they were important. Practitioners later followed up workshops with structured interviews with capability stakeholders (senior staff, managers, and customers [funders]). Practitioners obtained information on capability income and costs from finance staff.

Data from interviews was used to compile a stakeholder analysis – a modified version of G. Morgan's (1997) pig diagram. Instead of showing what shapes stakeholder views, as in G. Morgan's (1997) pig diagram (the 'meaning and significance' of the capability to stakeholders [p. 3]), the stakeholder analysis illustrated stakeholders' involvement from the perspective of the capability, i.e., what each stakeholder does for or with the capability (e.g., funding or joint working) on lines linking stakeholders with the capability (in the middle). What the capability does for stakeholders (e.g., types of services stakeholders receive for their funding) was set out in accompanying notes, alongside links between the intervention client and other stakeholders' funding of the capability in relation to some of those activities. Overall, the stakeholder analysis informed practitioners' development of a shared stakeholder view of the capability, and development of options and other practitioner recommendations.

The workshops and interviews provided information used to develop **taxonomies** of experts required, capability areas, and types of benefits of capability activities, **grids** showing expertise and facilities required by capability areas, **dependency mapping** showing cross-linkages across facilities, expertise, and capability areas, **activity mapping** to understand interdependencies between people and facilities, and **further conversations** with capability staff. Practitioners moved to **talking to and emailing people** (particularly senior capability staff), '[…] to step back from a formal method' and take a pragmatic approach to understanding activities, people and facilities required and why. Practitioners used the information gathered in **development of options** for the capability, in consultation with senior capability staff. Practitioners sought to model the capability by defining a minimum capability and building on that to develop a series of options for the capability, each of which was bigger than the last, including more activities and therefore more people and assets.

Practitioners' report was reviewed by capability customers, the capability, and a red team of 'high level' people not working in the capability who,

> […] understood […] the relative importance of [the capability] versus other things. Because what you wanted to do was be able to put in a case that put in a view that said it's important […] compared to something else that isn't. So it was trying to get a realism in what we were doing and that it was coming across in the right way […]

Practitioners' final report introduced and illustrated the suggested options for the capability in a flow chart, a Venn diagram, and a bar chart (comparing overall costs and risks associated with each

option). It provided an overview of current capability funding by source (in a bar chart showing funding divided into long-term and project-based), grids and descriptions showing the extent to which each option was expected to meet each strategic need, and analyses of costs.

Agency: Considered alongside the other cases and the survey in the previous chapter, practitioners' actions in this case appeared to be reflective of a wider tendency amongst practitioners to use workshops and structured interviews. Practitioners themselves reported an expectation, in addressing a complex system, to try lots of different methods to understand capability activities, and a tendency to use both soft systems methods, and to take an 'informal' approach to method use.

Culture: Practitioners sought advice from colleagues as to which methods to use. Their use of activity mapping meant they had 'crossed that technique off'.

Relations: Practitioners sought to engage stakeholders to understand what they needed from the capability, and from their report, with a view to obtaining stakeholders' buy-in to future change. Practitioners sought evidence to justify capability activities, and to understand how capability users would be affected by change.

Mechanisms of method choice

Method choice mechanisms for case 3 are illustrated in Figure 34 below.

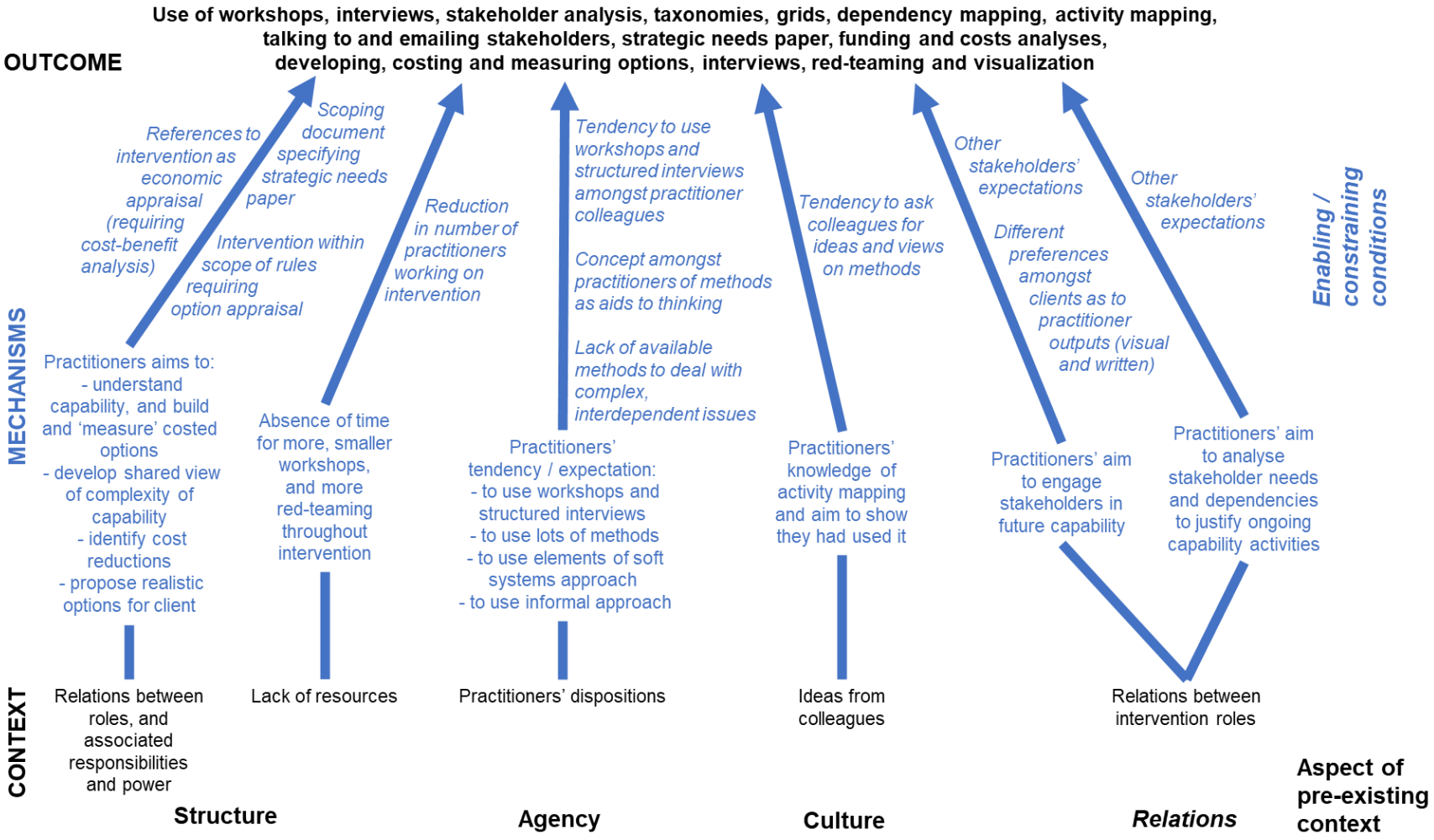


Figure 34: Mechanisms of method choice - case 3

Case 4: Review of options for the future organizational model and governance of an organization comprising a number of national capabilities

Case report

Structure: Practitioners working in a government policy team were tasked with reviewing an organization comprising a number of national capabilities. They were to respond to specific questions from government guidance for this type of project and from clients about the future need for and delivery of the capabilities, and the organization's sourcing of 'services and supplies', governance, and executive management. The aim of the project was, 'To recommend the most appropriate [organizational] model [...] that delivers the [required services] and offers best value' with governance to 'maximise transparency and accountability' (scoping document).

Practitioners would consider examples of organizational models used in government 'that could be applicable', and implications for different functional areas of the organization. The team would produce a shortlist of options and a set of assessment criteria in an interim report. Practitioners would then compare the shortlist of options and produce, 'A final report with accompanying cost/benefits analysis' of the options, include recommendations on governance and organizational policies aspects, and an implementation plan (scoping document). The project team were to use evidence, including from previous reviews of the same organization, latest government policy and guidance, and other ongoing, wider strategy work.

The organization 'wasn't doing anything different to what it had always done' and had 'grown because of its success over the years'. However, some change to the existing organizational model was required because of a change in government rules, and other change was required because of a recent ministerial decision following a wider strategic review. The scoping document was approved at the highest levels in the government department. The project was expected to be delivered in a short amount of time and expected not to have a surprise outcome.

Culture: In developing their scoping document, the team had consulted government guidance and the government organizations that owned that guidance for this type of project as to 'what needs to be covered', and looked at how similar projects for the same and other organizations had been scoped, and 'their methodology'. According to the scoping document, and reflective of government

guidance for this type of project, the team would 'engage widely' with stakeholders of the organization (inside and outside government, and in other nations). Government guidance stated that strategy tools 'such as SWOT analysis and gap analysis' were potentially useful for this type of project. The project team produced a project plan, which was approved by a steering committee set up for the intervention, representing key stakeholders.

Structure: Practitioners undertook documentation and literature review to gather 'factual information' about the organization (such as breakdowns of revenues and activities) and its services that they used to answer questions from the scoping document and, later, as input for systems and financial analyses. 'In order to effectively evaluate the options', the project team 'identified, a range of options [...] that [the organization] could have'. These models were taken from the team's research into available organizational models in government guidance and from talking with experts across government, and individuals in 'organizations that were that particular model' who understood how the models operated in practice. The team approached comparative organizations that had been the subject of recent projects of the same type where the organizational model had changed as a result, to understand current models and why changes had been made.

Agency: Producing a stakeholder engagement plan was one of practitioners' first activities, because 'absolutely fundamental to the project plan, to our approach, was to have that heavy consultation phase across the [the first months], and then to do the detailed analytical work after that'. Practitioners explained,

> [...] When you're working in a policy team, where they don't generally work in that rigorous, scientific way, it tends to operate a bit differently. [...] So, it's more of a qualitative approach, and a lot of it focuses on, gathering opinions of the stakeholders, and that consultation process. And again that's quite normal for a piece of policy work, is you consult.

The team used their knowledge and past experience to identify individuals and 'the type of things that they're going to be interested in understanding about' the organizational model. Interviews were designed to be a two-way process, and with some information sent to interviewees in advance (including the scoping document).

Relations: The team sought written evidence of some points, and undertook structured interviews and meetings with stakeholders, including capability users, to test the team's understanding and findings, socialise ideas, engage stakeholders, and build consensus and buy in to recommended

options. Throughout the intervention phase, the team leader provided regular updates at meetings of the organization's board, and used the opportunity to check the board's views were 'properly' reflected in intervention outputs (scoping document, interim and final reports).

In interviews, the team sought views on the organization now and in future, and views on the impact of changing its organizational model, explaining to individuals the work they were undertaking, what different options might be, their strengths and weaknesses, and seeking views on what the future model should be. Interviewees were asked about benefits they obtain from the organization, their requirements of the organization, and what they would like to see changed. The project team took notes during interviews and wrote a summary of each interview after the event.

Structure: The documentation and literature review and stakeholder consultation informed practitioners' development of organizational models (options). The team also sought to understand and illustrate evidence on the impact (positive, negative or neutral) of different organizational models on key issues for the organization (some of which had been identified in an earlier phase of the project), including workforce planning and capital investment. 'To effectively evaluate the options', the project team identified –

> [...] a set of criteria and principles [... . ...] trying to set out, what are the important, characteristics of the model, that we need to look at all of the models against, and they ranged, everything, from capital investments, people aspects, how they would impact operationally on the ability to do [organization capability activities], international relations, there was a number of them, so we got the [steering committee] to endorse those characteristics and those principles, and we could then be able to do a, mixture of quantitative and qualitative assessments against those characteristics, for each of the chosen models. So that was the reference framework [...]

The principles were '[...] a number of bullet points [that] said, this is what, all the stakeholders tell us they want the future of [the organization] to be'. The project team had developed an initial set of success criteria and 'the evaluation methodology' in an 'internal' [team] workshop, which they refined and added to with findings from stakeholder interviews and visits. The project team then workshopped and analysed thematically their findings between themselves, before including them in the interim report. Within the project team,

> [...] we did a sort of gap analysis saying, 'OK well we've got this information from these individuals, we've got this information perhaps from the documents, here's where either it doesn't stack up or, we've got a bit of a hole that we need to fill which we haven't quite got the information or we should have asked that question [...]

Practitioners developed a scoring mechanism (two points for a 'Benefit', zero points for 'No Change' and minus two points for 'Negative Impact') to 'measure' options against the success criteria in the form of numbers, rather than words which could 'lead the witness'. The interim report listed 'Possible Measures' and data sources against each criterion. The scoring was to be used to differentiate between the options for making final recommendations to the steering committee. Practitioners commented,

> [...] it's that, classic thing of, we the team felt that probably the first draft of the criteria were, in about the right place, but, what was more important was that they landed with all of the main stakeholders and that the stakeholders would recognise them as well so that they made sense, in terms of what they told us through the consultations. [...] we were also looking for confirmation as well so lots of the customers kept telling us very similar things, which is good because that meant we had a strong evidential basis for moving forward [...]

In the interim report, the project team sought approval from the steering committee of their proposal to eliminate certain, more extreme options and the 'set of criteria' and 'principles' for assessing options. These were 'signed off by the [steering committee]'. The remaining 'potentially viable options' were to be considered further by the project team ([steering committee] minutes). Practitioners commented:

> [...] we, had a good evidence set [from the consultation exercise] that said [a small number] of these options are just not feasible. And there was pretty good agreement with that at the steering group, but they also gave us a steer in terms of which of the remaining [small number of options] they thought were the, more likely and the less likely, and that inevitably focused the analysis for the second part of the [project]. And that, again that's quite a common thing in a piece of policy work [...]

In fact, '[...] the scoring didn't come out too far apart anyway but that was, the intent'. After the interim report, the team undertook further stakeholder consultation, including workshops. They asked questions about possible models and ways of operating in interviews with stakeholders and customers, and further tested their evidence:

> [...] it was a mixture of, interviewing various people, so, bodies that were involved in that, or used, those models. Talking to, stakeholders and customers, going back to some of them around, 'OK, if you provide this, what are the, what concerns would you have, will it address this issue, can you think of any other issues that might arise from this?' so, it was trying to understand, a bit more, in [the organizational] context how some of those models might operate, the issues that people might face, how, certain risks might get mitigated or, not in certain models.

Relations: The project team had become smaller. Stakeholder consultation now included practitioner-devised and -facilitated workshops engaging leaders from the organization:

> I got [a small number of [real]] organizations that each represented one of those [remaining] models, and I split them [the organization workshop participants] into groups and said, 'Here you go, this is [the organization] in the future you tell me, you know, what's good and what's bad about being a [...] leader, in that organization, in the future. [...]
>
> [...] I had a choice of, well, we could do it theoretically, we could do it more realistically. And I decided to go for the more realistic option because I think it was just a bit more engaging, and people could relate to it more [...] But the value of that was that it was real. [...] and that brought it to life for people, [...]

Structure: In preparation for the final report, the project team prepared a more detailed policy analysis of benefits and risks of options shortlisted in the interim report against the principles and success criteria. In practitioners' words:

> [...] So, what you have at the end of it is that fairly superficial table. Well it looks superficial on the face of it. But there's a lot of detail underneath it in terms of the consultation we did. And if you multiply 30-odd stakeholders or however many we had, certainly across the [small number of] models that gives you a sense of how much, we covered.
>
> So, for each of the models that we identified, we, characterised what that model would look like for [the organization]. So, how would [the organization] operate under that, particular model. So for each of these we effectively set out a very top-level organizational design. And then [...] for each of those models, we did an assessment against the criteria as to whether it was a good fit or a bad fit, [...]

In an earlier phase of the project, systems thinking practitioners had created a benefits diagram to show how the organization supported different elements of departmental policy. Elements of the organization were mapped to higher departmental-level outputs and benefits, with the name of the most recent departmental strategy at the top of the diagram. Elements relating to the organization were grouped, hierarchically, by themes relevant to the project – specific capability activities, 'Support Functions', and other features of the current organizational model. Colours were used to code map elements where there were there was a risk that change to the organization's model as a result of the project could have 'a quite substantive effect on the situation' or 'the effect would be, significant but probably not, as substantial'. Practitioners had considered which organizational elements could be changed in a move to a new organizational model, 'how is that likely to ripple back up through the system', and what supporting evidence was available, for example from comparative organizations. They considered whether they had evidence that changing the way in which specific features of the organization (e.g., pay) were managed (in moving to a different organizational model) would affect the performance of the organization, and which changes were possible.

This systems map was part of an approach systems practitioners had used successfully before where they had mapped part of a failing organization, explained the map in 'big meetings' with senior people in that organization, and started to weight and score elements of the map. Practitioners explained,

> [...] so the question is, OK so what levers do you have that you can pull that can make changes to the way that, you're delivering? And, how important are those levers? [...] it was a way of starting to get people from both, aspects of the problem to understand where the real issues are.

This led to 'big learning moments' and was considered 'quite a good way of getting people from different aspects of the problem to all talk around. It was a tool that enabled people to understand where each bit fitted together'.

In this project, practitioners decided to use this systems work to inform work on risk management for the final report. Systems practitioners simplified the diagram, effectively summarizing and highlighting key, relevant high-level departmental elements that could be adversely impacted by a change to the organizational model. They then created different versions of the diagram for the different shortlisted organizational model options, with brief descriptions of 'risks posed to achieving the goals/outcomes, by each of the models'. The risks were positioned with the relevant elements in the diagram, to show 'where your risks are going to come from [...] why the risks are going to come from there, and [...] how they play back up through the system.' to departmental-level benefits. Practitioners explained:

> [...] And it was just to try and give us another angle on the risk piece between, the preferred models, the two that we were focusing in on. Just to really try and make sure that our thinking was, almost validated, or going down the right track and we hadn't missed anything. [...] So we did have that more analytical underpinning.

Overall, the project team's analysis approach was, 'trying to get, [...] the mix of factual information, some quality quantitative information that we could put into [option costings], and then the whole series of qualitative and subjective assessments, information which we could judge against the other criteria.' Costings of options, which practitioners outsourced, were presented in practitioners' final report as additional evidence of 'benefits and disbenefits' alongside the team's policy analysis of options. The costings were 'a tool which is, well-understood, well-respected something which people are familiar with, it was, quite key. So, [...] that's one of the reasons why we selected, that as, part of our analysis toolkit'.

In their final report, the project team recommended one of the shortlisted options on the basis of lower risk and cost. The team included a table of risk classifications, i.e., colour coding of risks against the principles for each of the shortlisted models, that they had compiled using data from the documentation and literature review, and stakeholder consultation, including workshops. Their report contained other recommendations, responding to questions in the scoping document. There was some debate amongst steering committee members around some of the risk classifications. Once the steering committee was happy with the report and recommendations, the report went to 'the ministerial [oversight board], and then ultimately to, to the minister for a sign off.'

Mechanisms of method choice

Method choice mechanisms for case 4 are illustrated in Figure 35 below.

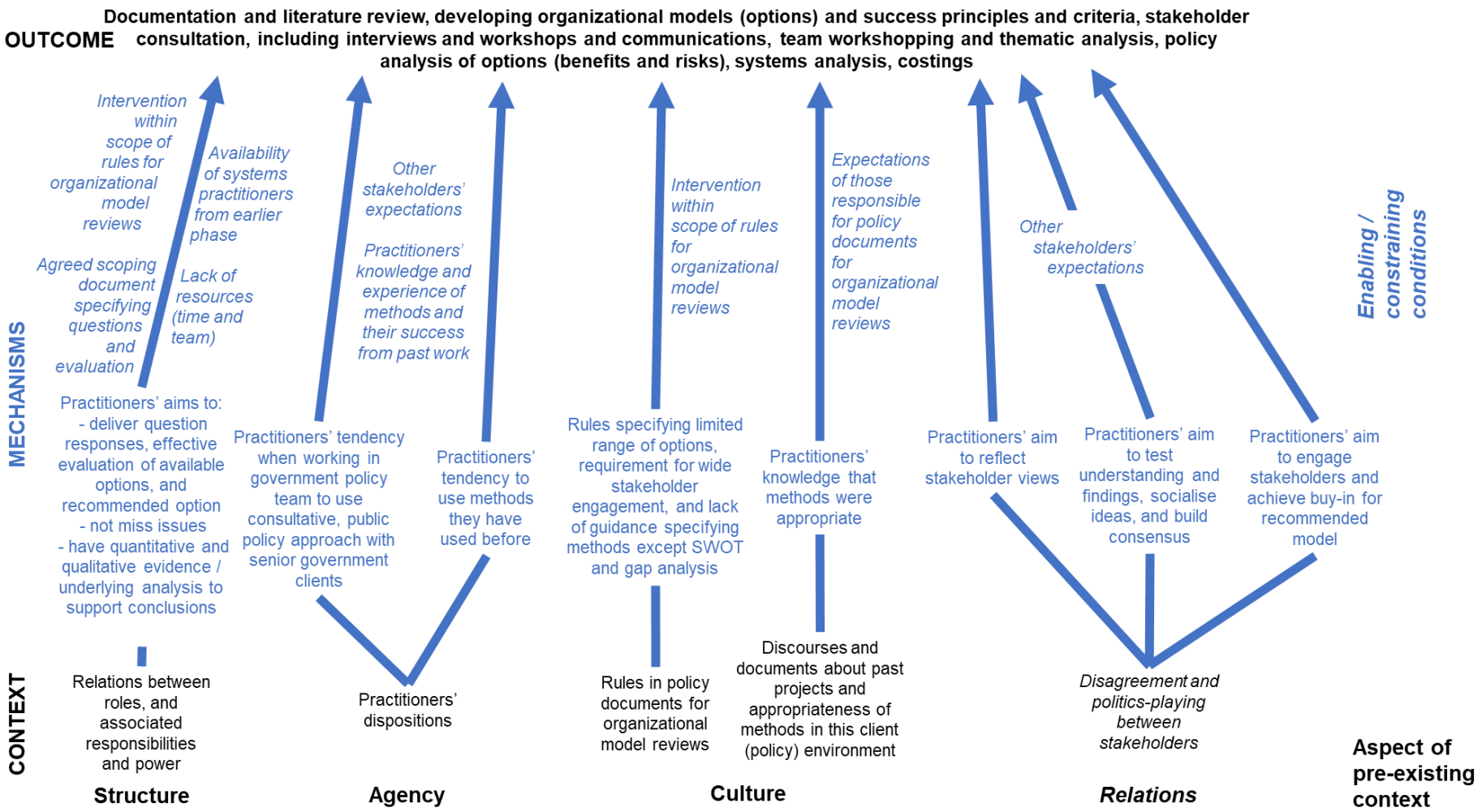


Figure 35: Mechanisms of method choice - case 4

Case 5: Review and prioritization of options for the future technological configuration of a national capability

Case report

Structure: This intervention was part of an overarching project, led by a national capability as client, to consider options for future delivery of the national capability, in anticipation of a new, wider organizational strategy. In previous phases of the intervention, practitioners had worked with capability stakeholders, outside consultants and industry representatives. They had generated data about: the current and planned future capability (including performance data, costs, and key capability gaps in future years due to equipment going out of service); future requirements from the capability; future equipment products (including their availability and performance); an initial set of options for potential new equipment configurations (including associated performance data); and, issues. These were used in scoping and carrying out their work.

In this intervention phase, practitioners were to assess further the future planned capability, identifying gaps and risks against requirements (developed in earlier phases, and from policy), and gaps that could be mitigated. They were to define and prioritize options for the technological configuration of the capability, balancing costs and risks, looking out over a defined period of more than ten years.

As captured in the scoping document they produced, in this phase, practitioners were to look at the possibility of adding a new type of equipment when existing equipment went out of service (in a particular year, identified in previous project phases) and compare it with other types of equipment available. They were also to look at the possibility of extending the technological configuration of equipment already planned to come into service, and/or acquiring the new type of equipment in a more affordable way so that it could be acquired earlier. They needed to consider the timing of the introduction of equipment and opportunities for reducing or smoothing costs across years.

In an earlier intervention phase, when practitioners had less time and fewer data, there had been a lack of trust in practitioners' output, and suspicion that a particular model of equipment had been targeted. Practitioners had run a mixed integer linear programme (LP) and reviewed results with

stakeholders. Intervention stakeholders had not questioned the 'quite complex' LP, but rather why equipment options had been rejected.

In this intervention phase, stakeholders sought a 'hard', quantitative approach, that also informed decision makers about risk. Intervention stakeholders were not looking for one recommended option, but instead to explore a range of options. One practitioner commented that project stakeholders, '[…] wanted the problem broken down into truisms that everyone could agree with, build that up through some sort of independent approach rather than […] go in at that macro level where [there were] lots of diversions of opinion'. In this intervention phase, clients wanted a comparison of the cost-effectiveness of options, and not just a ranking, because in a future intervention phase practitioners' analysis may well be required to satisfy assurers as part of a business case approval process (as in case 1). Practitioners explained,

> […] starting from the end of [the earlier phase], so we thought not LP [linear programming]. Other [portfolio appraisal] approaches like MCDA again people wanted a sense of, they didn't want to, put things in relative measure they wanted to understand some of the context for them. […] So things like the other classic approach MCDA just were a bit, soft. They wanted something hard. We knew that it couldn't be a linear programme so we weren't going to get into mathematical programming, or goal programming. So we, started out thinking we'd take a combinatorial approach. […]

Relations: There was disagreement and politics-playing between stakeholders, which influenced practitioners' approach, and was a challenge in terms of managing the scope of the project. Practitioners worked regularly with two stakeholder committees set up for the intervention, which comprised representatives of capability user groups, and were chaired by clients (capability leaders).

As an early step in their analysis in this intervention phase, practitioners used technical colleagues' conceptual modelling of equipment types, and findings on future capability requirements from earlier intervention phases, in generating **high-level approaches to mitigating key capability gaps** expected to result when equipment went out of service in future. They matched equipment types to subsets of future requirements they could deliver. This was to define – for comparison and costing – a broad range of ways in which future capability gaps could be mitigated, i.e., different combinations of different types of equipment replacing outgoing equipment. The high-level approaches were reviewed by a stakeholder committee for inclusion in practitioners' scoping document. The high-level approaches facilitated the building of feasible options for the technological

configuration of each of the different types of equipment (including the new type of equipment) in line with organizational policies.

A **spreadsheet model** was developed in Excel to generate, assess and cost options for mitigating future capability gaps, building on data and calculations from the LP from the earlier intervention phase, and using input data and spreadsheets from earlier intervention phases, technical colleagues, and outside consultants. The model did not apply or use output from the LP. Instead, practitioners added 'data generators', including 'rules' provided by technical colleagues for combining equipment. The spreadsheet model scaled combinations of equipment to requirements (for the capability as a whole) across different scenarios, in line with the high-level approaches. This included consideration of fixed and variable configurations of equipment, different staffing assumptions, equipment performance data, and associated cost implications. Practitioners described that,

> The option space we looked at, was broken down very much into, it wasn't a full-on, morphological analysis, but it [was] like a mini one so in essence we looked at what really drove, what really mattered, what combinations mattered, and broke that into e.g. [different types of equipment], [...] and looked at every single combination, got rid of the ones that didn't make sense and ended up with what we left. That list was [hundreds of thousands of] options. So we thought we're not going near an LP with that. So, quite happily, [...] it was actually, relatively simple as an optimization problem it wasn't complex, local minima didn't really exist [...] for example so we thought let's just brute force it, and literally throw them together in a whole series of combinations, so we designed a new little Excel tool which looked at every single combination, put them together in various [capability formats], costed them, and that was the core of our approach.

Practitioners' spreadsheet modelling was designed to provide a transparent, auditable approach, and evidence as to why options were not recommended, as well as evidence of recommended options. The modelling allowed for a broad and changing scope in terms of the (number of) options under consideration.

Agency: Practitioners described LP and combinatorial approaches as 'our comfort zone' for this type of situation, and as methods they were expert about. Practitioners were also used to scaling equipment to requirements across different scenarios to produce a technological configuration for future capability requirements.

Practitioners conducted **workshops** to generate and review inputs and assumptions for the spreadsheet model, and to review findings from particular aspects of the work. Workshops were

conducted with the senior stakeholder committee, who gave 'direction', and with the more junior working committee. Other subject matter experts also provided input. Practitioners described that,

> In terms of the actual approach [to facilitated workshops] we used several approaches. Some of there were very, open, like, 'Here's a list of assumptions', 'Let's talk about them'. Some of them were a bit more structured, so, it tended to be driven, mostly by, what the scale of the question was. Very open questions [led to] very open approaches. Where we had, received wisdom, you just write it down and then get people to endorse it. Where it was you didn't know the answer we, did one or two things either, probe it, saying, 'This is what we think' or just ask an open-ended question. [...] they were, structured but they weren't using any formal soft methods.

Practitioners reported for their work in this domain, 'to have got ourselves into a position where we rely on two or three soft approaches [judgement, expert workshops, benefits analysis] and a couple of models'. Practitioners did not tend to try new methods due to risk aversion because 'failure isn't an option'. An existing broad-scope **discrete event simulation (DES) model** was used with data on equipment characteristics to analyse potential operational risks associated with different options for the overall configuration of the capability (i.e., the management and use of combinations of equipment), with input from subject matter experts.

An iterative approach was to be taken to identifying the most cost-effective (overall) options for mitigating future capability gaps. According to practitioners' scoping document, a range of sets of candidate options would be generated at different cost or performance levels. Each set would contain options ranked by cost-effectiveness and risks (technical, supplier, and relating to equipment management and use). Earlier opportunities to introduce a new type of equipment or extend already planned equipment would then be compared with the ranked options in order to identify additional costs and risks and re-rank the options. A final ranking would be undertaken incorporating other risks and caveats from a workshop with the senior stakeholder committee following a briefing on the re-ranked options.

After each ranking, each set would be reviewed to identify its defining characteristics, risks, benefits in terms of risk mitigation, costs and cost profiles, and dependencies. These would form the basis of practitioners' outputs, which would take the form of a range of ranked options for the technological configuration of the capability over time, with indicative costs and risks (including benefits of more expensive options), and trends identified in terms of types and configurations of equipment and acquisition methods. Practitioners' report included **qualitative findings** regarding, for example, legal and financial ways of acquiring equipment. The final report included some **data visualization**

in the form of graphs. Delivery of work by practitioners involved **red teaming** by a group of advisors established by the client.

Mechanisms of method choice

Method choice mechanisms for case 5 are illustrated in Figure 36 below.

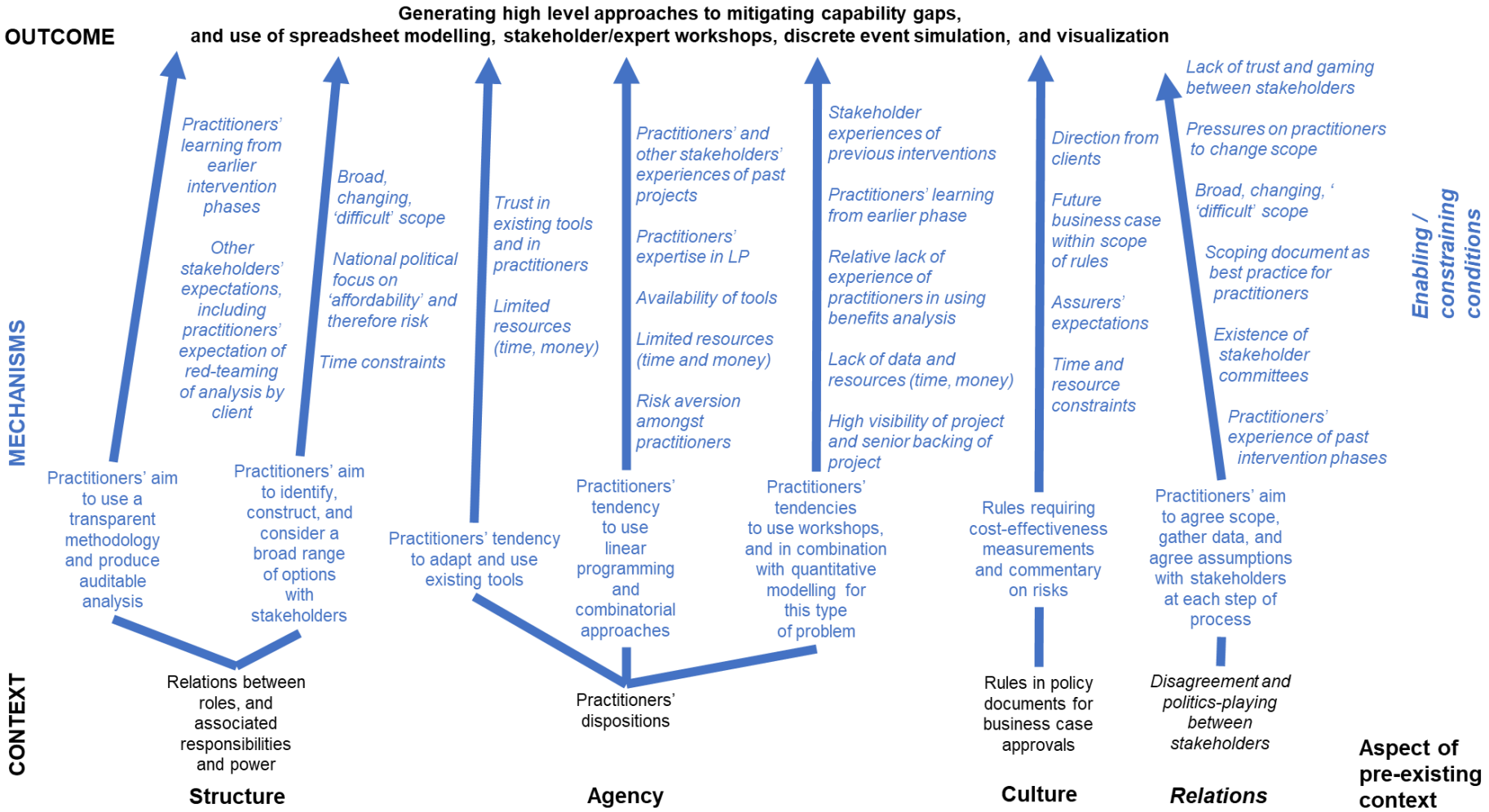


Figure 36: Mechanisms of method choice - case 5

Reasons for not using problem structuring methods or soft systems thinking

Given the interest in this research in using qualitative and quantitative OR methods, and the lack of widespread use of PSMs amongst survey respondents, it is interesting that practitioners did not use PSMs in these interventions. Practitioners addressed strategic issues that could be considered the sort of wicked problems or messes for which PSMs are considered appropriate. In all cases, there were conflicting interests across stakeholders. PSMs could have been used in workshops and for engaging organizational stakeholders, 'as a way of dealing with a range of qualitative views within a process of change' (Hindle, 2018, p. 7). In response to RQ2, I therefore looked further at reasons case practitioners reported for not using PSMs.

Many practitioners did not use PSMs because they were not trained in them or they did not have experience or confidence in their use (at least at the time of the intervention), despite their confidence in and tendencies to use workshops and structured interviews. In two cases (4 and 5), lack of time and lack of access to senior stakeholders were given as additional reasons as to why PSMs were not used. However, across the cases, practitioners tended not to be tasked with – or see their role as undertaking – the extent of exploration of purpose or problem framing associated with use of PSMs.

In case 1, practitioners were not asked broadly about how clients should deliver a capability in future. Rather, clients were looking for evidence to support a *continuing* capability as 'a good thing to do', together with some improvements to the capability where things were not working well, and making it fit for future government needs. More specifically, clients sought 'an underwritten and assured process to distinguish between the various options'. One stakeholder summed this up as follows:

> There was a feeling that a lot of people, [the clients], knew what they wanted, and they just wanted more of the same so, there's a feeling of 'oh this is just a hurdle to be got over'. That's a slightly depressing attitude but it's not an uncommon one sometimes, when project teams are very clear on, what they think the answer is, and sometimes the role of the [OR], is actually to challenge their preconceptions, and actually to point out that, their pet solution is not the only one and may not be the best one. But there was a bit of a feel[ing] in this case that [practitioners] were doing the study in order to prove that 'yes carry on as we are is a good thing'.

In case 2, practitioners were specifically tasked with speaking with a third-party commercial company in order to answer the client's questions about possible enhancement of capability processes. It was only in a later intervention phase, when working alongside systems thinking

practitioners, that practitioners used SSM to consider higher-level purpose for the capability as a whole in order to focus their recommendations.

In case 3, practitioners drafted a scoping document for the intervention, which specified 'structured conversations' with capability stakeholders, as well as a paper of high-level assumptions regarding strategic needs (taken from policy documents). However, the scoping document was compiled by triangulating clients' inputs rather than exploring problem frames with clients. One practitioner summed this up as follows:

> [...] we [practitioners] were getting so many different viewpoints, and so hence why we got numerous versions of it because we were trying to, you'd do it once and then, it would go round and, by the time you've got [a number of] people look at it, they've all got a different opinion of what's right and what's wrong, so, that was more a process of iteration until everyone was happy, or moderately happy, across the board. So it was more a, trying to get consensus than particularly a lot of thought going in from our side. Are we interpreting what you are saying right, are you all agreed? It probably wasn't as us-led as much as it should be.

In case 4, practitioners did not consider they were addressing a wicked problem and therefore did not see a need for PSMs. Rather, they considered that they were tasked with specific, well-defined questions documented in the scoping document, and to investigate the best amongst a number of options set out in government guidance, 'So, short of coming up with something completely new and radical, which would have been interesting but probably unviable, those kind of techniques ['broader, softer methodologies'] probably, weren't needed in that sense'. This was backed up with comments from a senior civil servant interviewee about the case:

> [...] we were doing the review because it had to be done, rather than because there was a need for fundamental change. [...] so where this interim report that says we agreed that [one option] should not be considered further, this was me saying [...] don't get distracted, by asking radical first order questions, if, basically the thing works. You know we've only got so much time, let's address ourselves to the complex first order principle questions, to things that are appropriate. So that was the steer I was giving. [...] So the feeling was how could we, keep it [the organization], as much, as possible like it was [...]

In contrast, in case 5, practitioners described the nature of their work at the beginning of the initiation stage as, 'Unbound, and difficult to scope and, [with a] challenging stakeholder base'. However, rather than using PSMs, practitioners used other methods for scoping and undertaking their analysis that were less risky because practitioners were more familiar with them, and because practitioners sought stakeholder acceptance of their recommendations and there was a lack of trust amongst those stakeholders regarding use of stakeholder judgement.

However, overall, there was evidence in practitioner interviews of greater awareness of systems thinking amongst OR practitioners than captured in previous research. In the one case where systems mapping was actually used, this had resulted from practitioners with such skills being available. And in interviews for three of the cases, practitioners expressed a desire or tendency to use systems thinking methods that they had since been trained in or were learning 'on the job'.

Use of methods as problem structuring methods

In response to RQ2, I also considered the extent to which practitioners used other methods *as PSMs*. This is an issue that has been explored recently in relation to a number of interventions (e.g., Harwood, 2020; W. Jones et al., 2022; Lami et al., 2014; Leong et al., 2023; Lowe et al., 2016; Yearworth & White, 2014) and methods (e.g., D. F. Andersen et al., 2007; Bell, 2012; Belton & Stewart, 2010). First, I compared case data on practitioners' methodological designs (summarized in Figure 26 to Figure 30 above) with dimensions of PSM use identified from reviews of PSM literature by Yearworth and White (2014, Table 1, P1-9; 'YW') and C. M. Smith and Shaw (2019, Figures 5-9, Q1-13; 'SS'), focusing on dimensions that distinguish use of PSMs from OR modelling generally. Assessment involved considering each of the cases in turn, and then coming to an overall conclusion across the cases (Table 80 and Table 82, Appendix V).

In summary, there were a number of indicators of PSM use across the cases. Practitioners acknowledged and worked participatively with different subjective views and interests of stakeholders on strategic issues. Disagreement between stakeholders influenced method choice, with practitioners acting as facilitators in workshops and interviews (sometimes with visuals and/or sticky notes). Across the cases, practitioners sought buy-in in relation ways of proceeding and/or to their findings. They sought 'politically feasible and implementable' recommendations (SS, p. 408, after Checkland, 1981) within the constraints of providing recommendations based on some form of cost-effectiveness analysis. Further, in relation to the modelling in cases 1 and 5, there was particular emphasis on achieving transparency in the modelling process. However, with the possible exception of the systems analysis in case 4, practitioners did not represent stakeholder views in the sort of qualitative, diagrammatic or systemic models seen as characteristic of PSMs. As a result, it is difficult to argue that case practitioners used methods as PSMs as defined by YW and SS.

In SS (Table 82, Appendix V), most of the PSM characteristics reference ways in which qualitative, diagrammatic models are built and used, including with stakeholders, so the lack of such modelling represents a major stumbling block to an interpretation of PSM use in the cases. Even in cases 1 and 4, the extent to which participants were involved in model building as opposed to data generation and testing was limited, and the structure of the models provided constraints on which and how stakeholders' views were represented.

In relation to the PSM propositions in YW, in addition to the requirement for systemic modelling (the 'Systemic approach' proposition Table 80, Appendix V), the key stumbling block to an interpretation of PSM use was the extent to which multiple worldviews were reflected in practitioners' 'process[es] of problematisation' (the 'Worldviews' proposition). For practical reasons, case practitioners' problem framing (or problematisation) tended to reflect a subset of stakeholder views, and generally privileged questions constructed by or with clients (see Table 81, Appendix V, for further analysis on this point). In other words, practitioners tended to frame problems with clients, or at least privileging their views, and then analyse and/or model one framing with the involvement of a wider group of stakeholders, as illustrated in Figure 37 below. Decision options were generally either largely defined or constructed prior to wider stakeholder workshops and interviews (cases 1, 4 and 5), or constructed after workshops and interviews in which a consensus view of an existing capability was sought (cases 2 and 3; see Table 79 and Table 81, Appendix V). We can also contrast the use of MCDA in case 1 from use of MCDA as a PSM as described by Belton and Stewart (2010, p. 234-235). The number of different problem frames considered in workshops and interviews was limited.

This general approach in the cases (Figure 37 below) is similar to how the hybrid VSM/HPM method reported in Lowe et al. (2016) was used in that government intervention, where,

> The [VSM/HPM] method only acknowledged and worked with different worldviews in as far as reflecting the differing degrees of belief in the performance of the functions in the model. The model structure, however, was fixed and thus could not reflect differing views about system structure (although it was developed and adapted in response to stakeholder perspectives elicited during group and individual consultations). In this regard the method could have constrained representational thought. (p. 7)

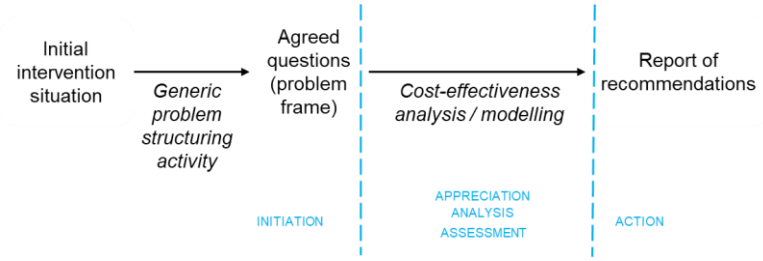


Figure 37: Illustration of general form of interventions (cross-case, simplified)

Lowe et al. (2016) concluded that capturing stakeholder views using a systemic VSM/HPM model that had framed the situation in a particular way was not a barrier to VSM/HPM being considered a PSM (they considered the 'Worldviews' proposition 'PARTIALLY TRUE' [p. 7]), however in the cases in this study, practitioners did not tend to undertake systemic modelling (so that the 'Systemic approach' proposition was not true). In Lowe et al. (2016), the 'Systemic approach' proposition (undertaking systemic modelling) was considered 'PARTIALLY TRUE' because VSM and HPM are systems thinking methods, even though practitioners did not take a formal approach to scoping their intervention using boundary critique. Overall, therefore, and in contrast with the cases in this study, Lowe et al. considered their VSM/HPM method a PSM on the basis that both the 'Worldviews' *and* 'Systemic approach' propositions were 'PARTIALLY TRUE'.

Second, I considered Franco and Rouwette's (2022, Table 23.2; 'FR') more recent set of criteria for PSMs based on Rosenhead and Mingers (2001b). The FR criteria focus on characteristics of 'tools and the processes' of PSM use, and not on 'products' such as stakeholder learning and agreed problem frames (p. 740). The FR criteria highlight, for example, that PSM interventions are iterative and phased in a way that the modelling in cases 1 and 5 was not. In those two cases, practitioners worked through the stages of their analysis in a more sequential way, and needed to complete all stages of the modelling process for decision makers to make conclusions because cost-effectiveness analysis was required by clients. The use of MCDA in case 1 can thus also be contrasted with the value focused thinking or decision conferencing that Franco and Rouwette (2022, Table 23.3) consider a PSM. However, across the cases, again, the lack of qualitative modelling and the lack of wide stakeholder involvement in problem framing were barriers to PSM use according to the FR criteria, notwithstanding that practitioners used simple tools in facilitated workshops to involve stakeholders

in shaping their analysis (Table 83, Appendix V). In summary, the multiple case study data supports that practitioners did not use PSMs. Nor did they use other methods *as PSMs*.

6.2.10 Why practitioners use multimethodology

We now move to the results in response to RQ2 on why practitioners use multimethodology. Across the cases, practitioners expressed a range of reasons for using more than one method in a project. In all cases, analysis of the effectiveness of decision options was combined with option costings. In cases 1 and 5, practitioners calculated the cost-effectiveness of options as required by rules in policy documents applying to the cases. In cases 2, 3 and 4, practitioners presented options costings alongside their effectiveness analyses, reflecting a more general requirement for option appraisal in government analysis (HM Treasury, 2003).

In case 1, practitioners included a significant amount of qualitative analysis alongside their quantitative MCDA results in order to explain different stakeholders' issues with different options (expressed in workshops and interviews), and back up some of the points practitioners wanted to bring out, as well as their recommendations regarding how to address stakeholder concerns and disagreements. Practitioners analysed and reported more qualitative data than in other similar projects in the research context. However, this analysis was largely removed in their final report for the business case.

In case 2, practitioners conducted a workshop in order to obtain a more complete and consensus view of existing government processes and responses to questions set by the client, and to engage stakeholders who may be part of future change. In case 3, practitioners tried different methods to analyse the detailed data they gathered from workshops and interviews in order to develop options for the capability as a whole that they then costed and compared with strategic needs. They later added interviews and red teaming to check the feasibility of their recommendations (compared with other government options), and so they could tailor their reporting to stakeholders.

In case 4, practitioners' final report included recommendations and options (organizational models described and costed, with risks colour-coded for each option against principles for success). Practitioners had used systems analysis alongside their analysis of benefits and disbenefits of options to provide additional evidence supporting risks identified in their final report and, in part, because

systems practitioners were available to assist. However, like practitioners' scoring of benefits and disbenefits of options, the systems analysis was considered underlying evidence and not included in their final report.

In case 5, practitioners used workshops in order to generate data, test assumptions and review findings from their spreadsheet modelling with stakeholders. Practitioners added DES to identify operational issues arising from their findings. Practitioners reported that they tended to use modelling plus a qualitative approach in interventions with the same subject matter.

In summary, in all cases, practitioners appeared to add methods in order to respond better or more comprehensively to stakeholders' questions or project requirements. Often, stakeholder engagement or buy-in was also sought. These points were reflected in two of the practitioners' survey responses about why they used multiple methods in their example projects:

> To enable the most effective approach to the problem at hand, taking into account the data available and the stakeholder views. (survey, q5)
>
> One method does not guarantee the most useful and fully thought through answer/options. Using multiple methods adds extra layers of detail and perspectives that supports the customer in making a more robust decision or forward plan. [...] (survey, q5)

In cases 3 and 4, practitioners also added methods to try them out, to see if the methods could add to evidence for their recommendations. In case 5, practitioners used a DES model to consider options from another perspective (operational). Finally, in describing the interventions and in their survey responses (Table 76, Appendix V), all case practitioners described using multiple methods as a tendency in their work on complex or multi-disciplinary projects.

6.2.11 Causal complexity

Overall, in each case, structural and causal analysis resulted in identification of multiple, interrelated and interacting mechanisms of method choice, each emergent from aspects of pre-existing context. These aspects of pre-existing context – across structure, culture, agency, and their relations – were entities/structures identified in the realist ontology for each intervention (in structural analysis), which built on the generic OR intervention ontology developed in chapter 3 (summarized in Figure 31 above). Thus, practitioner method choice is shown to be causally complex. As Danermark et al. (2019) summarize in relation to the critical realist view of reality in the social sciences,

> … many different mechanisms are operating at the same time, and … the relation between the generative mechanisms and their effects is contingent: the outcome of the activity of the mechanisms – the events we can observe – is a complex combination of the influences from different mechanisms, some mechanisms reinforcing one another while others counteract one another's manifestations. (p. 221)

In other words, the theoretical framework and research methodology in chapters 3 and 4, employed and developed further in this chapter, have facilitated theory-informed description and causal explanation of the complexity of the process of practitioner method choice.

6.3 CONCLUSION

Practice in non-academic settings has long been underreported, and there are few published examples of UK government practitioners combining qualitative and quantitative methods, despite the claim that it is commonplace. Accordingly, in this chapter I reported a multiple case study of combinations of methods used by practitioners supporting strategic decision-making for or on behalf of the UK government, providing new evidence of the prevalence of multimethodology, methods used, the extent of their use in multimethodology, methodological approaches, and practitioners' explanations thereof.

The five cases reported in detail in this chapter all involved use of quantitative and qualitative aspects, however, the extent of use of quantitative and qualitative OR modelling was limited across the cases to participative MCDA, costs modelling, spreadsheet modelling, use of a DES model, and systems mapping. Practitioners tended to use general research methods, and in one case, policy analysis. The cases were also all participative in nature, with practitioners using facilitated workshops and often interviews to achieve acceptance of recommendations, and for stakeholder engagement and consultation, but not PSMs. As we shall discuss further in the next chapter, we found J. S. Morgan et al. (2017) and Christie's (2023) sets of multimethodological designs to be applicable to the cases.

Compared with previous studies, this study, and its underlying theoretical framework, provide a basis for an understanding of OR practice that moves from lists of dimensions that influence what practitioners do in interventions, towards a more theory-informed, causal understanding of the complexity of mechanisms (and the entities/structures from which they are emergent) that account for why OR practitioners use the methods and methodological designs they do. In the next chapter, I

bring together and review the results of the survey and multiple case study and discuss the main findings in relation to OR literature.

7 DISCUSSION

7.1 INTRODUCTION

Having presented the results of the survey of practitioners and multiple case study on the practice of OR in non-academic settings in chapters 5 and 6 in response to the research questions, in this penultimate chapter I compare the main findings with OR literature, identifying and interpreting the 'new knowledge' I have created (The Quality Assurance Agency for Higher Education, 2024, p. 27; The University of Kent, 2023, p. 13). I then discuss how the research in this dissertation contributes to literature in the burgeoning area of behavioural OR. I highlight my operationalization of critical realism in the new theoretical and methodological approach for evaluating the practice of multimethodology that I developed through the dissertation and employed in chapter 6 to provide causal explanation of practitioner method choice.

7.2 MAIN FINDINGS

> BOR [behavioural OR] researchers need to seek opportunities to collaborate with practitioners, as some already do, acting as observer, or being actively involved in the intervention, or helping to write the case up. (Ormerod, 2016, p. 518)

In this section, I summarize and discuss the main findings of the research in relation to OR literature by research question (RQ1 and RQ2).

RQ1. HOW DO OR PRACTITIONERS CHOOSE AND COMBINE OR METHODS TO SUPPORT STRATEGIC DECISION-MAKING?

In chapters 5 and 6, I responded to the first research question (RQ1) by presenting findings on the prevalence of use of multimethodology by practitioners (section 7.2.1 below), and by describing the methods practitioners use and combine (section 7.2.2 below), and the forms of multimethodology practitioners use (section 7.2.3 below).

7.2.1 Prevalence of use of multimethodology by practitioners

In the survey in chapter 5, most of 50 respondents supporting strategic decision-making in government reported that they use multiple methods in single projects most of the time. This was

backed up with 46 practitioners' 104 examples. Single method projects, while sometimes requested by clients (Ackermann & Howick, 2022), were associated by practitioners with simpler projects with limited time and scope, and use of previous work (Figure 12, chapter 5). The multiple case study in chapter 6 then provided in-depth evidence of use of multimethodology by practitioners supporting strategic decision-making. Across the cases, practitioners used different methods from different categories for different activities within and across different intervention stages (Figure 25 to Figure 30, chapter 6).

These findings are important because past research has not investigated the extent to which practitioners use multiple methods in their day-to-day work (section 2.10.1 above). This research therefore adds unique, empirical insights to the growing body of evidence that multimethod practice is commonplace and necessary for addressing complex, real-world issues (Ackermann & Howick, 2022; Dyson et al., 2021; Gomes Júnior & Schramm, 2022; French, 2022; Hämäläinen et al., 2013; Jackson, 2019; Mingers, 2015; Mingers & Brocklesby, 1997; Nastasi et al., 2010; NATO, 2012a; O'Brien, 2011; Onwuegbuzie, 2023; Ranyard et al., 2022; Wright et al., 2019).

7.2.2 Methods practitioners use and combine

Overview of survey and multiple case study results

Compared with previous surveys of non-academic practitioners addressing strategic issues, use and combinations of quantitative OR and management/strategy methods by practitioners was less predominant in this research. Compared with previous surveys, in chapter 5 we saw that lower proportions of practitioners reported using statistics, simulation, and forecasting, but that the extent of use of statistics in multimethod project examples was similar to that in O'Brien (2011). Lower use of optimization was also consistent with very few practitioners reporting use in supporting the strategy process in O'Brien (2011). Compared with previous surveys, much higher proportions of practitioners reported use of SWOT, scenarios, MCDA, and stakeholder analysis. Similar to previous surveys, the most combined management/strategy methods included scenarios, SWOT, and PESTLE. But in multimethod project examples, we found greater use of brainstorming, MCDA, CBA, project management, SSM, and VSM. And we found very high awareness and use of expert workshops, gaming, and historical analysis, which were not included in previous surveys, as well as stakeholder analysis. In multimethod projects, we also found high use of visualization, facilitation and

judgement, interviewing, graph/network analysis, and benefits modelling. In fact, quantitative OR methods (especially statistics, CBA, and simulation) were used most often with other quantitative methods, but then with expert workshops, scenarios, and historical analysis. We shall discuss these findings in more detail in the following subsections.

However, strikingly, the 104 project examples in the survey involved relatively less use of all of the most commonly combined OR methods across the 30 (mostly academic) practitioners' multimethod interventions in Howick and Ackermann's seminal (2011) systematic review of peer-reviewed OR journals (SSM, DES, SCA, SD, and SODA), although SSM and DES were in the top 20 methods in the project examples in this survey, and were amongst the top methods in their method categories (PSMs and Quantitative OR, respectively; Table 17, chapter 5). Overall, we found extensive evidence of the use of a broader range of non-quantitative methods in multimethod practice supporting *strategic* decision-making beyond academia, compared with Howick and Ackermann's review.

In the multiple case study in chapter 6, and as has been claimed is common in UK government OR, we found quantitative and qualitative aspects of practitioners' methodological approaches in all cases. As in the survey, we found widespread use of facilitated workshops, including with MCDA and with spreadsheet modelling. However, the extent of use of quantitative and qualitative OR methods was limited. Modelling, often seen as a hallmark of OR methods (Eden & Ackermann, 2006; Franco, 2013; Pidd, 2009), was evident in the use of participative MCDA with costs modelling in case 1, the spreadsheet modelling and use of a DES model in case 5, and the systems analysis in case 4. Otherwise, practitioners tended to use general research methods, and in case 4, policy analysis (Table 20, chapter 6).

Variety in methods used and combined

What is perhaps most striking about the project examples in the survey is the variety in the methods (Table 37, Appendix N) and combinations listed (Appendix T), as well as the subject matters (Figure 15, chapter 5), and times available (Figure 17, chapter 5). We found a great deal of variety across both projects and some practitioners, as well as evidence that some practitioners specialized in certain methods or types of method. Overall compared with previous surveys, in multimethod projects, practitioners used a much broader range of methods (quantitative and qualitative; Figure 19; Figure 20, chapter 5), nearly twice as many methods (Figure 18, chapter 5), and the same number or more

methods from each category. There were over four times as many different methods across the project examples (Table 40, Appendix O), and a broader range of quantitative and non-quantitative OR methods (beyond, and including, scenarios, statistics, SWOT, PESTLE, and financial modelling). Further, in contrast with Munro and Mingers' (2002, 2004) findings, we elicited 13 project examples with seven or more methods, over three-quarters of which included quantitative methods.

OR has long been recognized as a multi-disciplinary, applied discipline in which methodologically plural intervention is a requirement (Appendix B). Variety in methods used by practitioners has been seen in previous surveys (Clark & Scott, 1995; Munro & Mingers, 2002, 2004). Indeed, it was variety in methods used in published case studies that led Howick and Ackermann to conclude that, 'the area of mixing methods has considerable leverage and scope and is a worthwhile area for further development' (Howick & Ackermann, 2011, p. 508). However, the variety in the project examples in chapter 5 was considerably greater than in previous surveys, making the detailed presentation of 46 practitioners' 104 project examples in Appendix T a research contribution in itself. Notwithstanding that it was generated using a questionnaire rather than in-depth interviews, it provides 'a rich source for further analysis and the development of conceptual frameworks and ultimately theory' (Howick & Ackermann, 2011, p. 510). In fact, as we shall see in this discussion of the methods used and combined in this chapter, analysis in chapter 5 of the project examples in Appendix T highlights ways in which the use of OR in organizational strategy projects challenges existing definitions, categorizations, and characterizations of OR methods and OR itself (Dyson et al., 2021; Hindle et al., 2021; Appendix B).

Graph/network analysis, data mining/analytics and artificial intelligence

In the survey, we found that project examples with graph/network analysis or data mining/analytics, both quantitative OR methods not included in previous surveys of multimethodology, showed particular variety, including both quantitative *and* mixed projects. Their inclusion in question 1 in this survey likely facilitated the capturing of this aspect of practice. This new finding builds on historical accounts of the flexibility of graph/network analysis in combinations with quantitative methods and PSMs (e.g., Eden, 1989), as well as more recent academic case studies (Georgiou, 2012; Lienert et al., 2013; Scholten et al., 2015). For data analytics, in their literature review, Howick and Ackermann (2011, Table 1, Appendix B) found three practical interventions in which artificial

intelligence (AI) techniques or data mining were used with DES or SSM. Further, in Ranyard et al. (2015), one of the focuses was examining the growth of analytics in practice. The evidence of more operational and strategic projects in this survey shows that analytics (including pattern recognition and machine learning) is being used beyond the mostly financial and marketing applications in North America that Ranyard et al. (2015) reported (as an important finding), and with a wider variety of other methods. In fact, machine learning, AI and data science (including visualization) are recognized across OR as significant growth areas, with AI integrated in practice with a very broad range of quantitative and qualitative methods, including, for example, gaming and simulation, and system dynamics (Petropoulos et al., 2024), as well as participative, problem structuring approaches (Burger, 2024; C. J. Phillips, 2024; Sacco et al. 2024; Tan & White, 2024; White, 2024). The potential for AI to enhance practitioner method choice and use of multimethodology should be explored further. I shall return to this in the next chapter.

Cross-disciplinarity of methods used and combined

With OR techniques increasingly used across disciplinary boundaries, and beyond the discipline of OR, there is a pressing need to understand cross-disciplinary multimethod projects (Tolk et al., 2021), and this research captured some such practice from the perspective of OR practitioners. Overall, we captured a greater number of methods per project than previous surveys, partly because we captured a broader range of methods. In the survey, the average number of methods per project from each of the Management/Strategy methods, project management and PSMs categories was broadly consistent with previous survey results (for OR/MS practitioners generally in O'Brien, 2011), but it was higher in this survey for all other categories (Table 45, Appendix Q). The broader range of methods included general research methods (particularly interviewing), soft and consulting skills (particularly data visualization, project and programme management methods, and facilitation), stakeholder analysis, and methods from other disciplines (including historical analysis, engineering, and policy analysis). Greater use of methods in the project and programme management category in multimethod projects is perhaps unsurprising given that the use of such techniques has become widespread and institutionalized in UK government (UK Government, 2017).

Gaming and historical analysis

However, the extent of use of gaming and historical analysis are new findings. Gaming and historical analysis were used together in quantitative and mixed projects, and with methods from the Quantitative OR category (particularly simulation), and scenarios, as well as expert workshops, and MCDA. While both have been used in multimethod projects in government for some time (Mayer, 2009; Mayer & De Jong, 2004; A. P. Robinson et al., 2004), this survey is the first to attempt to capture the extent of their use in such projects. There is renewed interest in literature in the potential of serious games for multimethod projects (e.g., see Aubert et al., 2018), and this survey provides evidence for an increase in use within the UK Civil Service, where serious games have recently been promoted widely for policy design (Sabherwal & Sharma, 2022). Further, while historical analysis may be quantitative or qualitative, and we suspect was more quantitative in the project examples in the survey, one participant observed that,

> [...] Most HA [Historical Analysis] studies now combine a mix of quantitative HA plus qualitative HA (case study research, comparative analysis [grounded theory] and write-up) and provide for a broader understanding of the problem/question at hand. (q8)

Overall, then, we should expect to see more in OR literature on multimethodology involving gaming and historical analysis.

Facilitation, elicitation, and visualization

In the survey, workshops, facilitation and/or expert/stakeholder/team judgement were used in over half of projects containing most of the top 19 methods in the project examples, and was likely understated due to participants not always listing them. This widespread use, reported in the survey, of facilitation, elicitation, and visualization, with a very broad range of methods, is consistent with views on the importance of soft skills in OR practice (Dyson et al., 2021; Liberatore & Luo, 2013; Ormerod, 2008b, 2014b; Ranyard et al., 2015) and of facilitation skills and visualization in addressing complex policy and strategy issues in a time-efficient way that engages stakeholders (Eden et al., 2009), and not captured in previous surveys. Interestingly, regular users of historical analysis were even more likely than average to report use of expert workshops, while regular users of methods in the Quantitative OR and PSMs categories were not, while participants who were regular users of expert workshops were also regular users of Management/Strategy methods (particularly SWOT,

scenarios, brainstorming and PESTLE), OR less easily categorized (particularly gaming and MCDA/DA), Project Management, and historical analysis.

The findings in the survey on facilitation, elicitation, and visualization build on recent research that has shown how founders of OR known for their writing on quantitative modelling also used participative and stakeholder-focused approaches, including facilitation and visualization (or diagramming; Dyson et al., 2021). We go further by suggesting that use of workshops and facilitation in practice is underreported in OR literature, particularly with quantitative methods. Further, in OR literature, analysis of micro-practices in workshops has tended to focus on use of PSMs and other qualitative approaches (Ormerod et al., 2023), whereas in practice, workshops are used with a broad range of methods, and facilitation would appear to be a skill required by OR practitioners generally. In other words, the use of facilitation appears widespread not just in organizations (Franco & Montibeller, 2010), management and engineering (see Eppler's writing on visualization in Petropoulos et al., 2024, pp. 474-476), but widespread across this OR practice. Overall, the stakeholder and client orientation that Ranyard et al. (2015) associated with use of PSMs, risk analysis, system dynamics, cost benefit analysis, performance management, balanced scorecard and scenario planning, was more widespread across practice in this research, with facilitation used with a broad range of quantitative and qualitative methods. The findings of this research also provide further evidence that qualitative aspects of OR interventions (sometimes collectively termed 'soft OR') offer far more than just elicitation for quantitative modelling (Christie, 2021, 2023; Christie et al., 2022; Dyson, 2022; Flood & Romm, 1995; Mingers, 2006b, 2011; Westcombe et al., 2006; cf. French, 2022).[39]

Our results on the extent of use of visualization with a broad range of methods appear consistent with visualization having been a focus in UK government of late (Nelson, 2021). Visualization is also a potential future research area (Mortenson et al., 2015), building on the history of its use in facilitated workshops (Franco & Montibeller, 2010; Rosenhead, 1989; Sims et al., 1981; Vennix, 1996,

[39] Like many others before me, however, I agree with French (2022) that drawing distinctions between quantitative and qualitative approaches is challenging, and synthesis is preferred. Like Dyson et al. (2021), French's (2022) is another timely call for integration in OR practice. He draws attention to the need to train future OR practitioners in the process of model building, including a range of elicitation techniques and tools, and for mathematicians to report how they formulate problems, as well as insightful reporting of multimethod practical interventions in order to facilitate this learning.

1999), and more generally with PSMs in addressing complex issues (Rosenhead & Mingers, 2001a; Table 3, chapter 2).

Problem structuring methods and systems thinking

Previous surveys and literature reviews have suggested increasing use of problem structuring methods (PSMs). We add that in the survey, like statistics, SSM and SODA were used by more than half of participants – a proportion higher than previous surveys, including O'Brien (2011). Further, regular use of PSMs (primarily SODA and SSM) was associated with greater than average regular use of Systems Thinking (primarily VSM), Stakeholder Analysis, and Project Management.

Recent literature reviews suggest a rise in interest in and use of PSMs in multimethod projects (Christie, 2023; Franco & Rouwette, 2022; Gomes Júnior & Schramm, 2022), including SSM (Hanafizadeh & Mehrabioun, 2018) and cognitive mapping, especially in strategic and organizational management (Abuabara & Paucar-Caceres, 2021). It is surprising then that we found only SSM and VSM were listed by more than 10% of survey participants providing project examples, and that, as in O'Brien (2011), we generated few project examples involving SODA. It may be that there has been a more recent increase in use of SODA, i.e., an increase not reflected in completed projects that could be reported as examples in response to this questionnaire. Further research could investigate this.

We generally found low reported use (particularly frequent use), and awareness, of other problem structuring methods and qualitative/soft/critical OR, including SCA, yet around half of survey respondents had heard of VSM, CSH and TSI/SOSM. VSM was a notable exception, with higher use and awareness relative to previous surveys. It was common for practitioners to use VSM in organizational design, reorganization, governance, or change projects, and for practitioners to use VSM with other systems methods, though not SD as in O'Brien (2011).

In fact, overall, this research suggests greater awareness and practice of systems thinking (particularly SSM and VSM) amongst OR practitioners than captured in previous surveys of practitioners. Systems thinking practice has since been further encouraged with initiatives such as the promotion of systems thinking across the UK Civil Service by the Government Office for Science (2022). Interestingly, Hobbs and Midgley (2020), in their report to the UK Cabinet Office, have recommended development of an approach to multimethodology specifically for systems thinking

methods in government. This has been explored further by Midgley and Lilley (2023) in their conference presentation, 'Towards a New Framework for Methodological Pluralism'.

Non-use of problem structuring methods and critical methods in the multiple case study

In the five interventions in the multiple case study, practitioners did not use PSMs, nor methods *as PSMs*. A theoretical implication is that limiting the number of problem frames considered with stakeholders (Figure 37, chapter 6) raises ethical issues, whereas PSMs and critical methods (such as critical systems heuristics and boundary critique) can be used to facilitate what Lami and White (2022) term 'deliberation', being that aspect of problem structuring activity that relates to the ethical dimension of decision-making. More generally, as Ormerod and Ulrich (2013) state, 'Compared to mainstream OR, systems approaches and soft OR approaches provided much greater scope for reflection on ethical issues both prior to and during an OR intervention' (p. 297; see also Mingers, 2011, for specific aspects of PSM use that may be helpful).

In other words, practitioners' instrumental use of models or analysis in the form of cost-effectiveness analysis (rather than symbolic use of OR models – see White, 2016) provided a limit on, or at least direction as to, possible solutions (practitioners' recommendations), whereas symbolic model use with PSMs might have entailed and encouraged different problem frames and the advancement of a different set of stakeholder interests. As E. Reynolds (2021) argues,

> Through maintaining multiplicity of perspective and developing models that represent this multiplicity, PSMs increase the bandwidth of problem construal that is voiced and recorded, and so also increases the solution-space under consideration as groups work to develop and commit to change agendas. (p. 8)

In fact, in the multiple case study, practitioner interviewees noted challenges in selecting which stakeholders to involve in workshops, as well as having to deal with stakeholder partiality, exaggeration and bias in workshops and interviews, including attempts to influence outcomes. From case data, it is clear that practitioners involved ranges of stakeholders in workshops and interviews, stated their assumptions, triangulated data, undertook sensitivity analysis, and took steps not to favour particular stakeholders' views. Practitioners were also clear in stating in reports whom they had consulted, and their assumptions, for example, regarding requirements or benefits criteria (cases 1 and 4), strategic needs (case 3), and effectiveness measures (case 5).

Nonetheless, it is not clear from case data exactly how practitioners identified and managed ethical and moral issues in (1) what they were tasked to do; and, (2) method choice (Brocklesby, 2009). Neither did we examine in this research how interventions were initiated and scoped prior to their allocation to practitioner interviewees. However, practitioner interviewees did not use formal methods for critically examining or reporting on, for example, the operation of power relations, different moral stances of stakeholders, or ethics inherent in their choices of methods or which stakeholders to involve. Relatedly, some interviewees noted recent initiatives within the research context to review – across interventions: (1) how client requirements are defined, (2) how ethical aspects are dealt with, and (3) methods that can be used to deal with non-quantitative aspects of particular situations. Using PSMs for learning about stakeholders' objectives in relation to capabilities might also have led to opportunities for using different intervention methods and greater use of OR modelling – quantitative and qualitative – in place of general research methods (Mingers & Rosenhead, 2001; Vidoni, 2021).

Method combinations involving PSMs and soft systems thinking in the survey

In the survey, it was more common for SSM or cognitive mapping to be used in the same project as a Management/Strategy method or two than to be used with a Quantitative OR method. SWOT/PESTLE, scenarios and stakeholder analysis were used with MCDA (including AHP), but PSMs (Rosenhead, 1989, 1996; Rosenhead & Mingers, 2001a) were not (cf. Marttunen et al., 2017). In fact, across VSM, SSM and cognitive mapping, only SSM was used with quantitative OR, and only in very few projects. Further, in contrast with the tendency in Zolfagharian et al.'s (2018) literature review, SSM was used – in the one project with SD – *after* SD rather than within SD's conceptualization phase. More recent literature reviews (Abuabara & Paucar-Caceres, 2021; Gomes Júnior & Schramm, 2022) suggest increased reporting of use of combinations of PSMs (particularly SSM and SODA) with other methodologies, but systematic review of the methodologies with which PSMs were combined were beyond their scope.

Implications for multimethodology

Therefore, overall, this research suggests a lower prevalence of use of PSMs and soft systems thinking with more quantitative OR than that suggested by UK practitioners in Ranyard et al.'s (2022) review. This finding is consistent with indirect evidence (not based on data on actual interventions) in

Ranyard et al.'s (2015) survey, that, 'relatively few of the strategic planning applications used a mixture of PSMs and traditional [quantitative] OR' (p. 10). Alongside Christie's (2021, 2023) caution in drawing conclusions from then extant surveys of OR practitioners and systematic literature reviews about increasing use of quantitative OR and PSMs (as defined in Rosenhead, 1989) over the last 30 years (because, for example, of the reliance on self-selection and self-reporting, and over-representation of academic practitioners in OR literature), we found very few such examples. This was surprising given that across the survey and cases, practitioners addressed strategic issues, which continue to be associated in OR literature with PSMs (e.g., see Franco & Rouwette, 2022; Hindle et al., 2021).

Therefore, in relation to PSMs, in this research into practice supporting strategic decision-making in government, we found more recent support for 'the gap between academic research and practice' (Ranyard et al., 2015, p. 12, following Ackoff, 1979; Corbett & Van Wassenhove, 1993). While significant progress has been made in literature in examining how particular methodologies are combined, for example, for problem structuring for MCDA (e.g., Belton & Stewart, 2010; Ferretti, 2020; Lienert et al., 2013; Marttunen et al., 2017; Scholten et al., 2015), and for stakeholder participation, engagement and buy-in with simulation (e.g., Dutruel et al., 2024; Harper & Mustafee, 2023; Howick et al., 2008; Jahangirian et al., 2015; W. Jones et al., 2022; Kotiadis, 2007; Kotiadis & Mingers, 2006; Kotiadis & Tako, 2018, 2021; Kotiadis et al., 2014; Powell & Mustafee, 2017; S. Robinson et al., 2012; Proudlove et al., 2017; Rodriguez-Ulloa et al., 2011; Sachdeva et al., 2007; Tako & Kotiadis, 2015, 2018; Tian et al., 2023; cf. Zabell et al. 2021), in publishing these results we respond to calls to reduce the theory-practice gap (Ackermann & Howick, 2022; Howick & Ackermann, 2011; Ranyard et al., 2015). Our insights are complementary to reviews of multimethodological interventions in academic literature involving qualitative OR (Abuabara & Paucar-Caceres, 2021; Gomes Júnior & Schramm, 2022; Hanafizadeh & Mehrabioun, 2018; Howick & Ackermann, 2011; Marttunen et al., 2017; Zolfagharian et al., 2018), adding insight into different practice beyond academia.

Recently, there has been interest from academic practitioners using quantitative OR methods in using PSMs with quantitative OR (e.g., SSM with optimization), i.e., multiparadigm multimethodology (Mingers & Brocklesby, 1997), to achieve engagement with stakeholders and implementation and impact with quantitative analysis (Christie et al., 2022; e.g., Çoban et al., 2021;

Esposito Amideo et al., 2019; Noorain, 2024; Sinuany-Stern, 2022). However, evidence from the five interventions in the multiple case study shows practitioners in non-academic settings are already attempting to achieve such aims with their multimethodological interventions through stakeholder participation but without using PSMs, for example using simple workshop tools and interviews to achieve acceptance of recommendations, and for stakeholder engagement. Stakeholder consultation was common. Further, through in-depth study of interventions in non-academic settings we have shown *how* the stakeholder and client orientation that Ranyard et al. (2015) associated with the use of PSMs, risk analysis, cost benefit analysis and other methods to address 'messy (often strategic problems)' (p. 5) was adopted *in practice* across a range of methods, qualitative *and* quantitative, but *excluding PSMs*, in the context of government cost-effectiveness analysis supporting strategic decision-making.

Results from this research would suggest that the commonplace 'use of hard + soft (multi-methodology)' in current UK government OR practice reported in Ranyard et al. (2022, p. 6) refers to use of quantitative methods plus qualitative methods broadly defined, and not more specifically to the use of quantitative OR with PSMs (PSMs, broadly defined, being what Ranyard et al., 2022, report as the scope of their review).[40] This research *did* find that quantitative OR was used most commonly with workshops and scenarios. As Marttunen et al. (2017) found in literature, with MCDA, SWOT/PESTLE, scenarios and stakeholder analysis were used more than PSMs (as defined by Rosenhead, 1989). In-depth study of five interventions in chapter 6 then revealed that practitioners addressed conflicting interests and views across stakeholders *not* by using PSM-like approaches (involving the structuring of multiple worldviews in qualitative, diagrammatic or systemic models), but through stakeholder participation using stakeholder consultation, workshops and interviews to achieve acceptance of recommendations, and for stakeholder engagement. Alternatively, it could be that the more than 100 case examples in this research of practice supporting strategic decision-making for or on behalf of UK government are atypical of wider government practice, a point I return to below. Future research could investigate this.

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[40] Ranyard et al. (2022) report:

> **1.1. Soft OR:** We agreed (more or less) that the following approaches should be included: Clearly *PSMs (Soft Systems Methodology (SSM); Strategic Options Development and Analysis (SODA) and Strategyfinder (an online Group Support System, based on SODA); Strategic Choice Approach (SCA))* plus *Systems Thinking (ST), Viable System Model (VSM)* and possibly *System Dynamics (SD)*, *Scenario Analysis* and *Sensitivity Analysis – though in the event the latter three were not followed up*. … (p. 1, *emphasis in original*)

Nonetheless, the results of this research are significant because past research into multimethodology has tended to be based on accounts of academic practitioners' interventions, and surveys that lack details of single interventions or were undertaken many years ago when multimethodology was a relatively new topic in the literature. In the absence of a recent survey of practice globally, or in the UK, and given challenges commonly experienced in gaining project data on methods used in the UK Civil Service and beyond (Ranyard et al., 2022), this research provides an understanding of methods that practitioners use and combine in more than 100 interventions in an area of practice where we have few published examples – strategic decision support in government. Thus, insights from this research contribute to enhancing understanding of practice in non-academic settings, providing an opportunity to consider what is missing in OR literature (Ackermann & Howick, 2022, p. 1905). Thus, they contribute to closing 'the gap between academic research and practice' (Ranyard et al., 2015, p. 12, following Ackoff, 1979; Corbett & Van Wassenhove, 1993).

7.2.3 Forms of multimethodology practitioners use

Howick and Ackermann (2011) concluded that, 'it would be interesting in future to categorize case studies further using the labels mentioned in the literature' (p. 506). J. S. Morgan et al. (2011, 2017) responded with a set of designs for system dynamics (SD) and DES, that they claimed may also be applicable across other methods. Questions arising are whether the J. S. Morgan et al. set of designs and more recent typologies (section 2.6 above) reflect what practitioners do in OR interventions more generally, and their usefulness for practitioners addressing complex issues.

Howick and Ackermann (2011) also noted that,

> One hypothesis that might be proposed is that the rationale for mixing methods is related to the approach to mixing. For example, where the rationale argued for adopting different methods to support different stages, a more sequential approach would be taken, and where something 'new' was required, the approach would see a more interactive mix. This, however, was not borne out by the data. (p. 508)

Like Howick and Ackermann in their (2011) literature review, in this review of practice in government, we found plenty of evidence of sequential use of methods over time and supporting different stages or steps in analysis projects. Overall, in both the survey and multiple case study, we found that sequential use of methods (especially in cases 2 and 3 in chapter 6) tended to result from practitioners' working out their methodological design (sometimes on a 'trial and error' basis) as the intervention proceeded, and as circumstances changed or new data came to light. Practitioners

moved to using another method to build further understanding and move towards delivering conclusions to clients. In the multiple case study, we saw sequential use both within and across different intervention stages. And we found sequential use of methods across cases where practitioners' approaches were considered by stakeholders as more and less successful. One practitioner saw sequential use of methods in their experience as resulting from the amount of problem structuring undertaken at the outset of an intervention:

> [...] At the moment we tend to skimp on problem structuring or overdo it, there's a balance there. Skimping it or overdo it and [you] end up on this bit of a drunken walk which you end up on a sequential approach.

The implication is that a balance is required in designing the amount of problem structuring activity at the outset of an intervention.

In the survey in chapter 5, we also found some parallel and iterative use of methods. However, we were not able to collect sufficient data on single projects to be able to conclude as to their overall forms. Overall, however, the multiple case study in chapter 6 provides further, more recent and more detailed empirical evidence of the development of methodological designs *through* interventions (after Munro & Mingers, 2002, and Howick & Ackermann, 2011, and as reflected in my conceptualization of methodologies and methodological design in chapter 3), even where methods were 'well-specified in advance' (Mingers, 2006b, p. 232).

Applying multimethodological design categories

Moreover, for the first time as far as I am aware, with this research I sought to apply multimethodological design categories (J. S. Morgan et al.'s, 2011, 2017, generic linking designs) to OR practice in non-academic settings in interviews with practitioners (see section 4.8.6 above). Practitioner interviewees did not seem to have used generic sets of designs in their practice in the cases. However, as part of research interviews, when prompted, practitioner interviewees were able to use the J. S. Morgan et al. set of designs to describe their interventions, or at least some aspects of them (as reported in section 6.2.8 above).

The interviews also made clear some potential disadvantages with seeking to apply J. S. Morgan et al.'s (2011, 2017) linking designs. First, practitioners sometimes identified more than one of the designs in their intervention. Second, quite understandably, practitioners could not understand

quickly the 'interactive' design (after Schultz & Hatch, 1996). This seemed to be because it is based on assumed paradigm incommensurability, and also because it overlaps – by definition – with other designs (enhancement and integration, which also involve interaction between methods, although to different extents).

In fact, Christie's (2023) set of designs for PSMs and quantitative OR, which may also be applicable across OR practice more generally, was compiled in a way that avoids the issues identified above with J. S. Morgan et al.'s (2011, 2017) linking designs. First, as well as the designs being described in ways that allow for the combination of more than two methods (e.g., 'Design 1. Sequential: PSMs for problem structuring activity' allows for the use of *multiple* methods for problem structuring prior to modelling, as in Henao & Franco, 2016), the designs 'may be combined in use' (p. 169). This also potentially means that Christie's (2023) set can accommodate Nguyen et al.'s (2024) 'dynamically switching' design. Second, as Christie (2023) acknowledges, in addition to the designs,

> The interventions [examples of the designs in Christie (2023)] could also be described in other ways to explore different aspects of MMR [mixed methods research] in OR practice, including why particular methods were used (Morgan, 2013), how methodologies were adapted (Mingers & Rosenhead, 2004), how practitioners intervened together (Ackermann & Howick, 2021), and *practitioners' mental models* (Onwuegbuzie & Hitchcock, 2019) *or paradigm strategies* (Kotiadis & Mingers, 2006). (p. 174, *emphasis added*)

Thus, Christie keeps consideration of paradigm incommensurability out of the set of designs (for reasons discussed in sections 2.5.2 and 4.2.2 above). Further, where 'iterative' was used to describe the stakeholder consultation process in case 4, with Christie's set of designs, this iteration could be described as consultation methods (such as interviews) used interactively in parallel with the developing of options and success criteria.

The more recent Christie (2023) set of designs therefore has advantages over J. S. Morgan et al.'s (2011, 2017) linking designs when seeking to describe OR practice more generally across OR and may be useful in providing practitioners with insight into how methods can be combined. Sets of multimethodological designs have been useful in summarizing practice reported in OR literature (e.g., see Brailsford et al., 2018), and have therefore been used to understand and promote possibilities of multimethodology. In fact, the peer-reviewed book chapter in which the Christie (2023) designs were published, with examples and benefits, has already been used in training Systems Thinking Practitioner apprentices in the UK on multimethodology.

RQ2. WHY DO PRACTITIONERS TAKE THESE APPROACHES, MULTIMETHODOLOGICAL OR OTHERWISE?

In chapters 5 and 6, I responded to the second research question (RQ2) by presenting findings on reasons why practitioners use particular methods (section 7.2.4 below), and why practitioners use multimethodology (section 7.2.5below).

7.2.4 Why practitioners use particular methods

Survey

J. S. Morgan (2013) concluded that how method decisions are made in practice remains unclear, and this is particularly true across OR methods and interventions (Ackermann & Howick, 2022; Howick & Ackermann, 2011; Midgley et al., 2013). Compared with previous research, the survey in chapter 5 provided a more detailed, nuanced, and broader understanding of why practitioners chose particular methods, based on evidence from 42 practitioners and their 104 recent projects (summarized in Table 19, chapter 5). This is notwithstanding Howick and Ackermann's (2011) point, when recommending interviews and written records of interventions, that, 'Reference to papers or even use of questionnaires is unlikely to tease out the deep knowledge held by individuals' (p. 509).

For example, in the first theme, across 46 project examples, we identified functions and features of methods as drivers of method choice, separating what methods were used for (in method choice theme 1) from, for example, perceived requirements of the project situation (theme 2), and resources available to the project (theme 3). This builds on our critique that perceived merits of methods were a 'key factor' (J. S. Morgan, 2013, p. 254) in method choice across all three of Munro and Mingers' (2002, p. 375) method choice approaches – *unreflective*, *tacit* and *reflective* (section 2.4.1 above; Appendix E) – while providing empirical support for the conceptualization of method choice (in chapter 3) as multi-dimensional, and including affordances of (material aspects of) methodologies (Figure 53, Appendix R).

In fact, half of respondents in the survey expressed multiple reasons for using particular methods, and each theme related to a range of methods. In relation to strategic decision support practice in this government context, this survey therefore provides empirical justification for theories of method choice that foreground the selection of particular methods according to what practitioners seek to

achieve, and that highlight numerous other influences of the intervention context. However, as appears to have been the case in previous surveys, practitioners rarely made reference to the theoretical frameworks in section 2.9.

Amongst reasons implicating practitioners themselves in method choice, we separated 'appropriate' methods from 'familiar' methods and from tendencies to use the same methods in multiple projects, providing a more nuanced empirical understanding than Munro and Mingers' three themes and Ackermann and Howick's (2022) theme, 'Influenced by modellers' confidence or experience' (p. 1918). Our findings also build on previous surveys that have linked practitioner background and organizational context with methods used (Fildes & Ranyard, 1997; Fildes et al., 1999; Munro & Mingers, 2002; Ranyard et al., 2015) in, for example, implicating practitioners' organizational roles.

Looking back at the Munro and Mingers (2002) survey in light of the results in this survey, practitioners in their *reflective* category, by definition, tended to discuss relative merits of methods they used (broadly, our theme 1), which were tailored to the particular situation (broadly, our themes 2 and 8). We see that project aspects that influenced method choice tended to relate to client needs and requests (Table 24, Appendix E), including in particular in relation to stakeholders and their participation (see Ormerod, 1997a). Somewhat similarly, all participants who directly implicated stakeholders in method choice in this survey (our theme 8) also implicated the nature or requirements of the project or problem(s) or situation (theme 2) and at least one other theme. In fact, we found project stakeholders implicated in multiple different ways in method choice across the themes, beyond 'client demand' (Ackermann & Howick, 2022, p. 1918; Mingers, 2001a).

Overall, then, these findings therefore provide empirical support for a range of reasons for method choice. The findings build on previous studies, and provide a better basis for synthesizing extant theoretical understanding as it relates to this strategic decision support practice in government.

Multiple case study

Howick and Ackermann (2011) suggested that in-depth, semi-structured interviews with practitioners should reveal more regarding the *process* of choosing combinations of methods. Therefore, in addition to the survey, I conducted a multiple case study designed to explore practitioners' reasons for using particular methods, and for using more than one method in an

intervention. I sought to go further than the results of the survey and other past research by adopting a multimethod approach that included insights from a range of intervention stakeholders and documents, and by seeking to explain practitioners' methodological decisions using structural and causal analysis to develop theory-informed, causal understanding of method choice mechanisms.

In-depth case analysis facilitated rich description of interventions, including methods used and not used, with structural and causal analysis resulting in (provisional) mechanisms of method choice (summarized in Table 21, chapter 6). The multiple case study facilitated a move from reviewing what methods were used for (being the most common theme in the survey), to considering in detail what led to their use, given what they could be used for (including, but not exhausted by, their affordances). Case analysis involved consideration of what methods were used for, which facilitated consideration of which other methods could have been used to deliver similar, as well as why particular methods were used in particular contexts.

Whereas in the survey a particular method was used, for example, to analyse or elicit data (e.g., to represent a system or options in a DES model or using a RACI matrix) or to develop understanding (Table 19, chapter 5; Figure 53, Appendix R), case analysis led to multiple underlying reasons resulting from aspects of the pre-existing context in the form of practitioners' aims given their roles, relations between intervention roles, stakeholder disagreement and politics, available resources, applicable government policy and guidance (rules), practitioner knowledge and confidence from discourses and documents in the intervention context, and, practitioners' tendencies, with mechanisms enabled and constrained by, for example, other stakeholders' expectations. For example, in case 1 (Figure 32, chapter 6), practitioners chose MCDA because it facilitated participative weighting and scoring of quantitative and non-quantitative decision dimensions, but it was rules requiring quantitative measurement of cost-effectiveness, and other 'more objective' cost-effectiveness methods being unsuitable and rejected by other stakeholders, that led – in interaction with other mechanisms – to MCDA being chosen over other methods.

More generally in this study, mechanisms of method choice included effects of practitioners' reflexive deliberation and values (and other aspects of agency, including norms [after Fleetwood, 2021]), as well as their circumstances, and social structural conditioning (Bhaskar, 2016, p. 66). Given their intervention and employment roles, practitioners aimed to deliver that sought and

expected by clients and other stakeholders. Beyond that, method choice seemed to be largely governed by practitioner tendencies (given their past experience and skills) *and those of their colleagues*, and collective views of similar past projects, and/or rules that restricted the range of acceptable methods. In most cases, practitioners and other stakeholders also noted limited resources (time and/or money) for interventions and for practitioners to try new methods. Generally, using new or different methods was considered risky in the context of these resource-constrained interventions, in that it may not give an answer or be understood by stakeholders. The other key influence on method choice across the cases was disagreement between stakeholders and politics playing, which led to practitioners' aims to capture different stakeholder views and consensus or stakeholders' acceptance of practitioners' recommendations and/or to engage stakeholders in the future capability they were investigating.

Implications for multimethodology

> … *what should I/we do?* … continually confronts us in our praxis. We always have to make choices, to act or not to act, to move in this way or that, circumscribed by the apparent **constraints** and absences of the social and material worlds on the one hand, and our own personal world on the other.
> …
> … My contention is that, in fact, OR interventions consist largely of testing and exploring constraints both within the problem content system and within the intervention system.
> …
> … power is an ever-present, unavoidable force that is both enabling and constraining.
>
> (Mingers, 2006b, pp. 247-248, 253, *emphasis in original*)

Recently, there have been renewed calls for empirical evidence to support theories of multimethodology (Brocklesby, 2023; Cabrera, 2023; Zhu, 2022). My aim in comparing multiple cases was to develop provisional, testable, data-driven middle-range theory developments (Easton, 2010; Eisenhardt, 1989; White, 2006) by 'qualifying the underlying mechanisms' in order to 'deepen existing theories' (Van Burg et al., 2020, p. 10). Practitioners in the multiple case study did not report using theoretical frameworks in their method choice, nor even lists of methods available in the research context that they referred to elsewhere in interviews. Rather, in relation to strategic decision support practice in this government context, the research provides empirical justification for theories of method choice that foreground the selection of particular methods according to what practitioners seek to achieve (including affordances of methods), and that highlight numerous other influences of the intervention context, including clients, and advice from practitioner colleagues. The empirical evidence supports theories of method choice that are both multi-dimensional and which conceptualize method choice as a complex process, such as multimethodology (Mingers 2003;

2006b, 2014; Mingers & Brocklesby, 1997), and creative design of methods in systemic intervention (Midgley, 2000, 2023), rather than theories based on simpler conceptualization of method choice by types of problem or issue (see section 2.9).

In language of multimethodology, for practical reasons, as one might expect, the case interventions were not 'fully comprehensive' (Mingers, 2014, p. 186; Table 26, Appendix F). While many of the interventions involved making recommendations regarding future organizational roles (i.e., social aspects), and relied on subjective data from stakeholders (i.e., personal aspects), analysis was framed in the form of cost-effectiveness analysis, thereby emphasizing objective, quantitative data as far as possible, i.e., material decision aspects were first-order considerations (Mingers, 2014, p. 187). This is what clients sought, and was reflected in government policy and guidance.

Interviews and workshops were used to consider personal and social issues because stakeholders had divergent views and interests, and given practitioners' aims to achieve stakeholder acceptance of their recommendations. However, workshop and interview outputs (stakeholder judgement in the form of data gathered, categorized, weighted, ranked, scored, and/or voted on) tended to be used in analysing the effectiveness of options, i.e., for objective assessment of material decision aspects that could be accepted by stakeholders.

Stakeholder engagement and buy-in were sought, but changing social aspects was not prioritized because it was not within clients' and other stakeholders' expectations of practitioners. In other words, practitioners appeared to work within existing role and power structures (Jackson, 1999; Mingers 2000c, 2001a), and not jeopardizing existing decision-making processes (Luoma, 2016), to deliver practical outputs. The multiple case study therefore provides empirical evidence that supports Mingers' (2001a) claims regarding constraints on method choice and possible practitioner recommendations (in the context of pluralist action research), that,

> If the researcher is being employed as a consultant to achieve a particular outcome for the client, then this will be the dominant factor in determining what the researcher actually does. This must inevitably condition the results and imply a strongly managerialist perspective. Critical inquiries or methods that challenge the existing balance of power or accepted practices too radically may well not be acceptable (Mingers 2000c). Equally, it is likely that management will set the scope and boundaries of the project and perhaps impose particular solutions, e.g., downsizing. (Mingers, 2001a, p. 256)

Overall, the multiple case study, and its underlying, critical realist theoretical framework, provide a new basis for understanding OR practice that moves us away from lists of dimensions that influence

what practitioners do in interventions, to causal understanding of the many interrelated rationales, justifications and other reasons for method choice. With the multiple case study in chapter 6, I enhanced current understanding of the process of multimethodology by identifying multiple, interacting and interrelated causal mechanisms that led to particular methods being used together in particular ways, and started to understand the relative importance of different method choice mechanisms. In other words, by employing critical realism, I have shown that practitioner method choice in non-academic settings is causally complex in that it results from the conjuncture of multiple generative mechanisms (Gerrits & Verweij, 2013; Ragin, 1987) across structure, culture and agency (Archer, 1995, 1996, 2024), with each mechanism operating contingently (Danermark et al., 2019; Porpora, 2016).

7.2.5 Why practitioners use multimethodology

Survey

Again, our analysis of why practitioners chose to use two or more methods in their recent projects was novel, and builds on previous OR research with evidence from much greater numbers of practitioners, and from outside academia (Table 53, Appendix S). The survey provides significant additional evidence consistent with Howick and Ackermann's (2011) literature review in that we found rationales in previous theoretical work on the benefits of multimethodology (Jackson, 1999; Mingers, 2000b, 2003a; Mingers & Brocklesby, 1997). Such themes include to intervene with complexity more comprehensively (theme 4, though absent explicit discussion of material, personal, social aspects; cf. section 2.7.1 above), in different phases of intervention activity as they moved towards solution or an end or advice (theme 5; cf. section 2.7.5), and for triangulation (theme 8; cf. section 2.7.2). These are three of Jackson's 'five main reasons given for why MM [multimethodology] thinking and practice is desirable and has become popular' (Jackson, 2019, pp. 531-532, following Mingers, 2014; Mingers & Brocklesby, 1997). Jackson's other two main reasons are more historical, being to avoid grand narratives in a postmodern sense (cf. section 2.7.7), and to avoid failure of hard systems approaches in information systems in the past (cf. section 2.7.6).

Further to Ackermann and Howick's (2022) conclusion from two interviewees' responses that additional methods may be used to support project management (albeit while adding to the extent of project management required), we found project management to be a popular method in project

examples (Table 17, chapter 5). Further, two practitioners used specific methods (pre-mortem, stakeholder profiling, stakeholder engagement and visualization) within their multimethod projects in order to manage project risk.

Howick and Ackermann (2011) found two papers reporting mixing of methods to 'gain decision maker involvement and thus model confidence and ownership', and in their interview study, comments from two academic interviewees led Ackermann and Howick (2022) to conclude that mixed methods may help achieve stakeholder buy-in. With this survey, we add that seven practitioners in government reported using multiple methods to support or facilitate stakeholder engagement or interest, achieve buy-in, or take into account stakeholder views.

Overall, however, across a far greater number of non-academic practitioners, we found project stakeholders implicated in multiple different ways in the choice of methodological approach (cf. section 2.7.8). In relation to their relationships with stakeholders, practitioners reported using multiple methods in order to *respond* to intervention stakeholder questions or project requirements, and because of their concern for the *quality* of their answers and project outputs for enhancing their clients' decision-making (Table 53, Appendix S). Further, overall, participants were much more likely to implicate project stakeholders in using multimethodology than in choosing a particular method (Table 19, chapter 5).

A new empirical finding in this survey, which builds on Corbett et al.'s (1995) observations regarding practitioners drawing on strands of (past) practice and learning, and collective webs of practice in choosing methods (Ormerod, 2002, 2008b), is the extent to which practitioners employed their and their colleagues' tendencies (Midgley, 2000, 2023), including *to use multiple methods*, *and particular combinations* (as well as established approaches and histories), in explaining their use of multiple methods. We also found evidence of the impact of resource constraints and technological opportunities, reflecting more of the project practicalities anticipated in theoretical frameworks, for example Mingers' conceptualization of the dimensions of an intervention situation (Checkland's problem content system) in the context of a multimethodology intervention (Mingers, 1997b, 2006b; see also Ormerod, 1997a). These are all detailed considerations that Munro and Mingers (2002) necessarily glossed over with their three method choice categories (section 2.4.1 above; Appendix E),

and they build on previous empirical research into OR practice (Corbett et al., 1995; Overmeer et al., 1998).

However, following Howick and Ackermann's (2011) suggestions, we did not find a link between the 'nature of the problem' or 'owners of the problem' and particular combinations of methods. Nor did we find a link between the time available and the number of methods used.

Finally in terms of themes, when practitioners described specific strengths and weaknesses of different methods (another theme that Howick & Ackermann, 2011, highlight), these tended to relate to other themes, challenging the distinctiveness and value of strengths and weakness (or complementarity of methods; Table 8, chapter 2) as a theme. This reminds us of criticism of methods-led approaches to multimethodology in OR (Ulrich, 2003), as well as criticism of different strengths and weaknesses of single methods as a rationale for mixed methods research in evidential pluralism (Shan & Williamson, 2023), since the use of multiple methods by practitioners can be explained otherwise. I found the same in allocating benefits from the multimethodological interventions in Christie (2023) to theoretical benefits in Table 8 (chapter 2). Strengths and weaknesses is therefore perhaps better viewed as an overarching theme, similar to Jackson's (2019) overarching argument in relation to systems approaches (separate from his five main benefits of multimethodology) that,

> ... we have the best chance of managing complexity overall if we can understand and capitalize on their different strengths and compensate for their different weaknesses by using them in combination. (p. xxvii)

Implications for multimethodology

Together, the themes in chapter 5 provide a new empirical basis for understanding the many interrelated rationales, justifications and other reasons practitioners use methods together in practical interventions, and should help facilitate a synthesis of theoretical understandings through bringing together practice and theory. While survey respondents did not tend to report their 'paradigm strategies' (though a number referred to the need to combine, for example, qualitative and quantitative approaches), the results add doubt to claims that practitioners are unreflective about method choice, and suggest that we can now move beyond single dimension understanding of practitioner reasons for choosing methods to working with practitioners to understand better the

causal complexity of their practical decisions (Plakoyiannaki & Budhwar, 2021), as I did with the multiple case study (discussed above).

Multiple case study

Whereas a new finding in the survey was the extent to which practitioners employed their and their colleagues' tendencies (including to use multiple methods, and particular combinations), as well as established approaches, and histories, in explaining their use of multiple methods, we found all practitioner interviewees in the cases reported using multiple methods as a tendency in their work on complex or multi-disciplinary projects. In the cases, practitioners tended to use particular combinations of methods in particular circumstances, or to need to use additional methods as they proceeded with intervention. Further, practitioners overcame barriers of individual specialization and acculturation (Kotiadis & Mingers, 2006) by consulting colleagues and previous projects (Midgley, 2000, 2023) for input when considering their methodological approach (cf. Ackermann & Howick, 2022).

In their interview study, Ackermann and Howick (2022) found little evidence of synergistic use of methods in combination. Similarly, we found it difficult to extricate reasons for using multimethodology from reasons for using particular methods. We were left concluding that methods were 'added' for particular purposes, including – in all cases – the addition of costings to analysis of the effectiveness of decision options in order to assess the cost-effectiveness of options in line with government guidance.

In particular, as in the survey (Table 53, Appendix S), in all cases we found stakeholders implicated in the choice of multimethodology. Practitioners added methods in order to respond better or more comprehensively to stakeholder questions or project requirements, and often sought stakeholder engagement or buy-in. This seemed akin to Midgley's (2023) description of systemic intervention that:

> … when mixing methods, the aim is to find appropriate ways to address a *set* of intervention purposes. … *synergies* are looked for.
> …
> Of course, it is also possible to develop entirely new methods from scratch, if and when no previous methods seem to meet the needs of the project.
>
> (pp. 12-13, *emphasis in original*)

We also found further evidence of methods used in sequence on more of a 'trial and error' basis to build understanding and reach a solution.

However, overall, we found empirical evidence for a number of reasons as to why practitioners did *not* use multimethodology involving quantitative and qualitative *OR modelling methods* (cf. the barriers and challenges in section 2.8 above), specifically: rules (government policy and guidance) restricting the methods that are acceptable (and how those rules are interpreted); risk aversion in the intervention context and amongst practitioners; inevitable limits to expertise and experience amongst stakeholders involved in any one intervention; limited resources (time and money); and, limits in the extent to which practitioners saw their role as to explore higher-level purpose or problem framing.

This is important because most of the evidence of rationales for using multimethodology in OR in past research come from theoretical work and single cases reported in OR literature. There are few empirical cross-case studies, with reviews of personal approaches of practitioners providing some useful exceptions (e.g., see Hoverstadt & Loh, 2023; Jackson, 2019; Midgley, 2023, 2000; and Ormerod, 1997a). Hence, while OR is known as a science of improvement, the science of intervention design has been underdeveloped because of a lack of empirical evidence from cross-case field studies of multimethodological design.

Implications for multimethodology

Arguably, as identified in chapter 2, there has been a tendency in OR scholarship to consider some academic and non-academic practitioners' approaches as less sophisticated or unreflective (Munro & Mingers, 2002, 2004), as pragmatic with a small 'p', ignoring issues of paradigm (Brocklesby, 2023) and paradigm incommensurability (Howick & Ackermann, 2011), taking atheoretical methodological approaches (Jackson, 1987), and/or simply pulling together what methods are available (Hoverstadt & Loh, 2023; Howick, 2023 [see The Operational Research Society, 2023]). In comparison, by adopting critical realism and giving voice to practitioners in this research, we have seen how practitioners in this research context outside academia take into account multiple considerations (chapter 5), consider and reject multiple methods, and are subject to multiple constraints (chapter 6). In the multiple case study, we found practitioners to be heavily influenced by other intervention stakeholders, and focused on responding to questions agreed with their clients as interventions

unfolded (Greene, 2015). *As a result*, case practitioners focused in their analyses on objective assessment of material decision aspects that could be accepted by stakeholders, and practitioners did not combine qualitative and quantitative OR modelling. Thus, further to the points I made on paradigms in sections 2.5.2 and 4.2.2, consideration by practitioners of paradigms associated with methodologies and methods was much less relevant than it has been to scholars of multimethodology in OR/systems (Ormerod, 1996a, 1997a). Instead, this research offers a new, alternative account of 'how, in concrete settings experienced [and, in this research, also some less experienced] practitioners put together their own creative combinations based upon their own 'logics' that have emerged from accumulated experience', which has been missing in OR literature (Brocklesby, 2023, p. 12).

7.3 CONTRIBUTIONS TO BEHAVIOURAL OR

7.3.1 Enhanced understanding of method choice and intervention design in OR practice

> Behavioural OR (BOR) is concerned with the study of human behaviour in OR-supported settings. Specifically, BOR examines how the behaviour of individuals affects, or is affected by, an OR-supported intervention. (Petropoulos et al., 2024, p. 428)

In contributing to understanding of the practice of OR, building on work on the 'process of OR' (Keys, 1997) and OR 'beyond the model' (Brocklesby, 2009; Le Menestrel & Van Wassenhove, 2004; White, 2016a), this research adds to the burgeoning area of behavioural OR (BOR; Brocklesby, 2016; Franco et al., 2021; Hämäläinen et al., 2013; Kunc et al., 2016; White, 2016b; White et al., 2020). BOR is an area where there is 'growing interest … in OR scholarship' (Ormerod et al., 2023, p. 810). As an external researcher, I investigated and reported on otherwise unpublished practitioner interventions in an academically rigorous, reflective and critical way to enhance OR scholarship (Ormerod, 2014a, p. 1254; 2016, p. 518). This research also responds to calls for case studies in BOR to provide more detailed, less sanitized accounts of intervention processes that show the impact of social relations (Brocklesby & Beall, 2018; Ormerod, 2014a; Velez-Castiblanco et al., 2016) and other behavioural aspects (Hämäläinen et al., 2013), and to use non-positivist approaches from the social sciences to understand human and social aspects 'that influence what components of OR are used, how they are used and for what purpose' (Brocklesby, 2016, p. 796), thereby providing understanding of intervention complexity (Franco & Greiffenhagen, 2018). Specifically, this research adds understanding of the role of the OR practitioner in method choice (Luoma, 2016; Velez-Castiblanco

et al., 2016) and intervention design (Christie, 2017a; Franco & Hämäläinen, 2016b; White et al., 2020), which are often given little word count in single case reports, and on which there has been relatively less focus to date within BOR. These are vital aspects of BOR (Christie, 2017a), and are now clearly recognized as such (Ackermann & Howick, 2022; Franco et al., 2021).

7.3.2 Operationalizing critical realism for evaluating multimethodological OR practice

Moreover, the main contribution of this research is that, for the first time as far as I am aware, I operationalized critical realism for evaluating multimethodological OR practice. This facilitated causal explanation of practitioner method choice in the multiple case study in response to the second research question (RQ2).

While the possibility and impossibility of evaluating OR interventions has been much discussed in literature, especially in relation to PSMs (Connell, 2001; Midgley et al., 2013; Ormerod, 2014b; Westcombe et al. 2006; White, 2006), it is known that objective evaluation of interventions is challenging, if not impossible, because every intervention is unique and cannot be replicated (Checkland, 1981; Midgley et al., 2013; Yearworth & White, 2014). But it is only by understanding single cases, each one unique, that we can generate learning across OR interventions (Brocklesby & Beall, 2018). Evaluation of multimethodology in OR practice is a more recent development, but it is not clear in literature how multimethodological interventions should be evaluated, particularly across interventions and methods (Ackermann & Howick, 2022; Howick et al., 2017; Midgley et al., 2013). This is a concern, since in the applied discipline of OR, cumulative knowledge of methods and the practice of OR is applied to change or improve real-world situations.

For evaluating multimethodological practice in the multiple case study, I sought a systematic and systemic scientific approach. For practical and ethical reasons, I did not believe it was possible to employ quantitative comparison of interventions (cf. Midgley et al., 2013; Yearworth & White, 2014), nor to understand sufficiently the context and detail of the interventions by reducing their complexity to a set of variables for modelling or practical experimentation (cf. Finlay, 1998; Franco et al., 2021). I therefore sought to build on cross-case evaluations of multimethodological practice across OR, reviewed in chapter 2, that have used deductive and inductive thematic analysis (Ackermann & Howick, 2022; Christie, 2023; Howick & Ackermann, 2011; Mingers & Munro, 2002, 2004), as well as sociomaterial approaches to understanding participant actions, such as actor

network theory, that have been useful in foregrounding the role of social-political and material aspects and their relations (Keys, 1997; Ormerod, 2014a; Ormerod et al., 2023; White, 2009; Yearworth & White, 2018; see chapter 3). However, I developed a new, multimethod, critical realist, process approach (Okoli, 2022) as an alternative to, for example, Ormerod's (2016) mangle approach for writing case studies to ground theory, because critical realism (Bhaskar, 2008, 2016) affords the additional possibility of examining causality (Elder-Vass, 2015b; Modell, 2020; O'Mahoney et al., 2017; White, 2006, 2009, 2016b). As reported at the outset of chapter 3, critical realism had been advocated for exploring causation to evaluate interventions holistically, but not been operationalized for such research (White, 2016b). The new theoretical and methodological approach I developed and employed in this dissertation therefore advances multimethodology scholarship by providing a new way of investigating causality in the complex social process of multimethodological practice in OR.

This research thus responds to calls in BOR to use critical realism to understand OR practice (section 3.1.1 above), and to complement previous experimental and interventionalist approaches (White, 2016b). More specifically, this research builds on BOR studies at the micro-level of tool and model use in workshops (Burger, 2020; Franco, 2013; Ormerod et al., 2023; Paroutis et al., 2015) to consider other levels of whole OR interventions, including social aspects (White et al., 2015). In other words, the multiple case study is behavioural 'field research' (Franco et al., 2021, p. 402) that responds to interest in micro-processes *and* the wider process of OR. Further, it contributes beyond explanations of behaviour in recent BOR studies that have tended to foreground either 'determinist or voluntarist extremes' (Franco et al., 2021, p. 403) because I examined the interrelated and interacting causal influences of social structure and practitioner agency and reflexivity by adopting critical realism.

In proposing ways forward for evaluating interventions there has been an understandable tendency in OR to go to great lengths to fit within notions of replicability from the natural sciences (e.g., Midgley et al., 2013; Yearworth & White, 2014), thereby risking evaluating practice only according to a limited set of values, as has been witnessed in other areas of management in light of the open science movement (e.g., Pratt et al., 2020). This is something critical systems scholars in OR have long warned us about (Mingers, 2007). The theoretical framework and empirical research methodology presented in this dissertation provide a new, structured way of accumulating knowledge across interventions (Brocklesby & Beall, 2018) based on descriptions from those involved, or real-time observation. The approach clears the ground (Bhaskar, 2016, after Locke) for

applying critical realism to understand the operation of causation in interventions and provide actionable insights (Bhaskar, 2016, after Hegel) to improve multimethodological OR practice over time, and has a number of advantages. It is an approach that does not rely on assuming interventions are carried out in similar contexts (Midgley et al., 2013), it can be used to separate the influence of different events (including practitioner and other stakeholder actions [Franco & Hämäläinen, 2016a]), contextual aspects, and their interaction, and is scalable to consideration of other aspects of interventions. My approach to case analysis explicated in Table 14 (chapter 4) can be used with data and evidence from across research traditions (including for example, ethnography [Franco & Greiffenhagen, 2018; Horlick-Jones & Rosenhead, 2007] and possibly autoethnography [E. Reynolds, 2017; Tavella, 2018]), and can involve internal and/or external researchers. For recent suggestions as to methods and technologies, see Ormerod et al. (2023). The new approach presented in chapters 3 and 4 can be used for empirical research into OR regardless of the philosophical assumptions inherent in its practice (Jackson, 2023; Ulrich, 2007), to explore OR as actually practised in non-academic settings.

My approach therefore provides an alternative to Ormerod's (2016) mangle approach for writing case studies to ground BOR theory. More generally, my research approach is complementary to the social and practice theories reviewed by Ormerod et al. (2023) in accommodating consideration of both individual actions in interventions *and* interpretivist accounts thereof, while attending to 'cultural, social, political, and material context', thereby integrating micro and macro perspectives in a systemic way that also acknowledges 'OR as a continuous practice' (p. 824).

In OR, understanding the context of multimethodological OR interventions and their contribution to events and outcomes is challenging. From Ormerod et al.'s (2023) review of social theory approaches to studying OR micro practice, we might conclude that OR lacks a compelling understanding of how to study context, given the need to look at cultural, social, political and material aspects. In chapter 3, I showed how critical realism and Archer's morphogenetic approach can provide a framework for more systematic study of all these elements of context, as well as their interrelations at different levels of an OR intervention, and their interaction over time, including influences within and beyond an OR intervention. Thus, my research responds to calls to provide new, overarching (Ormerod et al., 2023) scientific and theoretical grounding and methodological guidelines for scholarship on OR

practice (Brocklesby, 2016; Hämäläinen et al., 2013; Howick et al., 2017; White, 2016b) to support and inform future practice (Petropoulos et al., 2024, p. 428).

7.3.3 Addressing issues with accessing OR practice in non-academic settings

Finally in relation to contributions to BOR scholarship, this research addressed a recognized challenge in OR – that of OR scholars accessing OR practice in non-academic settings (Mingers & Christie, 2022, as cited in Dyson, 2022; Ormerod, 1998; Ranyard et al., 2022) in order to increase reporting of innovative practice to improve OR (Dyson et aal., 2021) and learn and develop best practice (Ackermann & Howick, 2022). In fact, in light of few published examples of multimethodological OR interventions in government, this research has shown how lack of practitioner time and incentives for publishing (Ormerod, 2014a, 2016) and issues of confidentiality (Ormerod, 1998; Ranyard et al., 2022) can be dealt with to draw out lessons on multimethodology from such practice.

7.4 CONCLUSION

In this chapter, in my discussion of the main findings of the survey and multiple case study in relation to OR literature, I showed how I have fulfilled the research aim to create new knowledge, not least in the burgeoning area of behavioural OR. This new knowledge contributes to academia, providing a grounding for scholarship on multimethodology in the applied discipline of OR, and can also be used to support and inform future OR practice. In the next chapter, I review future research opportunities and limitations of the studies, summarize my research contributions to academia and practice, and conclude the dissertation.

8 CONCLUSIONS

8.1 INTRODUCTION

As explained in my description of the background to this research project in chapter 1, with the research reported in this dissertation, I aimed to enhance understanding of the use of multimethodology in OR practice. As examined in more detail in chapter 2, understanding of multimethodology practice in OR literature has been limited due to a lack of recent cross-case studies, be they field studies, practitioner interviews or surveys, or literature reviews. Yet use of multimethodology is widely seen as essential for OR practitioners addressing the complexity of real-world issues. In chapter 2, after introducing OR methods, I examined in detail existing studies and theories about how and why practitioners choose and combine methods, as well as terminology used to describe, understand and promote multimethodology. The specific research gap I identified was a lack of understanding of the use of multimethodology in OR practice, especially in non-academic settings, and a lack of causal understanding of the process of practitioners' methodological decisions. I then derived my research questions, which were concerned with how and why OR practitioners choose and combine analysis methods in the context of supporting strategic decision-making in UK government, and summarized more specific research opportunities regarding the prevalence of use of multimethodology, methods used and combined, forms of multimethodology (methodological designs), and practitioners' reasons for using particular methods and multimethodology (or not using multimethodology). In order to tackle the research questions, in chapter 3, I made a number of philosophical assumptions, and developed a critical realist, morphogenetic theoretical framework, which I used alongside my multimethodological research design, as set out in chapter 4. Then, in chapters 5 and 6, across more than 100 decision support interventions supporting strategic decision-making for or on behalf of the UK government – an area of practice where we have few published examples – I explored methods that practitioners use and combine, and why they do so, in response to the research questions. In chapter 7, I discussed the main findings from the survey and multiple case study on the practice of OR in non-academic settings in relation to OR literature. In this concluding chapter, I identify future research opportunities. I then discuss limitations of the research, summarize my research contributions to academia and practice, and conclude the dissertation.

8.2 FUTURE RESEARCH

In this section I summarize key opportunities for future research arising from this research. Opportunities are presented by research stage (Appreciation, Analysis, Assessment, Action [Mingers & Brocklesby, 1997]; Figure 8, chapter 4).

8.2.1 Appreciation: future survey and multiple case studies

Survey

It is now around 15 years since the last global survey of OR practice was conducted (Ranyard et al., 2015). Given the results in this research, it would only seem timelier for IFORS or the OR Society in the UK to consider commissioning a survey to understand the current scope of OR practice across practitioners in non-academic settings, and reassess the gaps between current OR scholarship and practice, perhaps this time with a focus on the use of multimethodology, and the methods from this survey highlighted in section 7.2.2, including gaming, facilitation, visualization and AI. However, any such survey should only be undertaken if the expected benefits outweigh the inherent limitations of such surveys, as discussed in chapter 4.

Multiple case study

In this research, the limited use of quantitative and qualitative OR methods across the multiple case study limited any 'generalised insights that could be of benefit to those seeking to undertake mixed methods OR interventions' (Ackermann & Howick, 2022, p. 1907). Future research should therefore look specifically to identify and explore retrospectively OR interventions in non-academic settings where quantitative and qualitative *OR modelling* have been used together, or to observe in real-time (Franco & Greiffenhagen, 2020; E. Reynolds, 2021) the work of practitioners who have such modelling within their repertoire. Gaining access to study such practice would also facilitate overcoming some of the limitations of this research, such as the inclusion of interventions completed some years before the empirical research was carried out.

8.2.2 Analysis: enhancing understanding of causal mechanisms and their interaction

It could be argued that the multiple case study in chapter 6 did not go far enough in only identifying causal mechanisms of method choice and reporting their interaction in a narrative way (cf. Porpora, 2016, p. 61). Further research, building on the theoretical framework in chapter 3, could look to model the interaction of mechanisms over time, drawing further on Archer's (1995, 1996) morphogenetic approach (reviewed in section 3.4.5). This could also build on Franco et al.'s (2021) proposal to use OR modelling to understand the process of OR practice and Mingers' (2006a) proposals for combining quantitative modelling (e.g., simulation or system dynamics) with qualitative analysis in critical realist research. It could help practitioners understand, in the context of particular interventions, for example, the more specific influence on method choice of issues such as path dependence (Hämäläinen & Lahtinen, 2016; Lahtinen et al., 2017) and distributed working (Ackermann, 2024), as well as participant engagement with OR models (Ackermann, 2024) and changes in participants' knowledge and skills (competences) and social identities (Ormerod 1997a; 2008b; 2014b) over time. Empirical evidence from the multiple case study also supports a potential need to understand better the operation of power in the determination of issues that practitioners address and the influence this has on method choice (Yearworth & White, 2021). Access to real-time interventions could facilitate all this.

Like Ackermann and Howick (2022) in their interview study, I focused in this research on individuals' reports of interventions (in survey responses and interview data), albeit that I included a wider group of stakeholders, beyond practitioners, and examined intervention documents. In future research, access to real-time interventions would also permit enhanced researcher attention to embodied and collective behaviour (Ackermann & Howick, 2022; Henao & Franco, 2016; White, 2016b; White et al., 2016) and their effects in multimethodological OR interventions, as well as 'model affordances provided by diverse means whether via a model or via the social (Franco, 2013)' (White, 2016b, p. 837). In future action research, scholars can employ the theoretical and methodological approach developed in this dissertation to analyse causal effects of their involvement on intervention events and outcomes (Midgley et al., 2013) by including themselves in the structural and causal analysis. The ontological analysis can also be broadened to include non-human agents (Stephens et al., 2019; Taket & White, 2023).

8.2.3 Assessment: corroboration of causal mechanisms, causal complexity, and designs

In relation to the method choice causal mechanisms in chapter 6, future research should examine whether the mechanisms are found more generally (Zachariadis et al., 2013; Wynn & Williams, 2012) across practice in non-academic settings, across practitioners, place (including beyond the UK), and time (Rutten, 2024). This would involve structural and causal analysis of other cases (Pula, 2021). Researchers could also seek to explicate the mechanisms identified in this research using theory from psychology and sociology, and, more broadly, across the behavioural sciences, to check for compatibility (Hedström & Ylikoski, 2010).

In order to investigate further the causal complexity of method choice, a critical realist approach to configurational analysis could then be used to identify and seek to explain how the contingent operation of conjunctures (combinations) of mechanisms lead to practitioner use of similar or different combinations of methods across cases. This could build on Henfridsson and Bystad's (2013) use in IS of a case survey of digital infrastructure evolution in organizations to identify both equifinality (multiple different configurations of mechanisms leading to the same outcome, being successful evolution) and multifinality (other configurations leading to other outcomes).

However, in future research, set-analytic configurational approaches, such as qualitative comparative analysis (QCA; Furnari et al., 2021; Ragin, 1987), may be useful. QCA can be used to compare sets of configurations of conditions and outcomes across cases in order to identify patterns (using necessity and sufficiency analysis) that give clues as to possible causal relationships (White, 2018). These patterns can then be analysed using a critical realist approach, especially abduction and retroduction, in order to identify causal mechanisms (Runde, 2020; Rutten, 2024). But in future studies, QCA could be used to compare *mechanisms* (Pula, 2021) and outcomes – across theories and practical cases of multimethodology. This could facilitate further understanding of the causal complexity of method choice as part of wider, multimethod approaches (Gerrits & Pagliarin, 2021; Gerrits & Verweij, 2016) that build on the methodology for multiple case study for evaluating multimethodological OR practice developed in this research.

Another research opportunity is to test further the applicability and usefulness in practice of Christie's (2023) set of designs. Analysis of the multimethodological design examples from literature in Christie (2023) and the cases in chapters 5 and 6 shows that describing how practitioners use

methods together often requires combining more than one of Christie's (2023) designs. Further research should consider whether the Christie designs are sufficient in combination to describe this complexity, including, for example, the interaction (Brailsford et al., 2018), iteration, recursion and/or dynamic switching between models (Nguyen et al., 2024) seen in multimethod OR practice. The illustrations of methodological designs (section 6.2.8) could also be enhanced to reflect how practitioners working in teams (Ackermann & Howick, 2022) work differently on different aspects of an intervention – as suggested for complex designs in mixed methods research by Creamer (2020). A clear, common framework for multimethodological designs across OR, or for particular areas (e.g., see Marttunen et al., 2017), would potentially contribute to further integration across OR practice (Dyson et al., 2021) by facilitating learning from interventions, the building of expertise, development of best practice, and identification of collaboration opportunities. Such a framework may also be more generally applicable across mixed methods research beyond OR (Cameron & Golenko, 2023; Hitchcock & Onwuegbuzie, 2022; Poth, 2023).

8.2.4 Action: use of research findings and new critical realist research approach in future scholarship and practice across OR and other disciplines

More generally, all my tentative findings and their limitations are presented in this dissertation and associated papers, and summarized in this chapter, to facilitate their further corroboration, development and refinement in future research. This is in addition to facilitating their use by practitioners, including at Dstl, to inform future practice.

Evaluating the effectiveness and impact of multimethodological OR practice

The new theoretical and methodological approach to evaluating multimethodological practice in OR developed and employed in this dissertation can be employed in future to evaluate the effectiveness of multimethodology in practice. Empirical evidence of the effectiveness of multimethodology, particularly across methods, interventions and practitioners is limited (Ackermann & Howick, 2022; Franco & Lord, 2011; Gomes Júnior & Schramm, 2022; Henao & Franco, 2016; Howick & Ackermann, 2011; Midgley et al., 2013). It is known that intervention success, or otherwise, does not follow directly from method choice (Ackermann & Howick, 2022; Midgley et al., 2013; Pidd, 1996). As Pidd comments in the context of Clark and Scott's (1995) survey of OR tools used in strategic management, 'the value may lie as much in the [practitioners'] approach rather than in the detailed

technique in many cases' (Pidd, 1996, p. 474). To the extent that practitioners deal with strategic decision issues that are wicked problems (Ackermann, 2024; Camillus, 2008; Grewatsch et al., 2023; Mingers & Rosenhead, 2011), Rittel and Webber's (1973) work would suggest that different stakeholders are likely to judge the same intervention outputs differently 'to accord with their group or personal interests, their special value-sets, and their ideological predilections' (p. 163). Indeed, this was supported by survey findings on intervention success (Appendix U) in that survey respondents together implicated a wide range of interrelated issues in explaining their assessments of their level of project success when using a single method as compared with multiple methods. Practitioners' explanatory issues ranged from the choice of methods and overall methodological approach, through aspects of managing the process of a project, to the dependence of intervention success upon client expectations and perceptions, including whether projects delivered what clients wanted to hear, and whether outputs were acted upon, or ignored. There was also acknowledgement that questions to be addressed changed during projects, and that rather than answers and solutions, practitioners may in some cases provide a broader understanding of issues, leading to 'tackling the real issue' (survey participant). I would therefore propose that future research examines *perceptions of success*, including whether clients' needs in terms of intervention outcomes are being met (Howick & Ackermann, 2011; Midgley et al., 2013), and how, during interventions, participants perceive progress relative to intervention and individual or shared goals (Ackermann, 2024).

Future research using and extending my critical realist, morphogenetic research approach could therefore investigate the causal impact of method choice and methodological design on decision processes and intervention outcomes (Velez-Castiblanco et al. 2016; Hämäläinen et al., 2013), and what makes use of multimethodology successful or otherwise (Ackermann & Howick, 2022; Howick & Ackermann, 2011) *for stakeholders*. As I found in this research, some stakeholders will be better placed to comment on outcome, or implementation (gaining insight or managing change), others intervention process (Connell, 2001; Ormerod, 2008b). We would not ask, 'what impact did use of this method have on intervention outcomes?', but 'how was the method (or other aspects of practitioners' approaches, or other intervention aspects, including stakeholder actions) implicated in real causal mechanisms that led to intervention outcomes and perceptions thereof?'. Thus, my framework facilitates a move beyond previous interpretive accounts of intervention success (Midgley et al., 2013; Ormerod et al., 2023) to unpick causal mechanisms and their complexity across projects

that lead to OR practitioners' interventions being perceived as successful. It can therefore be used to respond to the need to look at 'what works for whom and why' (White, 2006, p. 846; Connell, 2001). Such evaluation of the extent to which practitioners are facilitating improvement of situations, and for whom, is fundamental for the successful future practice of OR as an applied discipline.

There is also a lack of research into the influence of different stakeholders (including OR practitioners) on the process of strategic decision-making where this is supported with OR (O'Brien, 2015). Future research using my research approach could address this, thereby assisting OR practitioners to appreciate the impact of their work. As Midgley et al. (2013) conclude, 'Inquiry focused on an intervention can look, for example, at how satisfactorily the method addressed given purposes; what aspects of the context enabled or constrained its application; and whether it gave rise to anticipated or unanticipated outcomes.' (p. 146). Another option may be comparison of multiple cases of use of the same mixes in the same domain or similar contexts (Midgley et al., 2013).

Theorizing research design and evaluating mixed methods research across other disciplines

My conceptualization of methodologies in intervention activities (methodologies *in action*), and methodologies as used in past interventions (methodologies *as used*; Table 11), is also potentially relevant across mixed methods research (MMR), where the role of stakeholders as an influence on research design has recently started to be explicitly recognized (Poth, 2018). My new approach can be used for theorizing about this stakeholder influence on the process of method choice though structure, culture, and agency. More generally, the approach provides a theory-led basis for an alternative to ecological, interactive and other realist approaches to the theory of the complexity of designing interventions in MMR literature (e.g., Maxwell 2022a, 2022b; Nastasi et al., 2010; Plano Clark & Ivankova, 2016; Schoonenboom et al., 2018; Stoecker & Avila, 2021). Moreover, the new theoretical and empirical research approach can be adapted for evaluating mixed methods research projects in and across other disciplines, including their complexity (Poth, 2018) and practical utility (Dahler-Larsen, 2023).

Understanding how AI is and can be used to enhance multimethodological practice

Finally, in terms of future research opportunities, given the enormous recent growth in affordances and use of AI within and beyond OR (Petropoulos et al., 2024), future research should investigate

how AI is used in multimethodological practice. This would include understanding how AI is used as an additional method or source of tools within multimethodological practice across OR. But it would also include the potential for AI to enhance the process, effectiveness and impact of multimethodology, including in relation to method choice, which could be evaluated using the new evaluation approach developed in this dissertation, as discussed above.

For example, are organizations developing their own generative AI tools using large language models for multimethodology? One could envisage such a tool building on both academic scholarship on multimethodology *and* learning from past OR projects in which practitioners have combined methods. Such a tool could take into account, for example, organizational rules, policies and guidelines, and an organization's own tools for method choice, as well as practical knowhow about the persuasion and judgement – as well as analysis – required to address practical and inherently political strategic issues to support organizational decision-making. The literature review and theoretical, empirical and methodological findings in this dissertation, and their implications for scholarship and practice (summarized later in this chapter) would provide useful inputs to such a tool.

8.3 RESEARCH LIMITATIONS

> From the CR [critical realist] perspective, it is not neutrality that is to be demanded of competent scientific researchers, but intellectual honesty – the honesty to admit when their own expectations go unmet, the honesty to admit when rivals have the better argument. (Porpora, 2016, p. 210)

Having discussed future research opportunities, I now discuss key limitations of this research by research stage (Appreciation, Analysis, Assessment, Action [Mingers & Brocklesby, 1997]; Figure 8, chapter 4).

8.3.1 Appreciation: research methods and tools

Research methodology

My qualitative-led empirical research described in chapters 4, 5 and 6 is in stark contrast to BOR studies that seek and privilege the observation and objective measurement of phenomena, for example, through the use of standard questionnaires before and after workshops (De Gooyert et al., 2022; Midgley et al., 2013), and therefore limit research to that which is measurable. I made different

assumptions about intervention practitioners and participants. I privileged their stated views and sought to understand them in context. Not least because this research was – necessarily – mostly retrospective, this was based on beliefs that it is practitioners and other intervention participants themselves who are best placed to understand their own reasoning and actions, and that they make statements purposively. In other words, for this research, so-called 'self-reports' were actually a good place to start (Franco et al., 2021; De Gooyert et al., 2022; cf. E. Reynolds, 2021) within a systematic and systemic, multimethod approach that allowed for collaboration of data, findings, and theory across participants and sources, and used an abductive and retroductive approach (Franco et al., 2021; Midgley et al., 2013) to try to understand, 'if they said that, what must be the case?'. However, it may be countered that this research is anecdotal – a type of research that should be avoided in BOR studies (Franco et al., 2021). However, I would argue that it is not because I reported and compared multiple, albeit unique cases in a systematic way. Like Henao and Franco (2016), I used their extension of Mingers and Brocklesby's (1997) 4As framework (Figure 8, chapter 4; Figure 46, Appendix G), though in a different way, to 'go beyond simply sharing experiences and lessons in a story-telling or anecdotal manner, and move towards a more structured and systematic way of reflecting upon intervention evaluation data' (pp. 693-694). I also acknowledge where care is required regarding the interpretation of results. However, a potential disadvantage of the new theoretical and methodological approach developed and employed through this dissertation is that I found it time-consuming, albeit that this was exacerbated by needs to understand a plethora of context-specific jargon and to do my own transcription of interviews, and that this was my first attempt.

Research participants

As reported in chapter 4, research participants were informed about the research topic – both in communications and discussions about the research project, and in the survey and interviews. For example, they could have read up about multimethodology in anticipation of their participation in the research, and they may well have been aware of it anyway. In fact, informing participants that the research was about the use of multimethodology supporting strategic decision-making was part of the research approach and expected to encourage participation of these time-limited practitioners outside academia. I interpreted the research data taking this into account, but nevertheless my conclusions should be interpreted with this potential limitation in mind. Anyway, regardless of the

information provided to practitioners in this and any other research, practitioners can always 'reason and respond to theories' in OR,

> … resulting in a causal interdependency between human sciences and their subject matters, and epistemological limits – which are the limits to knowledge due to the openness of social systems leading to the impossibility of obtaining decisive test situations. These limits cannot be overcome and have the consequence of making social sciences prone to error. (Ash, 2022, pp. 44-45)

Regarding practitioners, there may be a question as to whether it is appropriate to claim that all practitioner research participants were *OR* practitioners (see also G. C. Jones, 1993). As this was exploratory research aimed at gaining insight into practitioners' work from their perspectives, I did not define OR in the survey. And in the multiple case study, practitioners used few OR modelling methods. However, I suspect, not least given the variety of methods used by practitioners (section 7.2.2) and that OR is cross-disciplinary (chapter 2), there are as many definitions as there are practitioners, as exemplified by comments received from survey respondents (Figure 38 below).

> […] In the last 2 years I have been, to some extent, specialising in connecting methods as indicated in Q2a but this is as a consultant focussing on benefits analysis and systems thinking. *My customers don't refer to what I do as OR*. I am in the process of extending how I use cost-benefit analysis methods to include simple statistical analysis to be able to deal with uncertainty in cost and benefit estimation data. (response to q10, *emphasis added*)
>
> *need to define OR*, need to include soft skills if you want well-rounded, rich and complete answers. (q10, *emphasis added*)
>
> *OR is a very broad term* and as you have illustrated there are lots of different techniques that may or may not be useful depending upon the circumstances. As you probably have gathered I am not one for a tyranny of the expert approach or the pedant as this way of supporting decision making rarely in my opinion pays dividends. (q10, *emphasis added*)
>
> *To be honest, I'm not sure what OR is, or if what I do is OR***.** I conduct analyses to help people understand their complex problems, this is usually "soft" analysis as the problems are subjective and not expressed in quantifiable terms (q10, *emphasis added*)
>
> *Whilst not an OR methodology per se*, I find that good knowledge management, collaboration and customer collaboration are equally as important to the solution of problems. (q10, *emphasis added*)
>
> […] *I'm never sure what is and is not OR* […] (participant email, *emphasis added*)

Figure 38: Practitioner definitions of operational research in the survey

Survey

In contrast to some previous surveys (e.g., see Table 16, chapter 5), in the survey I did not define regular use (of methods) for participants. While this was intentional, I gathered the following comments from respondents, which provide further insights into their day-to-day work and additional points to bear in mind when interpreting the results (discussed in section 7.2.2 above) or considering future research in this area:

> It might have been helpful to define what you mean by regularly - though I suspect it is dependent upon the duration and effort spent on individual projects (i.e., if you are engaged in 1 project a month - then regularly might mean using a method every 3-4 months). [...] (q10)
>
> There are a large number of 'not regularly'. This is due to the varying nature of what we do, and that we will use something regularly (i.e., every day) in short bursts, before moving onto something else that requires a different technique. (q1)

Multiple case study

Potential limitations of the multiple case study arise from the size of the cases (their long duration, wide subject matters, and that lots of people were involved), and their sensitive nature, as well as the fact that some years had elapsed between some (but not all) of the interventions and this research. As a result, there may be gaps in case descriptions, documents I was not given access to, people I did not speak to, and/or incomplete recall of what happened. Further, to keep this research manageable, I focused in this dissertation on one intervention phase per case, and, more generally, was not in a position as researcher to investigate the wider journey of engagement and collaboration that practitioners may have embarked on beyond intervention as defined for the purposes of this research. But it is widely acknowledged that researchers cannot consider all aspects of cases, even when they are closely involved in the intervention itself (Ormerod, 2014a). Further, as explained in more detail in chapter 4, I sought to reduce negative impact from retrospective sense-making and impression management by interviewing a range of diverse intervention stakeholders, and interviewing practitioners more than once over time so that I could, for example, examine and interpret conflicting data (Eisenhardt & Graebner, 2007). In this dissertation I then presented a synthesis of data on the elements of each case most relevant to the research questions for further corroboration.

8.3.2 Analysis: interpretation of research results

Clustering and categorization of methods

The research results needed careful interpretation as they depended on how methods and tools were defined, clustered and categorized (section 5.2.2), and this should be borne in mind in reviewing the findings discussed in the previous chapter. Categorization of OR methods is divisive, and always to some extent arbitrary (see, e.g., Christie, 2023; Franco & Rouwette, 2022; Friend, 2006; Hopes et al., 2022; Mingers & Rosenhead, 2004; T. Williams, 2008), but it was invaluable in this research in making sense of questionnaire responses (in particular, method combinations), in comparing results across survey questions and with the multiple case study, and responding to the research questions. Categorization was an iterative process involving close review of data alongside relevant literature. Clustering of method listings also facilitated comparison of what 'counted' as a method for different participants, and I took this into account in interpreting the results. Future research could investigate the applicability of the categories and clusters in other practice in non-academic settings in order to understand what else is OR.

Survey

There is a possibility that de-identification of survey results, and indeed what practitioners were able to contribute as survey data in the time available, including the extent of what they were consciously aware of as influencing their methodological approaches, limited the findings. Careful interpretation was required as the data on method choice could include participant recollections of reasons for choosing methods or expected benefits of methods at the time of their interventions, as well as subsequent justifications, and other insights and interpretations. However, I was encouraged by consistency in the results across survey questions, and explored the research topics further in the multiple case study.

Care was also required with the survey regarding the possibility of some overlap between example projects where more than one participant worked on the same project (as has appeared typical in multimethod OR projects; see, e.g., Ackermann & Howick, 2022). However, tables of examples of projects with key details allowed quick comparison, and in the event, I excluded no projects.

I did not generate detailed understanding of the project examples in the survey, but rather, interesting but not comprehensive insights about how methods were adapted, adjusted and used together (as has been typical in single case study reports [Howick & Ackermann, 2011]). We did not ask practitioners to provide details of *how* they used methods and methodologies, for example, which parts they used and did not use, nor whether they used single and/or multiple methods in a more participative, qualitative, or quantitative way, and so on. I was not able to report, for example, where methods were used in a PSM-like way (D. F. Andersen et al., 2007; Bell, 2012; Belton & Stewart, 2010; Harwood, 2020; Lami et al., 2014; Leong et al., 2023; Lowe et al., 2016; Yearworth & White, 2014). Notwithstanding this absence of comprehensive, detailed project descriptions, we generated data that was sufficient to draw the interesting conclusions and new findings discussed in the previous chapter, shining a light on underreported aspects of OR practice.

Multiple case study

The multimethod approach I adopted in the multiple case study facilitated corroboration across participants, survey questions, interviews and documents (Mingers, 2015), with the resulting rich description of cases, including summary narrative descriptions of each case of up to 100 pages in length, including quotations (section 4.10.5). For reasons of confidentiality, and to respect my commitments to research participants (Pratt et al., 2020), I am not publishing full case descriptions. Anyway, no journal would accept them due to their length. Rather, my aim was to provide provisional and justifiable answers to the research questions, drawing on the case descriptions, as required, to support claims. I went to great lengths to limit reported details to those necessary for the conclusions. The opportunity to compare results across cases and with the survey provides additional critique.

8.3.3 Assessment: corroboration of research findings

As part of my critical realist approach to justification and corroboration, further critique is invited. Regarding one specific area of the research, the generation of data in the survey was opportunistic in that we did not ask practitioners why they chose particular methods, so the results in section 7.2.4 above should be interpreted with caution, in particular, they are not exhaustive, including at the project and practitioner level.

More generally, as debates about the suitability of replicability for assessing research quality rage (Pratt et al., 2020), I have no doubt that replication of this survey and multiple case study research is not possible (Checkland, 1999; Midgley et al., 2013; Yearworth & White, 2014). I described my research design, methods and results in detail in this dissertation and in the appendices, in the interests of transparency (Van Burg et al., 2020), trustworthiness (Foster-Collins, 2020) and credibility (Nowell et al., 2017), balancing those needs with needs for confidentiality and anonymity (or at least de-identification of individuals), and the practicalities of finishing the research and writing within the word limit.

8.3.4 Action: generalization

In devising the survey, we struck a balance between generating insightful results, covering a range of methods, and producing a not overly long questionnaire, considering that this was a first, exploratory step in a wider research project in which interviews and workshops with practitioners would be possible. However, it may be countered that the survey results are not generalizable because the participants were a subset of government OR practitioners known to my industrial supervisor and colleagues in the UK. Indeed, like all previous surveys, the survey findings have limitations due to sampling (Ranyard et al., 2015), however the findings might be explained in terms of the participants and the nature of their projects supporting strategic decision-making, about which I generated, reported, and interpreted data. Although I would characterize the research as qualitative led, the project example data from the survey may be viewed as a large N, purposive sample of single case studies (Schreier, 2018; M. L. Small, 2009), with a list of key dimensions and some commentary from practitioners.

In fact, as explained in more detail in chapter 3, I did not intend that the survey and multiple case data would constitute statistically representative samples from which I could generalize to a wider population of practitioners' decision support work, though some interventions were described by my industrial supervisor and colleagues as typical. With the survey I sought understanding of some recent OR practice within the research context in order to inform the rest of the research. Taking a scientific, critical realist approach, I then sought in this dissertation to employ the survey and multiple case data in developing more plausible descriptions and explanations of the use of multimethodology than previous research in the context of this practice supporting strategic

decision making for or on behalf of government. Future, corroborative research can examine whether the survey and multiple case study findings, including causal mechanisms, can be found more generally across practice in government, and more generally in non-academic settings, and beyond the UK.

8.4 SUMMARY OF RESEARCH CONTRIBUTIONS TO ACADEMIA

In summary, the following key academic contributions of this doctoral research are noted.

8.4.1 New reviews of prevalence of use of qualitative with quantitative OR

Recently there has been renewed interest amongst scholars and practitioners in OR practice combining qualitative and quantitative approaches (Christie, 2023). In response, I produced a new, narrative review of the prevalence of use of PSMs with quantitative OR as reflected in practitioner surveys and systematic literature reviews going back 30 years (Christie, 2023, pp. 166, 168; Christie et al., 2022, pp. 8-14; Christie, 2021, pp. 6-7), and extended the review in chapter 2 to include combinations of quantitative OR with other qualitative methods (section 2.3).

8.4.2 New set of six designs for combining PSMs and quantitative OR

There have also recently been renewed calls from academics and practitioners for guidance on how to integrate PSMs with quantitative OR methods, and its benefits (e.g., Abuabara & Paucar-Caceres, 2021; Marttunen et al., 2017; Murray, 2021). Building on the prevalence study in Christie (2023) and previous typologies in OR and mixed methods research, I responded by compiling a new set of designs specifically for this type of practice, with a wide range of examples and their benefits from OR literature (Christie, 2021, 2023; Christie et al., 2022), as summarized in chapter 2 (section 2.6.4). As reported in Christie (2023, p. 169), 'As far as I am aware, this is the first study to propose a set of designs specifically for using PSMs with traditional [quantitative] OR'. Novelly, the set of designs foregrounds how PSMs (as defined by Rosenhead, 1989; Rosenhead & Mingers, 2001a), or parts thereof, are positioned within six different designs, thereby highlighting the use of PSMs beyond generic problem structuring (Mingers, 2011; Westcombe et al., 2006), and throughout interventions, alongside (more) quantitative OR (Christie et al., 2022). As discussed in section 7.2.3 above, the designs may be more widely applicable across OR practice and mixed methods research and future research can test further their applicability and usefulness in practice.

8.4.3 New approach for evaluating multimethodological OR practice

For the first time as far as I am aware, I operationalized critical realism for evaluating multimethodological OR practice. I developed a plausible theoretical framework (Easton, 2010) – a theory-informed, critical realist analysis of a generic multimethodological OR intervention. This provides a 'compelling basis' (White, 2016b, p. 827) for scholarship on OR practice and makes critical realism more accessible in research (Maisuria & Banfield, 2023; Shaw et al., 2019). The theoretical framework built on previous critical realist studies in OR and recent developments in philosophy and social science, and synthesized existing theoretical scholarship and empirical findings from literature on multimethodological OR practice. Overall, my critical realist, morphogenetic conceptualization of the ontology of an OR intervention (summarized in Figure 5 and Figure 6, chapter 3) and of methodologies (Table 11, chapter 3), together with my empirical research design (Figure 8, chapter 4), and in particular my explication of the stages of critical realist case analysis for evaluating multimethodological OR interventions (Table 14, chapter 4), provide a new approach for deriving and identifying causal mechanisms and the entities/structure in the intervention context from which they are emergent. In this research, my employment of the new theoretical and methodological approach facilitated causal explanation of practitioner method choice. As discussed in the previous chapter, the new approach can be extended to examine causal mechanisms that lead to other stakeholders' and collective actions in interventions (and their complexity), and other intervention outcomes, including intervention success, and may be more generally applicable for the theory, practice and evaluation of MMR across other disciplines.

8.4.4 Empirical evidence of the prevalence of multimethodology

Unlike previous research, I studied the extent to which practitioners adopt multimethodology in their day-to-day work. I found that use of multimethodology is not just becoming a norm (Ackermann & Howick, 2022; Mingers, 2014, 2015), but was a tendency amongst practitioners supporting strategic decision-making in this UK government context. Single method projects in practice, while sometimes requested by clients (Ackermann & Howick, 2022), were associated by practitioners with simpler projects with limited time and scope, and use of previous work. These findings extend our understanding beyond recent anecdotal evidence of the extent of multimethodology in OR practice in non-academic settings (e.g., Brocklesby, 2023; Hoverstadt &

Loh, 2023; Ranyard et al., 2022), providing grounding for scholarship on multimethodology in the applied discipline of OR.

8.4.5 Analysis of 46 practitioners' 104 multimethod project examples

Responding to specific and still extant calls in literature (Ackermann & Howick, 2022; Hopes, 2021; Howick & Ackermann, 2011; Ranyard et al., 2015; Ranyard et al., 2022), the database of 46 practitioners' 104 multimethod project examples in Appendix T from the survey provides details of subject matters, customers, time available, methods used, and reasons for using more than one method. It provides a useful overview of a wide variety of combinations of methods used by practitioners in supporting strategic decision-making for or on behalf of the UK government. It is a unique contribution to the literature, reflecting a way of gathering data at scale to check the relevance of theoretical work, with detailed analysis, commentary and discussion of the data in chapters 5 and 7, the key contributions of which are summarized below.

8.4.6 Five in-depth case studies of use of multimethodology

OR practice in non-academic settings is underrepresented in OR literature (Christie, 2023; Howick & Ackermann, 2011; Munro & Mingers, 2002; Wijnmalen & Curtis, 2013). In chapter 6, I provided new insight into such OR practice in my multiple case study of five interventions supporting strategic decision-making in UK government, with a focus on method choice and methodological design.

8.4.7 New empirical evidence on methods used and combined in OR practice

My discussion of the empirical survey results on methods used and combined in section 7.2.2 highlighted the much greater variety in OR projects in this research context compared with previous surveys. This was also the first research to attempt to capture the extent of use of gaming and historical analysis in multimethod OR practice. We found widespread use of facilitated workshops and visualization with a very broad range of methods, together with the suggestion that facilitation is a skill required by OR practitioners generally, and likely underreported in OR literature. Overall, this research also suggests greater awareness and practice of systems thinking (particularly SSM and VSM) amongst OR practitioners than captured in previous surveys of practitioners.

However, overall, this research suggests a lower prevalence of use of PSMs and soft systems thinking with more quantitative OR than that suggested by UK practitioners in Ranyard et al.'s (2022) review. This was surprising given that across the survey and cases, practitioners addressed strategic issues, which continue to be associated in OR literature with PSMs (e.g., Franco & Rouwette, 2022; Hindle et al., 2021). Through in-depth study of interventions in non-academic settings in the multiple case study I showed *how* the stakeholder and client orientation that Ranyard et al. (2015) associated with the use of PSMs, risk analysis, cost benefit analysis and other methods to address 'messy (often strategic problems)' (p. 5) was adopted *in practice* across a range of methods, qualitative *and* quantitative, but *excluding PSMs*, in the context of government cost-effectiveness analysis supporting strategic decision-making.

8.4.8 New empirical evidence on reasons for practitioners' method choice

As discussed in detail in section 7.2.4, compared with previous research, the survey in chapter 5 led to a more detailed, nuanced, and broader understanding of why practitioners chose particular methods. In-depth case analysis in the multiple case study resulted in (provisional) mechanisms of method choice. Given their intervention and employment roles, practitioners aimed to deliver that sought and expected by clients and other stakeholders. Beyond that, method choice seemed to be largely governed by practitioner tendencies (given their past experience and skills) *and those of their colleagues*, and collective views of similar past projects, and/or rules. Limited resources were implicated; using new or different methods was considered risky. The other key influence on method choice was disagreement between stakeholders and associated politics. These results provide empirical support for a range of reasons for method choice that built on previous studies, and provide a better basis for synthesizing extant theoretical understanding as it relates to this strategic decision support practice in government.

8.4.9 New empirical evidence on reasons for practitioners' use of multimethodology

As discussed in section 7.2.5, my analysis of why practitioners chose to use two or more methods in their recent projects was novel. We found project stakeholders implicated in multiple different ways in the choice of methodological approach, and, in particular in using multimethodology. The extent to which practitioners employed their and their colleagues' tendencies, including *to use multiple methods*, *and particular combinations* to explain their use of multiple methods was a new finding. In

the cases, practitioners 'added' methods for particular purposes, and in particular to respond better or more comprehensively to stakeholder questions or project requirements. Practitioners often sought stakeholder engagement or buy-in. Reasons for *not* using multimethodology involving quantitative and qualitative OR modelling methods included organizational rules, risk aversion, and limits to expertise, experience, resources, and the extent to which practitioners saw their role as to explore higher-level purpose or problem framing. These findings build on previous OR research, and provide a new empirical basis for theoretical understanding of why practitioners outside academia use methods together. The empirical evidence supports theories of method choice that are both multi-dimensional and which conceptualize method choice as a complex process.

8.4.10 Proof that 'strengths and weaknesses' rationale can be better specified

An empirical finding from the survey, and from my analysis allocating benefits of practical multimethodological interventions in OR literature in Christie (2023) to theoretical benefits in the final column of Table 8 (chapter 2), was that strengths and weaknesses of methods as a motivation for combining methods can be better specified by more specific reasons for using more than one method in an intervention, supporting that it is best viewed as an overarching theme.

8.4.11 New causal understanding of method choice and use of multimethodology

In the multiple case study, I enhanced current understanding of the process of multimethodology by providing theory-informed description and causal explanation of the complexity of the process of practitioner method choice, identifying multiple, interacting causal mechanisms that led to particular methods being used together in particular ways in this practice in non-academic settings.

8.5 SUMMARY OF RESEARCH CONTRIBUTIONS TO PRACTICE

> The ultimate goal of BOR is to generate an improved understanding of the behavioural dimension of OR practice, and use this understanding to design and implement better OR-supported interventions. (Petropoulos et al., 2024, p. 428)

The academic contributions in the previous section, including insights into 'structures, their mechanisms and tendencies' (Ackroyd & Karlsson, 2014, p. 37) are all 'generalised insights that could be of benefit to those seeking to undertake mixed methods OR interventions' (Ackermann & Howick, 2022, p. 1907). In addition, the following key implications for OR practice, training and education

are noted. These are in addition to the practical impact recorded to date under 'Practical impact' (page ix). This doctoral research therefore complements research ongoing at the University of Strathclyde into how mixing methods should be taught. The academic and practical findings could also be used in supporting a culture amongst OR practitioners of ongoing experiential learning from multimethodological projects, including during apprenticeships (Ackermann & Howick, 2022), and, as discussed in section 8.2.4, in developing AI tools to enhance future multimethodological practice.

8.5.1 Understanding of theoretical frameworks for multimethodology

My review and discussion of theoretical frameworks for multimethodology in this dissertation (including in sections 2.6 and 2.9 of the literature review chapter and chapter 3) may be useful for the new Systems Thinking Practitioner apprenticeship in the UK, where a distinction requires that the apprentice, 'Combines approaches and alters the approach, scale and scope of the modelling to address unfolding situation, including System of Systems Methods (SOSM), and/or supplementary methods' (IFATE, 2020b, p. 18). In section 2.9.2, I provide an overview of SOSM and also the most recent version of critical systems practice (Jackson, 2020, 2021, 2022a, 2022b), in which the SOSM grid is abandoned in favour of choosing 'appropriate systems methodologies' (Jackson, 2021, p. 598) for 'complex real-world problem situations' (Jackson, 2021, p. 594) using systems metaphors (machine, organism, cultural/political, societal/environmental).

In relation to the strategic decision support practice in the government context in this research, the research findings provide empirical justification for theories of method choice that foreground the selection of particular methods according to what practitioners seek to achieve (including affordances of methods), and that highlight numerous other influences of the intervention context, including clients, and advice from practitioner colleagues. Overall, the empirical evidence particularly supports theories of method choice that are both multi-dimensional and which conceptualize method choice as a complex process, such as multimethodology (Mingers 2003; 2006b, 2014; Mingers & Brocklesby, 1997), and creative design of methods in systemic intervention (Midgley, 2000, 2023), rather than theories based on simpler conceptualization of method choice by types of problem or issues.

8.5.2 Identification of need for training and education in facilitation for OR

The widespread use of facilitated workshops with a very broad range of methods in this research would suggest that facilitation is a skill required by OR practitioners generally, or at least teams of practitioners. Yet while the new apprenticeship in the UK defines a Systems Thinking Practitioner as a provider of, 'expert systemic analysis, advice *and facilitation*' (IFATE, 2020d, para. 1, *emphasis added*), the Operational Research Specialists apprenticeship does not specifically mention facilitation (IFATE, 2020c). Whether it is the role of universities to develop students' practical skills has been debated and there are different views (e.g., Mingers, 1991; Ormerod, 2014b; Rosenhead, 1992a; V. L. Smith, 1991, 1992), however, this study would suggest that facilitation is a skill required by OR practitioners generally (i.e., not only by practitioners using PSMs), with implications for education and training of OR practitioners.

8.5.3 Potential use of PSMs and critical methods for power relations, morals, and ethics

As discussed in the previous chapter, multiple case study data suggested that practitioners did not use formal methods for critically examining or reporting on the operation of power relations, different moral stances of stakeholders, or ethics inherent in their choices of methods or which stakeholders to involve in their interventions. Relatedly, some interviewees noted recent initiatives within the research context to review – across interventions: (1) how client requirements are defined, (2) how ethical aspects are dealt with, and (3) methods that can be used to deal with non-quantitative aspects of particular situations. There is therefore a potential opportunity for practitioners in this research context to consider using methods, such as PSMs (or methods *as PSMs*), critical systems heuristics and boundary critique, to manage ethical and moral issues in: (1) what practitioners were tasked to do; and, (2) method choice.

Therefore, drawing on tools of multimethodology, practitioners could look to use more of the methods in the top two rows of Mingers' (2014) mapping of research methods to address personal, social, and ethical aspects of their interventions more formally (Figure 39 below). Using PSMs for learning about stakeholders' objectives might also lead to opportunities for using different intervention methods.

8.5.4 Understanding barriers to innovation in method use (resources, risk-taking, rules)

In the resource-constrained interventions in the multiple case study, using new or different methods was considered by practitioners and other project stakeholders to be risky in that it may not give an answer or be understood by stakeholders, such as decision makers. It would seem, at least as far as these cases of strategic decision-support in government are concerned, that innovation in methods practitioners use would require additional resources (investment in developing new expertise and experience with methods amongst practitioners and their colleagues), and some risk-taking, and/or changing rules restricting the methods that are acceptable or how rules are interpreted.

While practitioners noted the availability of tools such as lists of methods in the research context, they emphasized the role of practitioner colleagues in assisting practitioners with choosing and using new methods, and the need to be aware of a broader range of methods, as captured, for example, in the following quotations from research interviews:

> We've the [name of] tool. That's very helpful. [...] But it is it is still very, you look at that and think, 'Wow look at all those methods!' And then you dip into a few of them and think, 'Yep, I could use that, yep, I could use that, yep, I could use that, oh, I still don't know which one to choose', so then you need to go and talk to. You need a person not a tool (case practitioner)

> [...] understanding what tool, all the approaches and how they can knit together and understanding is the key. We're still a little bit away from there but [...] when I look at that [integration form of multimethodology] I'm thinking yeah that's what we're trying to achieve. [...]
> We need to move together to a place where we can use bits of OR approaches across the spectrum of soft and hard together, in combination, to achieve a common purpose [...] we need to have a chunkier awareness across the board. (case practitioner)

[REDACTED]

Source: Mingers (2014, Table 9.2)

Figure 39: Mapping of research methods – 4As, 3Ws (Mingers 2014)

8.6 CONCLUSION

In this chapter, following a summary of the previous chapters of this dissertation, I identified a range of future research opportunities, building on my literature review, theoretical framework and research methodology, and research findings. As with any research, my research was not without limitations. Accordingly, in this chapter I also reviewed key limitations that should be considered when interpreting, corroborating, and applying the knowledge I generated. I then summarized my contributions to academia and practice. At the time of writing, it is intended that the research findings will help Dstl review how it identifies analysis methods and consider alternative approaches to supporting strategic decision-making. Dstl is considering building on the work to develop guidance on designing multimethodological analysis. In short, as set out in this chapter, I have contributed in numerous ways to closing 'the gap between academic research and practice' (Ranyard et al., 2015, p. 12).

APPENDICES

Appendix A Dstl and multimethodology: An introduction

> It is important to recognise that there are, in general, subjective phases in otherwise objective approaches, typically in the problem structuring and scenario definition phases, and that this guidance [from the UK's Ministry of Defence 'on the Use of Subjective Methods in Operational Analysis'] is relevant to them. It is likely that a multi-methodology strategy, implemented in accordance with this guidance, is the right approach for most assessments. This is consistent with the heritage of OR/OA [operational research/operational analysis], and most likely to result in well-structured, rigorous and quantitative analysis, of maximum utility to the decision maker. (Director General (Scrutiny and Analysis) [DG(S&A)], 2001, as cited in A. P. Robinson et al., 2004, p. 191)

1. Background

The Defence Science and Technology Laboratory (Dstl) has a history of adapting and using multimethodology, and they continue to seek new approaches to problems. This is partly because of the complexity of the environment in which they operate, and the complexity and strategic nature of issues they address – a rational response is to network widely and use a broad range of approaches (Duijnhoven & Neef, 2015). It is also consistent with a wider view that elicitation of expert and stakeholder views is critical for increasing the chances that subsequent responses to issues are innovative and robust against unlikely events (The Grantham Institute, 2016).

In defence, there has been a move to use human and social science approaches to deal with social and political complexity, including methods and practice beyond OR (Richardson et al., 2003). Consideration of so-called 'soft' or 'subjective' methods, including problem structuring methods (PSMs), and their combination with quantitative OR approaches has reportedly increased (Curtis et al., 2006; A. P. Robinson et al., 2004), mirroring wider developments in OR practice. This is despite considerable resistance from some operational researchers (Heyer, 2004) and warnings to analysts regarding problems of rigour (Richardson et al., 2003) and limitations of non-quantitative OR and its use alongside quantitative methods (DG(S&A), 2001, as cited in A. P. Robinson et al., 2004; North Atlantic Treaty Organization [NATO], 2012a).[41]

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[41] UK Ministry of Defence guidance states:

> Critical issues specific to subjective approaches include:
> - The distortions deriving from un-represented effects of interactions between factors;
> - The provenance and validity of data has heightened significance because it is derived from judgements;
> - Auditability through clear separation (of objective and subjective methods, and of methods and data).
>
> (DG(S&A), 2001, as cited in A. P. Robinson et al., 2004, p. 191)

NATO guidance warns of a particular issue with the 'interleaving of 'soft' and 'hard' methods', as follows:

> Particular care needs to be taken where 'soft' and 'hard' methods are interleaved. In general, the relative simplicity of representation achievable by a 'soft' method can significantly degrade the credibility and resolution of predecessor 'hard' techniques. A 'hard' method can successfully address the interaction of distinct factors; if a 'soft' method is subsequently applied to the outputs of that 'hard' method, there is a danger that the impact of such interactions will be dissipated by

2. Multimethod approaches developed by Dstl

Dstl have developed multimethod approaches for addressing particular types of problem (Morrill, 2007). Examples include strategic assessment method (Morrill, 2006; A. P. Robinson et al., 2004), benefits mapping (Mathieson, 2004), psychologically profiled experimental gaming (Morrill, 2007), and psycho-political analysis method (developed by Paul Willis at the Defence Evaluation and Research Agency, Dstl's predecessor organization; Mingers, 2001b).

3. Examples of use of multimethodology by Dstl

Published examples of the use of multimethodology in defence include analysis from Dstl, the US and Germany involving PSMs, observation, process analysis, simulation, historical analysis and gaming that informed the restructuring of a key NATO task force (Lambert, 2004), and served as a test case for NATO's Concept Development and Experimentation programme (Nijs, 2010).

4. Benefits of multimethodology in defence

Recording of benefits of multimethodology in defence includes using facilitated workshops early on in an intervention being recognized as an opportunity for practitioners to demonstrate competence in soft OR to customers and gain their trust (NATO, 2012a). Corroboration of findings from PSMs and traditional, quantitative OR enhances the judgement and rigour applied in an intervention (NATO, 2012a). Anecdotal evidence suggests that combinations of traditional OR and PSMs can reduce judgement, promote awareness and improve buy-in for studies compared with single method approaches (Clutterbuck, 2001).

5. Method choice in defence

> Hence we have a dilemma. On the one hand we have trusted methods which seem incapable of dealing with the whole problem (although they are still powerful in parts of it) and we have social science approaches which embrace the whole problem but often lack the level of rigour which OA traditionally demands. (Richardson et al., 2003, p. 4)

> the architecture of the 'soft' method. A final opinion-based step may be defensible especially if it involves the decision makers themselves. Difficulties arise in particular where a judgement-based step is planned between the application of two 'hard' methods. (NATO, 2012a, p. 6 – 14[*sic*])

In Australian defence, Heyer (2004) proposes a preliminary framework for the choice of PSMs by the type of problem (to understand perception of problem, to decide between alternatives, to deal with high levels of uncertainty, to develop future strategy, to analyse relations between actors, to identify areas for change), and makes suggestions for combinations of OR methods for dealing with socio-political and psychological issues, particularly in asymmetric conflict-related risks, such as terrorist threats.

NATO guidance states that PSMs/soft OR methods should be selected based on fitness for purpose given the problem situation, anticipated outcomes and study phase (divergent or convergent), the nature and degree of uncertainty, the theoretical soundness or proven success of the method in similar circumstances, practicalities such as time available, data requirements, consultant knowledge, competence and experience, the understanding and degree of comfort of stakeholders with the method, and organizational culture (NATO, 2012a).

Dstl training materials suggest a number of design heuristics for OR study design, including engaging technical and subject matter experts, working backwards from the scope and type of outputs sought in order to consider what sort of analysis will be needed, and decomposing and recombining problems, varying the problem, and using analogy to consider different potential approaches (P. Jones, 2015).

6. Theoretical frameworks in defence

Multimethodology (the design of multimethodological interventions) has been included in Dstl training materials and NATO guidance (P. Jones & Forder, 2013; NATO, 2012a, 2012b). For messes (Ackoff, 1979) or wicked problems (Rittel & Webber, 1973) in defence, NATO guidance, which Dstl was involved in producing, draws heavily on Mingers and Brocklesby's (1997) work in recommending the combining of methods, possibly across paradigms and/or disciplines, in order to achieve theoretical benefits of multimethodology in situations of complexity (NATO, 2012a). Total systems intervention (TSI; Flood & Jackson, 1991a) is mentioned in a footnote and the use of Mingers' approach to multimethodology is rationalized as better fitting NATO's definitions and phases approach. According to the guidance, successful use of multimethodology requires the intervener to have a mind open to other approaches and collaboration with people who are knowledgeable about other methods and disciplines (NATO, 2012a).

NATO guidance proposes two trajectories for OR interventions – type 1 in which a perceived mess is reduced using problem structuring and other techniques to a problem proper for solving using traditional OR, and type 2 where a perceived mess is structured into a manageable mess, or problem (NATO, 2012a). Stakeholders then have a role in judging which tamed problem to solve (Rittel & Webber, 1973).

TSI has been further developed into Composite OR TSI by the Swedish military for complex and long-term projects (Agrell & Holmberg, 1998). It has also been used in Australia for evaluating military organizations (Yates & Burke, 2001).

Appendix B The discipline and practice of operational research: An introduction

1. Definitions

Operational research (OR), including systems thinking, has much to offer executives of organizations dealing with complex, interrelated issues. It is problem-oriented, its methods have been developed for responding to real-world issues, and its practice is aimed at improving situations for stakeholders using modelling (Mingers & Rosenhead, 2004; Pidd, 2009). As Christie (2023) notes, 'OR is also known as management science, operations research, operational analysis, and analytics' (p. 163).

Many early definitions of OR foregrounded the 'application of scientific method' (Blackett, 1950, as cited in Dyson et al., 2021, p. 729). It follows that in reports of their practice, OR practitioners emphasize logic and rationality (substantive and/or procedural [Simon, 1954, as cited in Pidd 2004a; L. C. Phillips & Bana e Costa, 2007]), claiming that analysis is rigorous, systematic and/or systemic. Recent so-called 'fourth wave' scholarship in critical systems thinking addressing marginalization also promotes ways of knowing beyond rational analytical (Midgley & Rajagopalan, 2021; Rajagopalan, 2016, 2020; Rajagopalan & Midgley, 2015).

Yet 'methods, techniques and tools' have been core to OR as a discipline since its beginnings (Churchman et al., 1957, p. 9, as cited in O'Brien, 2015), and it is now types of methods employed that tend to be highlighted in definitions of OR (Dyson et al., 2021). We see this focus on methods elsewhere. Most OR literature comprises reports of different modelling techniques and their applications (Mustafee & Katsaliaki, 2020), and calls for OR conferences have similar focuses (Colorni & Tsoukiàs, 2024). Methods make up a large part of popular university textbooks (Hillier & Lieberman, 2020; Pidd, 2009; Rosenhead & Mingers, 2001b; T. Williams, 2008), and new practitioners are acculturated (Brocklesby, 1993; Kotiadis & Mingers, 2006, 2014; Mingers & Brocklesby, 1997) and apprenticed with methods (e.g., in the UK, see The Institute for Apprenticeships and Technical Education [IFATE], 2020a, 2020b, 2020c, 2020d; The Operational Research Society [ORS], n.d.-b). It is perhaps not surprising then that OR methods are still often collectively referred to as the OR practitioner's 'toolkit' (Ranyard et al., 2022; cf. Corbett et al., 1995).

Thus, 'The OR community has always been sensitive about 'technique orientation', yet the techniques are amongst the basic tools of the trade' (V. L. Smith, 1991, p. 924).

To take an example definition of OR relevant to this research, the Government Operational Research Service in the UK (GORS), which 'supports policy-making, strategy and operations in many different [UK government] departments and agencies' (GORS, n.d.-a, para. 1) has used the following definition:

> Operational Research, also variously known as "Management Science", "Business Analytics" or "Data Science" (see below), is a multidisciplinary vocation which applies scientific and mathematical expertise and methodologies to problems outside the traditional boundaries of these fields. The aim is to influence and improve organisational decision making and so drive better outcomes.
>
> OR practitioners start with an analytical perspective and knowledge of mathematical modelling and statistics. They combine this with consultancy skills and formal techniques for stakeholder engagement and consensus building, to **define**, **model** and **solve** complex real-world problems.
>
> (GORS, n.d.-c, para.s 1-2, **emphasis in original**)

The definition reflects that, historically, there has been a focus in OR on quantification (Christie, 2023; The Institute for Operations Research and the Management Sciences [INFORMS], n.d.; Mingers, 1989). In fact, OR literature is dominated by reports of applications of quantitative methods, such as, optimization, simulation and statistical analysis (Mustafee & Katsaliaki, 2020).

Similarly, in summing up the activities of its members, The Operational Research Society in the UK (ORS) describes OR as 'the science + art of problem solving' and 'the science of better decision making' (ORS, n.d.-c; cf. Mingers, 2007). As in the GORS definition of OR, there is a focus on multi-disciplinarity, science, problem-solving, decision-making, and improvement.

2. Multi-disciplinarity and methodological pluralism

> The **discipline of OR**, at least in the UK, has origins in the Second World War, when mathematicians and scientists successfully supported military operations (Keys, 1991). Its practice spread to industry, the public sector, academia, commerce (Fildes & Ranyard, 1997), the third sector and cross-sector projects (Johnson et al., 2018). OR thus has a long history of cross-disciplinarity in terms of issues addressed, and methods used (Ranyard et al., 2015). (Christie, 2021, p. 1, **emphasis in original**)

In the UK, OR has origins in defence in the 1930s as a scientific and practical discipline applying methods from mathematics and the natural and social sciences (Keys, 1995). For example, Stansfield, one of the pioneers of OR, collaborated with an experimental psychologist in 1939 and 1940, and later often worked with social anthropologists. He thus argued convincingly that, 'O.R. studies

problems in organizations and systems, in all of which people form part and take part. So, from its earliest days, knowledge and expertise from the field of the human sciences have been relevant.' (Stansfield, 1989, p. 139). To take another example, in the 1960s, Friend and colleagues started working with social scientists to tackle multi-disciplinary policy issues, developing the methodology Strategic Choice Approach (SCA).

However, in the 1980s and 1990s, interest grew in documenting, understanding and theorizing about methodological pluralism in OR/systems practice (Bennett, 1985; Eden, 1989; Eden & Radford, 1990; Flood, 1989a, 1989b, 1995a, 1995b; Flood & Jackson, 1991a, 1991b; Flood & Room, 1995, 1996; W. J. Gregory, 1996; Jackson, 1987, 1999, 2000; Jackson et al., 1989; Midgley, 1990, 1992a, 1992c, 1997a, 2000; Miles, 1992; Mingers, 2000; Mingers & Brocklesby, 1997; Mingers & Gill, 1997; Mingers & Taylor, 1992; Nicholls et al., 2001; Ormerod, 1997a). Scholars have since documented increased adoption of pluralist approaches in research in business and management, and social sciences (e.g., Mingers, 2015; Molina-Azorín et al., 2017). In OR and beyond, the view that complex, real-world issues need to be addressed with multiple methods is now widely held (e.g., Ackermann & Howick, 2022; Dyson et al., 2021; Gomes Júnior & Schramm, 2022; Jackson, 2019; Mingers, 2015; Nastasi et al., 2010; North Atlantic Treaty Organization [NATO], 2012a, 2012b; O'Brien, 2011; Poth, 2018; Ranyard et al., 2022; Wright et al., 2019). Further, and of particular relevance to this research, Ackermann and Howick (2022) highlight that,

> … "*the use of different quantitative and qualitative models* is an essential part of the public policy process" (our emphasis). Thus, the ability to combine and apply multiple methods plays a key role in successful OR practice. (p. 1905, citing Hämäläinen et al., 2013, p. 624)

There are also recent examples of OR practitioners seeking to integrate quantitative and qualitative OR in cross-disciplinary approaches to address complex policy issues, such as the COVID-19 pandemic, and the UN Sustainable Development Goals (e.g., Bammer, 2018; Scaparra et al., 2019; Tolk et al., 2021; Weaver et al., 2020).

3. Socio-political aspects

> Blackett's pioneering work in military OR was undertaken by a multidisciplinary team, bringing different perspectives, which came to be known as Blackett's Circus. His work typically brought him into contact with a variety of decision makers and stakeholder groups such as military leaders and personnel. (Dyson et al., 2021, p. 732)

Intervention by OR practitioners in real-world situations has always required more than quantitative methods (Dyson et al., 2021). OR practitioners intervene in situations involving multiple stakeholders, and other personal and social aspects that defy quantification (Rosenhead, 1992b). Problems to be addressed, and methods to be used to tackle them, must be negotiated and agreed (Eden, 1982; Midgley, 2000; Mingers, 2006b, 2018; Ormerod, 1997a; Willemain, 1994; Woolley & Pidd, 1981). In supporting decision-making in organizations, there is a recognized need for 'effective engagement with the dynamic social and decision context, and with stakeholders (Tomlinson, 1984; cf. Poth, 2018), including clients, throughout interventions (Eden & Ackermann, 2004; T. Williams, 2008)' (Christie, 2023, p. 165). Langley's (1989) study of the use of formal analysis in organizations showed that analysis provides social 'glue' (p. 626) for stakeholder commitment and action in group decision-making, facilitating pluralism more than rationality. This is also the case in securing implementation of the results of OR interventions, where Tomlinson (1984) observes that,

> ... although decisions may appear to be made on the basis of the visible, often economic, facts - acceptance and implementation will certainly depend on proper account having been taken of the hidden, qualitative, reality underlying the situation. (p. 211)

In fact, surveys of practitioners have pointed to the need for – and relatively high value of – using qualitative methods to address socio-political aspects of OR interventions (Abdel-Malek et al., 1999, pp. 1001–1002). Yet scholars have tended not to describe practical, process issues and problem structuring in reports of their application of quantitative methods in OR literature (Dyson et al., 2021; Woolley & Pidd, 1981). But Dyson et al. (2021) highlight exceptions amongst founders of OR, for example:

> Rivett demonstrated his concern for process-related issues by identifying nine principles of modelling (Rivett, 1994) as well as a number of texts on the OR method (e.g. Rivett 1968, 1972). He also signaled his recognition of multiple stakeholders, noting that there needed to be continual contact with those who would affect or be affected by the OR work. (p. 15)

4. Conclusion

Definitions of OR and its practice, particularly in the UK, emphasize science, methods used, multi-disciplinarity, problem-solving, decision-making, and improvement. Addressing complex, real-world issues is recognized as requiring methodologically plural (quantitative and qualitative), multi-disciplinary approaches, with qualitative methodologies needed for addressing socio-political aspects of practice.

Appendix C Definitions of mixed methods research and multiple methods research

Most definitions of *mixed methods research* in the social sciences have required both qualitative and quantitative approaches to data, analysis and/or interpretation in any one research study – hence the use of the word *mixed* to describe the use of both the qualitative and the quantitative within and/or across different stages of a research project (Johnson et al., 2007). However, the term *mixed research* is preferred over *mixed methods research* by some authors as, in addition to methods, methodologies, and paradigms, other aspects, including social-political commitments, may be mixed (Onwuegbuzie & Hitchcock, 2019).[42]

Although definitions vary, and while *multimethod research* was originally used to refer to combinations of quantitative methods (Campbell & Fiske, 1959; Figure 40 below), *multiple methods research* (also known as *multimethod research*; Table 7, chapter 2) is now used to describe use of more than one method, whether quantitative-based, qualitative-based, or mixed (Hitchcock & Onwuegbuzie, 2019). Thus, *mixed methods research* is a subset of *multiple methods research*, and refers to the combination of quantitative and qualitative approaches (as in Johnson et al., 2007). In operational research (OR), for different audiences and over the years, the terms *multimethodology*, *mixed methods research* and *multimethod research* have also been used interchangeably (e.g., see Mingers, 2000b, 2014, 2015; White & Taket, 2000).

42 More recently, Onwuegbuzie and Hitchcock have called for 'full integration' in mixed methods research in which 'research approaches, methodologies, philosophies, methods, techniques, concepts, language, modes, disciplines, fields, and/or teams' are used (in any of a wide variety of ways) 'within a single study' (Hitchcock & Onwuegbuzie, 2022, p. 3; Onwuegbuzie & Hitchcock, 2022, p. 598). Onwuegbuzie (2023) calls for integration not just of '(a) quantitative and qualitative research approaches', but also across, '(b) mixed methods research and multimethod research approaches, (c) disciplines/fields, (d) arts and sciences, (e) Global North and Global South researchers, (f) online and offline spaces, and (g) researchers and participants … to address increasingly complex and complicated research questions in an attempt to come closer to verstehen' (p. 4).

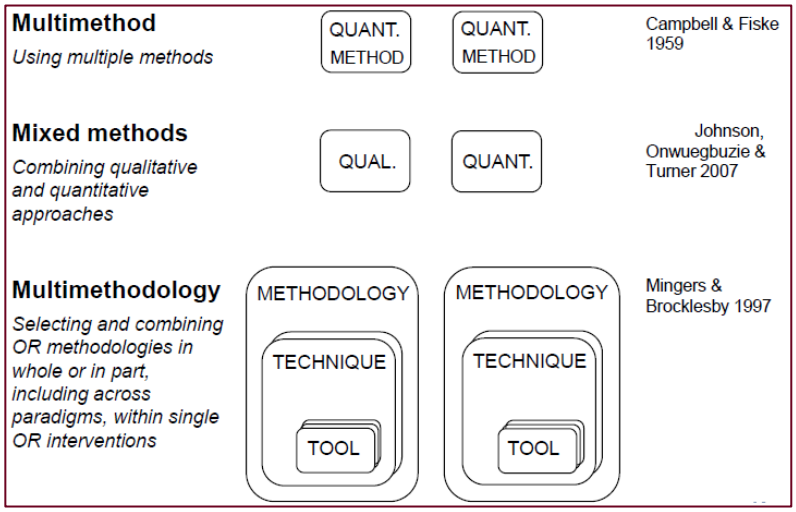


Figure adapted from Christie (2017a, p. 4)

Figure 40: Illustration of selected definitions of multimethodology

Appendix D Hybrid simulation and hybrid modelling

[REDACTED]

Adapted from Mustafee et al. (2020), Tolk et al. (2021) and Mustafee and Powell (2018). Illustration by author.

Figure 41: Hybrid simulation and hybrid models (Mustafee et al. 2020; Tolk et al. 2021; Mustafee & Powell 2018)

Appendix E Approaches to choosing methods

Table 22: Approaches to choosing particular multimethodology intervention methods (Munro & Mingers 2002)

[REDACTED]

Source: Munro and Mingers (2002, pp. 375-377)

Table 23: Other explanations for choosing methods in the tacit approach (data from Munro & Mingers 2002)

Other explanation	**Supporting data (Table 8, *emphasis added by author*)**
Merits and/or limitations of different methods	[REDACTED]
Experience developed over time across similar interventions and groups of practitioners within organizations	[REDACTED]
Lack of knowledge or experience of other methods	[REDACTED]
Constraints or opportunity of, or need to adapt to, or, in situation	[REDACTED]

Source: Munro and Mingers (2002, Table 8, p. 376)

Table 24: Explanations for choosing particular methods in the reflective approach (Munro & Mingers 2002)

[REDACTED]

Source: Munro and Mingers (2002, Table 9, p. 377, emphasis added by author)

Appendix F Theoretical frameworks for multimethodology

Table 25: System of systems methodologies: problem contexts for classifying methodologies (Jackson 2001, 2006a, 2007; Jackson & Keys 1984)

[REDACTED]

Adapted from Jackson (2001, 2006a, 2007) and Jackson & Keys (1984)

[REDACTED]

Source: Figure 21.1 in Jackson (2019)

Figure 42: System of systems methodologies (Jackson 2019)

[REDACTED]

Note: Bullet points in italics are example dimensions of the three notional systems (PCS, IRS and IS) highlighted in the questions under (A), (B) and (C) – added by author.
Adapted from "Figure 15.1 The multimethodology context" in Mingers (1997b), "Figure 10.1. Context of an intervention" in Mingers (2006b), "Table 10.1 Questions of Context" in Mingers (2006b), and 'a series of questions ... about the design of the intervention' in Mingers (1997b, pp. 420-421)

Figure 43: Context of a practical intervention with questions of context to guide methodology choices (adapted from Mingers 1997b, 2006b)

[REDACTED]

Source: Mingers (2017, p. 5)

Figure 44: Questions to be addressed in constructing an initial problem statement (Mingers 2017)

Table 26: Framework for mapping intervention tasks and methodologies (adapted from Mingers 2014; Mingers & Brocklesby 1997)

[REDACTED]

Adapted from 'Fig. 3a. A framework for mapping methodologies' (Mingers & Brocklesby, 1997) and Mingers (2014, pp. 185-186)

Table 27: Framework for categorizing the function or task performed by OR methods - Choosing Methodologies for Complex Decision Contexts (Mingers 2017)

[REDACTED]

Adapted from Mingers (2017)

[REDACTED]

Source: 'Fig. 10. (a). Methodology selection (Lorenz & Jost, 2006, p. 14). (b) Framework to inform method selection and facilitate the use of mixed methods.' in J. S. Morgan et al. (2017, p. 916)

Figure 45: Framework to inform method selection and facilitate the use of mixed methods (J. S. Morgan et al. 2017)

Appendix G Research design overview

	Appreciation of	Analysis of	Assessment of	Action to	Potential impact
Social (intersubjective)	**social/organizational roles, practices, culture and power relations:** • Literature review • Case studies, including consideration of constraints, boundaries and stakeholders • Secondary data review, including client reports • Meetings	**practices, culture and underlying social structures, distortions, conflicts, interests:** • Rich description of cases • Comparative analysis of cases • Qualitative coding and thematic analysis	**ways of altering existing structures / changing existing roles, practices, culture and power relations:** • Evaluation of competing explanations (multimethod empirical and theoretical corroboration, and justification)	**generate empowerment and enlightenment of social situation:** • Critical evaluation of OR practice • Implications for OR theory • Implications for OR research methodology • Implications for OR practice	• Empirical evidence of OR practice • Theoretical developments • Methodological developments • Changes in practice • Changes in social relations, e.g., between consultants and clients
Personal/ Cognitive/ Conceptual (subjective)	**individual beliefs, meanings, values, norms and emotions:** • Questionnaire • Case studies, including consideration of stakeholders' perspectives • Interviews	**differing perceptions and personal rationalities:** • Rich description of cases • Comparative analysis of cases • Qualitative coding and thematic analysis	**alternative conceptualizations and constructions:** • Evaluation of competing explanations (multimethod empirical and theoretical corroboration, and justification)	**generate understanding, personal learning, accommodation of views and consensus:** • Presentation of research findings	• Changes in conceptualization and perspectives of issues and interventions • Different perspectives adopted by practitioners
Material (objective)	**material and physical processes, arrangements and other circumstances:** • Questionnaire • Case studies, including review of underlying data • Review of other secondary data	**underlying causal structures:** • Descriptive statistics • Rich description of cases • Comparative analysis of cases • Identification of systems, components, relationships and processes and their interaction • Retroduction and retrodiction	**alternative physical and structural arrangements:** • Evaluation of competing explanations (multimethod empirical and theoretical corroboration, and justification)	**select and implement best alternatives:** • Policy recommendations	• Changes in UK government / department / Defence Science and Technology Laboratory (Dstl) policy

Framework adapted from Mingers (2006b, 2014, 2015), Wynn and Williams, (2012, p. 796), Henao and Franco (2016, p. 685) and chapter 3

Figure 46: Research design overview

Appendix H Research codebook

Table 28: Research codebook – topic nodes and sub-nodes, by research question

Nodes	Sub-nodes	Sub-nodes
RQ1. How do OR practitioners choose and combine OR methods to support strategic decision-making?		
Methods	Q1 method list [47 clusters of OR and strategy methodologies, methods and tools] [Other methods] Q2 [UP TO 10 METHODS FOR EACH PROJECT EXAMPLE] Q4 1 2 3 4 5 6 7 8 9 10	Q1 rating scale • USE REGULARLY • USE, BUT NOT REGULARLY • FAMILIAR WITH, BUT NOT USED • HEARD OF • NOT HEARD OF
Method combinations		
Forms of multimethodology	Single methodology Sequence Parallel Enhancement Interaction Integration *Other* *Use parts* *Derivation of findings* *Iteration*	
Prevalence of multimethodology	Q3 rating scale 0 (I NEVER COMBINE METHODS) 1 2 3 4 5 6 7 8 9 10 (I ALWAYS COMBINE METHODS)	
Multimethodological [theoretical] frameworks		
RQ2. Why do practitioners take these approaches, multimethodological or otherwise?		
Why?	*Why / why not this method?* Why this combination? Why this form? Why single methodology? Why multimethodology? Q5	
Description of interventions/cases		
Stakeholders [including roles and relations]	Done for (Customer) Doer (Practitioner) Done with (Participant) Done to (Outside project) Done without (Affected) Owner [Checkland] *Implementer* *Liaison* *Outside consultants* *Other*	Q4 CUSTOMER TYPE & LEVEL
Issues and problems		
Activities [later merged with Timeline]		
Case description [later merged with Timeline]		
Timeline [including events, dates, deadlines, changes, activities, outputs – refined as coding progressed]		
Dimensions [of interventions]	Domain	

Nodes	Sub-nodes	Sub-nodes
Outcome description *Decision influencers / drivers*	Subject matter Q4 Time available Q4 [Level of] Judgement [Level of] Disagreement Parties *Other*	
Success *SUCCESS SINGLE METHODOLOGY* Q8 SUCCESS MULTIMETHODOLOGY Q8 Success rating	Success definition More successful aspects Less successful aspects Q6, Q7 rating scale 0 (complete failure) 1 2 3 4 5 (partly successful partly unsuccessful) 6 7 8 9 10 (successful in every respect)	
Experiences Challenges Environmental constraints [Later combined]	Resources Culture, norms and values Other *Training course*	
Context Worldview		
Other comments Q10	*Definitions of method* *Definitions of OR* *Other emerging themes* *Personal background* *Technology and tools* *Variety of work* *To follow up or question further* *Limitations of study* Support available for methods Future of method choice Other *Secondary data* *Cross-case themes* *Theory development ideas* *For impact log* *Access to other stakeholders*	PRACTISING OR LESS THAN 5 YEARS Q9
Alternatives	Alternative problem definitions Alternative approaches Alternative methods	
	Alternative approaches - impacts	

Legend

1. **RQ** = research question
2. Q1 = survey question 1
3. FOR QUESTIONNAIRE RESPONSES ONLY (section 4.6.2 above refers)
4. *Added in response to questionnaire data (section 4.6.7 above refers)*
5. For cases (section 4.10.3 above refers)
6. *Added in response to case data*

Appendix I Survey questions

Table 29: OR and strategy methods in survey question 1 by category, mapped to Munro and Mingers (2002) and O'Brien (2011)

Clusters of / OR and strategy methodologies, methods and tools[43] with abbreviations and key names ***BY CATEGORY***	**Munro and Mingers (2002)**		**O'Brien (2011)**
	OR/Systems methodologies/techniques in knowledge and use of methods question (Figure 3)	'most commonly mentioned' 'other techniques' respondents had used (p. 373)	OR/MS and Management/Strategy tools referred to across survey questions (Appendices A-C)
QUANTITATIVE OR			
Agent-Based Modelling (ABM)	[Simulation]		Agent-based models
Bayesian Inference / Bayesian Networks/Models			
Cost-Benefit Analysis / Net Present Value / Financial Modelling			1. Cost benefit analysis 2. Financial analysis/ modelling
Data Envelopment Analysis (DEA) / Efficiency Evaluation	Data Envelopment Analysis (DEA)		DEA/efficiency evaluation
Data Mining / Data Analytics / Data Visualisation			Data mining[44]
Discrete Event Simulation	Simulation		Simulation[45]
Graph Theory / Network Analysis / Social Network Analysis[46]			
Mathematical Modelling using Catastrophe / Chaos / Complexity Theory	Maths Modelling		
Mathematical Programming/Optimization	Heuristics/ Combinatorial		1. Heuristic and combinatorial optimisation methods 2. Optimisation approaches
Project Management / Project Networks / Gantt Charts / Critical Path Analysis	Project Network		Project management
Queuing Theory	Queuing Theory		
Statistical Analysis	Statistical Analysis		1. Multivariate statistical analysis 2. Statistical analysis
Statistical Forecasting	Forecasting		Forecasting
PROBLEM STRUCTURING METHODS (Rosenhead, 1996)			
Cognitive Mapping / Causal mapping / Oval Mapping / Journey-Making / SODA (Eden)	Cognitive Mapping/ SODA		Cognitive mapping/SODA/Journey Making
Interactive Planning (Ackoff)	Interactive Planning		
Robustness Analysis (Rosenhead)	Robustness Analysis		Robustness analysis
Soft Systems Methodology (SSM) / Rich Pictures / CATWOE / Root Definitions / Conceptual Mapping / 3E's (Checkland)	Soft Systems Methodology (SSM)		Soft Systems Methodology (SSM)
Strategic Assumption Surfacing and Testing (SAST) (Mason & Mitroff)	Strategic Assumption Surfacing and Testing (SAST)		Strategic assumption surfacing and testing (SAST)
Strategic Choice Approach (SCA) / Analysis of Interactive Decision Areas (AIDA) (Friend)	Strategic Choice		Strategic choice approach

43 Some alternative, context-specific names of methods that were included in the questionnaire have been removed for reasons of confidentiality.
44 In their literature review, Howick and Ackermann (2011, Table 1, Appendix B) found three practical interventions in which artificial intelligence techniques or data mining were used with discrete event simulation or soft systems methodology.
45 The inclusion of this broad category limited the interpretation of O'Brien's (2011) results.
46 Examples include: (1) Georgiou (2012), who used graph theory with cognitive mapping of SSM transformations (SODA-T maps) to prioritize actions in a university research culture development plan; and, (2) Scholten et al. (2015), who present a case study in water supply infrastructure planning where participating stakeholders were selected by linking a social network analysis with a stakeholder analysis (Lienert et al., 2013).

Clusters of / OR and strategy methodologies, methods and tools[43] with abbreviations and key names ***BY CATEGORY***	**Munro and Mingers (2002)**		**O'Brien (2011)**
	OR/Systems methodologies/techniques in knowledge and use of methods question (Figure 3)	'most commonly mentioned' 'other techniques' respondents had used (p. 373)	OR/MS and Management/Strategy tools referred to across survey questions (Appendices A-C)
SYSTEMS THINKING			
Boundary Critique (Midgley)			
Critical Systems Heuristics (Ulrich)	Critical Systems Heuristics (CSH)		
System Dynamics (Forrester)	System Dynamics		System dynamics
Total Systems Intervention (TSI) (Jackson & Flood) / System of Systems Methodologies (Jackson & Keys)	Total Systems Intervention (TSI)		
Viable Systems Model (VSM) (Beer)	Viable Systems Model (VSM)		
QUALITATIVE/SOFT			
Expert Workshops[47]		focus groups	
Morphological Analysis (Zwicky)			Morphological analysis
Nominal Group Technique (NGT) (Delbecq)		Nominal Group Technique (NGT)	
Stakeholder Analysis/Mapping / Power-Interest Grids			Stakeholder analysis
Team Syntegrity (Beer)		team syntegrity	
Theory of Constraints (TOC) / Current and Future Reality Trees / Transition Tree / Evaporating Cloud or Conflict Resolution Diagram / Prerequisite Trees / Five Focusing Steps (Goldratt)[48]			
OR, LESS EASILY CATEGORIZED			
Analytical Hierarchy Process (AHP) (Saaty) / Analytical Network Process (ANP)	Analytical Hierarchy Process		Analytical hierarchy process
Delphi Technique (RAND)	Delphi		Delphi technique
Game Theory (von Neumann & Morgenstern) / Metagame Analysis / Drama Theory (Howard) / Hypergame Theory (Bennett)	1. Metagames 2. Hypergames	drama theory	1. Game theory 2. Drama theory 3. Hypergaming
Gaming[49]			
Multi-Criteria Decision Analysis (MCDA) / Decision Analysis (DA) / Decision Tree	1. Decision Analysis 2. Decision Conferencing		3. Decision analysis 4. MCDA (multi-criteria decision analysis)
MANAGEMENT/STRATEGY			
Balanced Scorecard (BSC)			Balanced scorecard
Brainstorming (Osborn)			Brainstorming
PESTLE (Political Economic Social Technological Legal Environmental Analysis)	SWOT/PEST		PEST (Political, economic, social, technological) analysis
Scenario Building/Planning/Analysis	Scenario Planning		Scenario planning
SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis	[SWOT/PEST]		SWOT analysis
OTHER DISCIPLINES, E.G.,ENGINEERING			
Diagramming Techniques / Structured Analysis and Design Technique (SADT) (Ross)	Structured analysis and design		
Historical Analysis			

47 Cf. Howick and Ackermann (2011), who categorize workshops, interviews and meetings as 'forms of intervention' (Table 7), and 'facilitated discussion' as a qualitative method (Appendix B) used with discrete event simulation in one of the papers they review (Table 1).
48 For example, Sommer and Mabin (2016) applied evaporating cloud and Boardman's soft systems methodology to the eldercare conundrum.
49 For example, see Mayer and De Jong (2004).

Clusters of / OR and strategy methodologies, methods and tools[43] with abbreviations and key names ***BY CATEGORY***	**Munro and Mingers (2002)**		**O'Brien (2011)**
	OR/Systems methodologies/techniques in knowledge and use of methods question (Figure 3)	'most commonly mentioned' 'other techniques' respondents had used (p. 373)	OR/MS and Management/Strategy tools referred to across survey questions (Appendices A-C)
DOMAIN-SPECIFIC			
[Five methodologies]			
Total: 47 clusters / methodologies			
	OTHER	***OTHER***	***OTHER***
	[REDACTED]	[REDACTED]	***SOFT OR/MS***
	[REDACTED]	[REDACTED]	[REDACTED]
	Total: 30 methodologies / techniques (including SWOT/PEST as one technique)	[REDACTED]	***OR/MS*** [50]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			MANAGEMENT/ STRATEGY[51]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			[REDACTED]
			Total: 52 tools

50 I excluded these other tools as I expected them to be less relevant to generalist practitioners in this context, or because they were least well known amongst O'Brien's (2011) respondents.
51 I excluded these for the reasons in the previous footnote, or because they were too general (e.g., benchmarking).

Table 30: Changes to survey questions following pilot

Question number		Changes
Final questionnaire	**Pilot questionnaire**	
All questions (where relevant)	All questions (where relevant)	I clarified and simplified some of the wording of questions and made changes to the way data could be entered to make it quicker to complete.
All questions (where relevant)	All questions (where relevant)	I used 'project' to describe interventions to reflect its more common use in practice.
1	1	I added options buttons so that respondents could only select one response per method, an optional comments field against each of the methods, and one additional method in the methods table.
2	2	I changed the wording so that participants were asked which other methods (OR and non-OR) they use – not just OR.
3	3	I simplified the wording to refer to combining methods, not combining one OR method with one or more other methods.
4 n/a	4 6, 7, 8	I shortened the table to include 6 rather than 10 lines for participants to enter examples of recent decision support projects. I removed three subsequent questions on how participants chose, combined, and adjusted or adapted the methods they had used.
5	5	Rather than ask for a reason for each example, I asked why the respondent used more than one method in the examples listed in question 4 (free response).
n/a	12	I removed a question that asked relevant respondents why they use only one method per project.
7	10	I changed the wording to ask about the success of projects using one OR method (without other OR or non-OR methods).
All questions (where relevant)	All questions (where relevant)	Consequent changes to references between questions.

Appendix J Case longlist

Table 31: Illustration of format of purposive case longlist showing dimensions considered in case selection

No.	Intervention (case) name	Suggested by	'Main practitioner'	Other people involved	Organizations involved	Year reported or ongoing	Current / Historical	Intervention / Decision status during research	Timeframe (Hours / Days / Months / Years)	Level of judgement required (Low / Medium / High)	Level of disagreement involved (Low / Medium / High)	Level of (perceived) success (Low / Medium / High)	Subject matter e.g., strategy development	Methods	Selected case? Yes / No	Key inclusion / exclusion criteria (including funding)
1																
2																
3																
...																

Appendix K Interview materials

Use of multimethodology by operational researchers supporting strategic decision-making in the UK government

Professor John Mingers and Jane S. Christie, Kent Business School, University of Kent

INTERVIEW GUIDE – for semi-structured interviews

NB: This guide is to be used flexibly in order to steer the discussion towards the research questions and understand the issues raised while letting respondents speak. There are many more questions here than it would be possible to cover in a one-hour interview, and not all will be relevant for each interview. For example, at least two to three interviews are envisaged per practitioner per case study. One interview with each customer may be sufficient (but may not be).

Thank you

Provide participant information sheet and consent form

- Recap aims of research project & purpose of interview (from participant information sheet)
- Recap key points re anonymity & right to withdraw (from consent form)
- Any questions?
- Please sign two copies – one for researcher, one for participant

If researcher considers it appropriate, discuss recording of interview with participant. If he/she consents:

Start recording

Thank you again

- I understand that you were involved in the [X] case
- I'm looking forward to our discussion, to hearing about your experiences of [providing / appraising] the decision support for [the [X] case] and your experience of the decision support process
- I am particularly interested in [e.g. how you chose/appraised the methodologies, methods and techniques used in the decision-making, for example …]

1. Introduction to case

So perhaps you could start by describing **your role** in the [X] case

Next, please could you describe the **subject matter** of the case [using as little jargon as possible]

2. Timeline

I'd like to take you back to when you were first involved in / initiated this work and hear you talk through the actions you took and the decisions you made, how you chose/used/appraised methods, and any changes made later as the case went on.

I'd like to put together with you a timeline of the work, focusing on your use of methods / evidence presented.

[Complete timeline on flipchart paper or similar with interviewee]

Ask probing questions, as appropriate/required to elicit timeline of activities, decisions and outcomes, including the key stages in the box below.

Key stages

1. Immediately you were aware of the work
2. When/how you started/commissioned the work
3. Phases of work / At key stages / plan / report stage
4. Outcomes
5. The future

Useful probing questions (in general):

- Can you tell me a little more about …?
- Could you describe an example of that?
- Why did you do that?
- How did you do that?
- What were the benefits?
- What were the challenges?
- How successful was the work? Why?
- What form did output take?
- What information / documentation is available on that, and in what form?

For [practitioner]s/consultants:

- What (issue) were you presented with?
- What were you expected to do/produce?
- Which methods did you consider?
- How did you choose which OR and other methods to use (in general)?
- What means/tools/guidance did you use to consider possible methods?
- What decisions did you make about methods? When did you make each of those decisions?
- Which **methods** did you use?
- Why did you choose that method / combination and not others?
- Which other methods / approaches did you consider?
- What else influenced your choice?
- Were there any other influences on your choice, perhaps that you were not aware of at the time?
- Are there methods you did not consider at the time? Which ones?
- [Refer to list of methods from questionnaire as appropriate]
- You have not mentioned any [hard OR / PSMs / critical methods] – why?
- What did you expect the benefits to be of your particular approach in terms of the methods you chose?
- What did you expect the challenges to be of your particular approach in terms of the methods you chose?

If multimethodology was used:

- How did you design your methodological approach?
- Did you adapt/adjust any of the methods in the way you used them?
- How did you combine the methods?
    - Could you draw how you combined them?
    - [Show toolkit of six linking designs (single methodology, sequence, parallel, enhancement, interaction, integration) in interview handout 1 to elicit/describe combination]
- What was your experience of using more than one method?
- What were the **benefits** of using more than one method? To whom?
- Did anyone / any other organization benefit? In what way?
- What about [benefits of multimethodology from literature not already mentioned]?
- What were the **challenges** of using more than one method?
- What about [challenges of multimethodology from literature not already mentioned]?
- Did you consider any multimethodological frameworks or guidance?
- Was using that/those method(s) as you expected it to be?
- Has your understanding the use of the method(s) changed? In what ways?

If multimethodology was not used:

- Did you consider using other methods, perhaps in combination with your chosen method?
- Why did you rule that out?
- What challenges did you foresee?

For decision makers:

- What were your requests and expectations in terms of the analysis/work you commissioned?
- In what ways were those needs met?
- In what ways were they not met?
- When and how did you act on the analysis presented?

- What did you decide / not decide?
- How did you decide?
- Why? What are/were the key drivers / influencers?
- How aware are you of the analysis methods that were used in this case?
- How important / irrelevant was the choice of method to you and others involved in the case?
- How do you view the success of the project/work?

3. Success

- On a scale of 0 to 10, how would you rate [intervention/project success], where 10 is successful in every respect, 5 is partly successful partly unsuccessful, and 0 is complete failure?

For [practitioner]s/consultants:

- On a scale of 0 to 10, how would you rate the success of your method choice in terms of its impact on customer outcomes, where 10 is successful in every respect, 5 is partly successful partly unsuccessful, and 0 is complete failure?
- Please explain your rating, for example, what was successful about your use of multiple methods? What was less successful or challenging about it?
- In what ways were customer needs met / not met?
- Why was it more/less successful than other work you have done?
- To what extent was this attributable to the methods chosen / used?

4. Dimensions

- If not already covered in discussion – how much **time** were you given / did you give to carry out the analysis?
- What was **your role / the role(s) of your organization vis-à-vis other parties**?
- Which other people/parties/stakeholders were involved?
    - Commissioner(s) / initiator of work
    - Practitioners
    - Managers
    - [Consider using a stakeholder grid to record these – see interview handout 2]
- What were your commitments to other stakeholders?
- How much power/interest did these stakeholders have?
- How much **judgement** was required, e.g. due to lack of data (high / medium / low)?
- What was the **level of disagreement** between the parties (high / medium / low)?
- How did you deal with / manage these aspects of the intervention?

5. Alternative approaches

- How else could you have commissioned the work / chosen and combined methods / designed the intervention / appraised the analysis presented?
- If you were starting the work again, would you approach it differently [in terms of your methods]? Why?
- If you could change some aspect of the way in which you chose/appraised method(s) or the wider impact method decisions have/had, what would you change? What stopped you?
- Was the choice of method(s) limiting in any way? Tell me more.
- **What other information will I need to be able to consider alternative approaches that could have been taken in this case to choosing and combining methods?**

6. **Other**

- How typical was this case? Of what? For you / your area of work / organization / OR practitioners / your decisions / decision support / advice you receive?
- How did method choice in this case compare with that of other cases you have worked on / are aware of?
- How do you see / feel about the future in terms of method choice and its impact on project success?
- What thoughts/views do you have on:
    - The support available for using different methods?
    - The challenges and benefits for you of choosing / relying on more than one method?
- How did/do others (involved in / aware of the case) view:
    - Your decisions and plans?
    - The project / methods?
    - The success of the work?

- How methods will be chosen in future
- Expected benefits/challenges of the approach you took
- How do you describe it to them? What words do you use?

7. Conclusions and debrief

That's the **end** of my questions. Is there anything you have not said that you would like to **add**?

Finally, do you have any **questions or comments** for me on any aspect of our time together today, or the research study more generally?

Stop recording

Any other business, thanks and goodbye / arrange follow-up interview / remind participant that they have contact details for interviewer and supervisor on participant information sheet

Monitor participant for any signs of distress / harm.

Subsequent interviews to:

- Further develop timeline
- Address further questions from interview guide
- Check understanding of events and case itself
- Explore issues raised in further detail
- Verify information in secondary data related to the case

Note: Some of the wording in this interview guide was changed prior to its inclusion in this dissertation for reasons of confidentiality.

Figure 47: Interview guide

OR intervention stakeholders by stakeholder category

Stakeholder category	**Examples of Dstl** [Defence Science and Technology Laboratory] **OR stakeholders**	**Stakeholders in this case**
Doers (practitioners)	Dstl consultants/analysts/facilitators Third party consultants/analysts/facilitators	
Done for (customers)	Military Commands MOD [Ministry of Defence] Head Office / Policy UK Government ministers	
Done with (participants)	[Varies by project]	
Done to (outside project, e.g., people interviewed)	[Varies by project]	
Done without (others within organizations and society not involved but affected by outcome)	MOD personnel Parliament Society	

Stakeholder categories adapted from Ormerod (2008a); examples informed by DSTL (2015a)

Note: Some of the wording in this interview handout was changed prior to its inclusion in this dissertation for reasons of confidentiality.

Figure 48: Interview handout 2: Stakeholder grid

Appendix L Rich case description elements

In this appendix, I describe the four elements of each of my rich case descriptions (summary description, timeline, stakeholder diagram, and table of practitioner methods, activities, and outputs). For an introduction and overview, see section 4.10.5 above.

1. Summary description

> … narrative, not a regression equation, is the canonical form of a CR [critical realist] explanation as it is of any scientific account of anything in the real world outside the laboratory.
> Narrative is particularly apt, in fact, for showing the combined effect of structure, culture, and agency. On the one hand, the effects of structure and culture show up mainly in the thoughts and actions of individuals. But because those socially structured thoughts and actions remain creative, they do not necessarily follow regular patterns. Given what is perhaps a unique conjuncture of structural and cultural mechanisms, the ensuing thought and behavior may well itself be unique. Unlike a statistical correlation, narrative can trace how thought and action, while remaining creative, were still nevertheless a (non-deterministically) caused cultural reaction to structural forces. (Porpora, 2016, p. 210)

For this qualitative, process research, I used a narrative strategy (Langley, 1999). Each summary description was a narrative description of a case of up to 100 pages in length (including quotations). My approach was necessarily selective. In deciding what was important to include (Langley, 1999; Ormerod, 2014a), I was guided by the research questions and my theoretical framework (chapter 3).

In OR, there is a long tradition of reporting cases. In constructing and compiling the summary descriptions, I was influenced by reports of practical case studies in OR literature, and guidance produced for case writing in OR journals, particularly from Ormerod (1998). The descriptions focus on the methods and activities of practitioners (what, why, with whom, and alternatives considered), method combinations, and more and less successful aspects of the overall methodological approach, including Ormerod's (1998) 'managerial and technical process and progress' (p. 1223). The descriptions are reports of what happened so that this was a reduction and re-telling of the data from the perspectives of the participants. They provide context, and an overview of how, for example, method choice and combination, came about. They include purposively selected quotations (relating to literature, the research questions, and themes; Watts, 2013).

Intervention phases

Some interventions, and/or wider projects they were part of, were described as having phases. In some cases, this was reflected in intervention or project documentation. For other interventions I employed temporal bracketing (Langley, 1999), identifying discontinuities in temporal sequences at which one phase (a unit of analysis) ended (typically, where practitioners reported their findings to clients) and another started (typically, when clients requested further work, and/or there was a change in direction of the project). I could then compare phases over time (Gehman et al., 2018; Langley, 1999) and across cases.

2. Timeline

> A visual mapping strategy is able to show how events are connected over time, emphasizing, for example, ordered sequences—events, activities, choices, entities which we tend to forget about when we are focusing on categories and variables. (Langley in Gehman et al., 2018, p. 290)

Timelines have been used in OR to describe interventions (e.g., Espinosa & Walker, 2013; Lienert et al., 2015; Mingers, 2006b; Pollack, 2005; Scott et al., 2013; Tavella & Papadopoulos, 2015, 2017). In this study, the case timelines comprised (1): an Excel database listing key events, activities, and outputs, such as plans and reports, with start and end dates, from data topic-coded to 'Timeline', organised into intervention phases (see above), and up to 70 lines in length; and, (2) a visualization of the data, generated in PowerPoint using Office Timeline. (1) involved corroborating statements between and across participants, interviews and documents, as well as checking dates and other information (where possible) to publicly available data. Where statements appeared to be in conflict, I highlighted this and sought clarification from other data, capturing sources and number of sources as I went.

(2) was a form of visual mapping (Langley, 1999) for analysing 'multiple holistic or embedded cases' (p. 702) or phases – 'an intermediary step between the raw [process] data and a more abstract conceptualization' (p. 702). It facilitated my comparison of the 'surface structure' of the cases for patterns and contrasts (Langley in Gehman et al., 2018, p. 293), the components being decisions, activities, and events, including project outputs, with short descriptions. Mapping drew my attention to ordering, precedence, and parallel processes, while facilitating data reduction and synthesis (Langley, 1999). Timelines were 'coded in multiple ways' (Langley, 1999, p. 700), for example, I used different symbols and colours for different types of events, and stakeholders. As well as facilitating

corroboration with other aspects of the rich case description, the visual mapping was an input to further analysis and mapping of method combinations in interventions.

3. Stakeholder diagram

In order to understand who was involved in and with interventions, when, and why, using tabled data coded to the 'Stakeholder' sub-nodes, I reviewed and made consistent (where possible) references to stakeholders and their roles in the summary case descriptions and timelines. I illustrated stakeholder roles for each case in a simplified **stakeholder diagram** to accompany the summary case description. The format of the diagrams was influenced by my experience of the use of organizational charts in business.

4. Table of practitioner methods, activities, and outputs

The practitioner methods and activities table was my attempt to understand and delineate single methods and activities of practitioners (what, why, who, outcomes, combinations, more and less successful aspects, and alternatives considered) and see how they related to each other. Each row related to a different method or activity (e.g., writing a final report). In the table I captured and summarized topic-coded data using the following column headings:

- Titles, names, or very short descriptions of the method or activity, capturing different names for them in the data;
- Descriptions of the method, or what practitioners did;
- Reasons for using the method, divided into:
    - 'Specific results that the' practitioner 'aims to bring about' by using this method (Mingers, 2006b, p. 223, after Checkland, 1990; see chapter 3) *and* other reasons practitioners gave for using the methods they did, and not using others;
    - Reasons suggested by other intervention stakeholders, and other reasons I inferred from the data, as researcher;
- Stakeholders with whom practitioners used the method;
- 'Outcomes' – what happened as a result of, or after using the method, including decisions and decision influencers (e.g., workshop findings and how they were used or received or acted upon) [used to construct timeline and understand causality];

- Links with other methods used (e.g., followed another method, or used insights from another method);
- Perceptions of more successful aspects of use of method;
- Perceptions of less successful aspects, including challenges, of use of method;
- Alternative methods considered (during case, and in hindsight); and,
- Data sources.

The tables provided yet another opportunity to cross-check results with the summary case descriptions, as well as a source of more detailed, but reduced data for responding to research questions.

Appendix M Previous surveys of practitioners

Table 32: Previous surveys – dates, purposes, participants, and rationales for using as comparatives

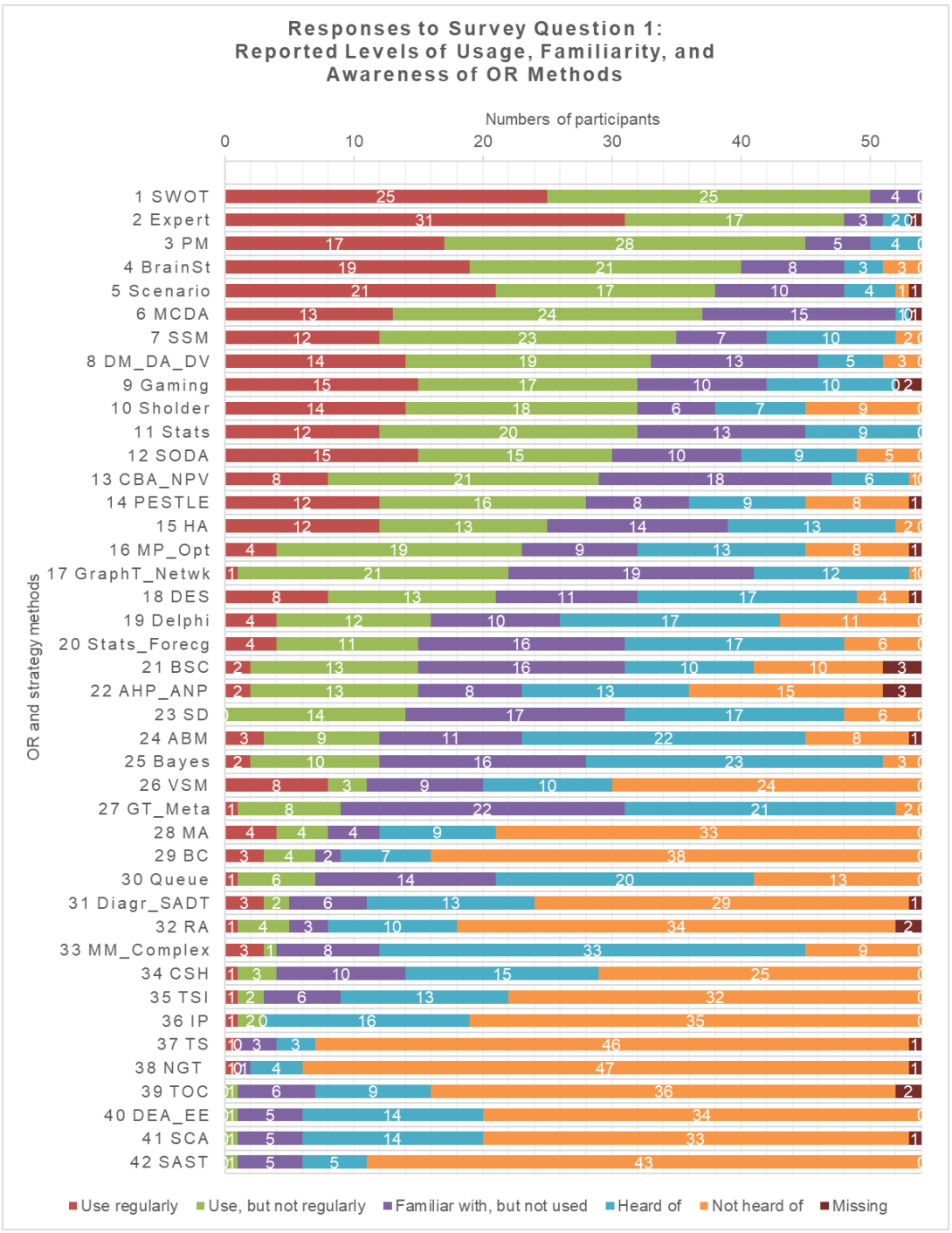
Survey Title (Journal) **Authors** (Date)	**The use of multimethodology in practice—results of a survey of practitioners** (JORS) **Munro & Mingers** (2002, 2004)	**Supporting the strategy process: a survey of UK OR/MS practitioners** (JORS) **O'Brien** (2011)	**Reassessing the scope of or practice: The Influences of Problem Structuring Methods and the Analytics Movement** (EJOR) **Ranyard, Fildes & Hu** (2015)	**The use of multimethodology in operational research practice supporting strategic decision-making** **Christie** (2024)
Abbreviation	**MM**	**OB**	**RFH**	**This survey**
Conducted	Not stated	Not stated	2008, 2009	2016, 2017
Purposes	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Participants	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Rationale for using as a comparative	**Most recent peer-reviewed survey of method use focusing on method choice and multimethodology**	**Most recent peer-reviewed survey of use of OR methods in supporting organizational strategy (globally or in UK)**	**Most recent peer-reviewed global survey of OR practitioners on methods**	**[This survey]**

Appendix N Survey: Method use, knowledge and awareness results

Table 33: All OR methods in question 1, ranked (1-42) by the number of participants who reported use (Figure 49 refers)

Rank *(Note 1)*	**OR Method** *(Note 2)*	**Label**
1	SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis	SWOT
2	Expert Workshops	Expert
3	Project Management / Project Networks / Gantt Charts / Critical Path Analysis	PM
4	Brainstorming (Osborn)	BrainSt
5	Scenario Building/Planning/Analysis	Scenario
6	Multi-Criteria Decision Analysis (MCDA) / Decision Analysis (DA) / Decision Tree	MCDA
7	Soft Systems Methodology (SSM) / Rich Pictures / CATWOE / Root Definitions / Conceptual Mapping / 3E's (Checkland)	SSM
8	Data Mining / Data Analytics / Data Visualisation	DM_DA_DV
9	Gaming	Gaming
10	Stakeholder Analysis/Mapping / Power-Interest Grids	Sholder
11	Statistical Analysis	Stats
12	Cognitive Mapping / Causal mapping / Oval Mapping / Journey-Making / SODA (Eden)	SODA
13	Cost-Benefit Analysis / Net Present Value / Financial Modelling	CBA_NPV
14	PESTLE (Political Economic Social Technological Legal Environmental Analysis)	PESTLE
15	Historical Analysis	HA
16	Mathematical Programming/Optimization	MP_Opt
17	Graph Theory / Network Analysis / Social Network Analysis	GraphT_Netwk
18	Discrete Event Simulation	DES
19	Delphi Technique (RAND)	Delphi
20	Statistical Forecasting	Stats_Forecg
21	Balanced Scorecard (BSC)	BSC
22	Analytical Hierarchy Process (AHP) (Saaty) / Analytical Network Process (ANP)	AHP_ANP
23	System Dynamics (Forrester)	SD
24	Agent-Based Modelling (ABM)	ABM
25	Bayesian Inference / Bayesian Networks/Models	Bayes
26	Viable Systems Model (VSM) (Beer)	VSM
27	Game Theory (von Neumann & Morgenstern) / Metagame Analysis / Drama Theory (Howard) / Hypergame Theory (Bennett)	GT_Meta
28	Morphological Analysis (Zwicky)	MA
29	Boundary Critique (Midgley)	BC
30	Queuing Theory	Queue
31	Diagramming Techniques / Structured Analysis and Design Technique (SADT) (Ross)	Diagr_SADT
32	Robustness Analysis (Rosenhead)	RA
33	Mathematical Modelling using Catastrophe / Chaos / Complexity Theory	MM_Complex
34	Critical Systems Heuristics (Ulrich)	CSH
35	Total Systems Intervention (TSI) (Jackson & Flood) / System of Systems Methodologies (Jackson & Keys)	TSI
36	Interactive Planning (Ackoff)	IP
37	Team Syntegrity (Beer)	TS
38	Nominal Group Technique (NGT) (Delbecq)	NGT
39	Theory of Constraints (TOC) / Current and Future Reality Trees / Transition Tree / Evaporating Cloud or Conflict Resolution Diagram / Prerequisite Trees / Five Focusing Steps (Goldratt)	TOC
40	Data Envelopment Analysis (DEA) / Efficiency Evaluation	DEA_EE
41	Strategic Choice Approach (SCA) / Analysis of Interactive Decision Areas (AIDA) (Friend)	SCA
42	Strategic Assumption Surfacing and Testing (SAST) (Mason & Mitroff)	SAST

Note 1: Methods are ranked by the number of participants who reported they use them (regularly or non-regularly), then by the number of participants who reported regular use, then by familiarity, then by awareness (as in Figure 49 below). Five domain-specific methods are excluded from the results for reasons of confidentiality (see also Table 29, Appendix I). The excluded methods were each used by fewer than 40 per cent of respondents. Their exclusion facilitated comparison of results with previous surveys.
Note 2: The second column shows how the clusters of OR and strategy methodologies, methods and tools were listed in survey question 1 with abbreviations and key names. Some alternative, context-specific names of methods that were included in the questionnaire have been removed for reasons of confidentiality.



Note: Methods are ranked by the number of participants who reported they use them (regularly or non-regularly), then by the number of participants who reported regular use, then by familiarity, then by awareness (as in Figure 49 below). Five domain-specific methods are excluded from the results for reasons of confidentiality (see also Table 29, Appendix I). The excluded methods were each used by fewer than 40 per cent of respondents. Their exclusion facilitated comparison of results with previous surveys.

Figure 49: Use, knowledge, and awareness of OR methods in question 1 (Table 33 refers)

Table 34: Use of methods by practitioners who had heard of them (question 1), compared with previous surveys, using O'Brien's median scores method

[REDACTED]

[REDACTED]

Table 35: Use, knowledge, and awareness of OR methods (question 1), compared with previous surveys, ranked by use

[REDACTED]

[REDACTED]

Table 36: Use, knowledge, and awareness of OR methods (question 1), compared with previous surveys, by category

[REDACTED]

[REDACTED]

Table 37: All methods used by practitioners, regularly and not regularly (questions 1 and 2), and in project examples (question 4), following clustering and categorization

Methods in question 1 ***BY CATEGORY***	**Other methods – Use regularly** Responses to question 2i (number of participants) ***BY CATEGORY***	**Other methods – Use, but not regularly** Responses to question 2ii (number of participants) ***BY CATEGORY***	**Methods in recent decision support projects** Responses to question 4 (numbers of participants, project examples, method listings) ***BY REVISED CATEGORIES***

QUANTITATIVE OR
• Agent-Based Modelling (ABM)
• Bayesian Inference / Bayesian Networks/Models
• Cost-Benefit Analysis / Net Present Value / Financial Modelling
• Data Envelopment Analysis (DEA) / Efficiency Evaluation
• Data Mining / Data Analytics / Data Visualisation
• Discrete Event Simulation
• Graph Theory / Network Analysis / Social Network Analysis
• Mathematical Modelling using Catastrophe / Chaos / Complexity Theory
• Mathematical Programming/Optimization
• Project Management / Project Networks / Gantt Charts / Critical Path Analysis
• Queuing Theory
• Statistical Analysis
• Statistical Forecasting
	QUANTITATIVE OR
	• **Bespoke modelling (usually in MS Excel VBA)** (1)
	• Cost Benefit Analysis (but not cost modelling - rely on others) (1)
	• **Data analysis** (data from training) (1)
	• **Dependency analysis (1)**
	• Mathematical modelling of processes and events. Ranging from simple time, distance, velocity calculations to meta-modelling. Work involves a heavy element of statistics within a chaotic scenario. (1)
	• Monte Carlo modelling (1)
	• Pattern recognition, machine learning (1)
	• **Risk matrix (1)**
	• Simulation models (1)
	• [Statistical analysis (2)]
	  ○ Regression Modelling, Proportional Hazards Modelling (1)
	  ○ Statistical analysis
	• Stochastic computer modelling, Deterministic modelling (1)
	[11 participants]
		QUANTITATIVE OR
		• Combinatorial optimisation (1)
		• **Cost Benefit and Achievability (tailored for application)** (1)
		• More quantitative techniques and statistical analysis (1)
		• **POTI [Processes, Organisation, Technology, Information; a programme management model] (1)**
		• **Reliability Growth Modelling (1)**
		• Response surface modelling (1)
		• **Spreadsheet modelling (1)**
		[7 participants]
			***QUANTITATIVE OR* (35, 57, 95)**
			• [Simulation]
			  ○ Agent-Based Modelling (ABM) (1, 1)
			  ○ Discrete Event Simulation (6, 7)
			  ○ **Hi-Fidelity simulations** (1, 1)
			  ○ **Simulation modelling** (5, 8)
			• **Bespoke Modelling, complex bespoke models** (2,2)
			• Cost-Benefit Analysis (8, 13)
			• [Net Present Value, Financial Modelling, Cost Analysis/Modelling (5, 5)]
			  ○ NPV / Financial Modelling (1, 1), Financial Modelling (1, 1), Financial modelling/prediction (1, 2), Cost analysis (1. 1), cost modelling (1, 1)
			• **Data analysis** (data from training) (1, 1)
			• [Data Mining, Data Analytics (4, 8)]
			  ○ Data Mining (1, 4), Data mining / analytics (1, 1), Data Analytics (1, 1), **Machine learning** (1, 1), **Pattern recognition** (1, 1)
			• **Deterministic modelling** (2, 3)
			• **Graphs** (1, 1)
			• Graph Analysis/Theory, Network Analysis (5, 6)]
			  ○ Graph Theory (1, 1), Graph Theory/ Network Analysis (1, 2), Graph Analysis (1, 1), Network analysis (1, 1), Networks (1, 1), **Isochrone analysis** (1, 1)
			• [Mathematical Programming/Optimization]
			  ○ LP (1, 1)
			  ○ Mathematical Programming **(2, 2)**
			  ○ Optimisation (2, 2)
			• [Monte Carlo, Stochastic modelling (2, 4)]
			  ○ **Monte Carlo**, **Monte Carlo modelling** (1, 2), **Stochastic computer modelling** (1, 2)
			• **Numerical analysis** (1, 2)
			• **Risk Analysis**, **Risk Matrix** (2, 2)
			• Sensitivity analysis (1, 1)
			• **Spreadsheet modelling, Spreadsheet, pivot tables** (2, 3)

Methods in question 1 ***BY CATEGORY***	**Other methods – Use regularly** Responses to question 2i (number of participants) ***BY CATEGORY***	**Other methods – Use, but not regularly** Responses to question 2ii (number of participants) ***BY CATEGORY***	**Methods in recent decision support projects** Responses to question 4 (numbers of participants, project examples, method listings) ***BY REVISED CATEGORIES***
			• [Statistical Analysis (10, 15)] ○ Statistical Analysis (8, 13), **Response surface modelling** (1, 1), Stats for hypothesis testing (1, 1), Descriptive/visual/regression analysis of the results (1, 1) • Statistical Forecasting (3, 4) <u>Total: 22 clusters</u> ***PROJECT MANAGEMENT*** **(8, 18, 19)** • Critical Path Analysis (1, 3) • **Managing Successful Programmes (1, 1)** • Project Management (4, 7), Project Management / Project Networks / Gantt Charts / Critical Path Analysis (1, 2), Project Management / Gantt Charts (1, 4), Gantt Chart (1, 1), **Prince II concepts (1, 1)** <u>Total: 3 clusters</u> ***VISUALIZATION*** **(11, 14, 14)** • Data Visualisation (5. 6), visualisation, (4. 4) Visualisation (graphs and geographic) (1, 1), Visualisation (sun ray diagram) (1, 1), Graphical Display Methods (1, 1), data visualisation means – Tableau (1, 1) <u>Total: 1 cluster</u>

Methods in question 1 ***BY CATEGORY***	**Other methods – Use regularly** Responses to question 2i (number of participants) ***BY CATEGORY***	**Other methods – Use, but not regularly** Responses to question 2ii (number of participants) ***BY CATEGORY***	**Methods in recent decision support projects** Responses to question 4 (numbers of participants, project examples, method listings) ***BY REVISED CATEGORIES***

PROBLEM STRUCTURING METHODS
• Cognitive Mapping / Causal mapping / Oval Mapping / Journey-Making / SODA (Eden)
• Interactive Planning (Ackoff)
• Robustness Analysis (Rosenhead)
• Soft Systems Methodology (SSM) / Rich Pictures / CATWOE / Root Definitions / Conceptual Mapping / 3E's (Checkland)
• Strategic Assumption Surfacing and Testing (SAST) (Mason & Mitroff)
• Strategic Choice Approach (SCA) / Analysis of Interactive Decision Areas (AIDA) (Friend)
	PROBLEM STRUCTURING METHODS
	-
		PROBLEM STRUCTURING METHODS
		• Soft Systems Methodology (1)
		• Various strategy development toolsets (see Eden/Ackermann) (1)
		[2 participants]
			***PROBLEM STRUCTURING METHODS* (9, 11, 11)**
			• Cognitive map, Elements of cognitive mapping, cognitive mapping (3, 3)
			• [Soft Systems Methodology (SSM) (7, 8)]
			  ○ CATWOE / concept mapping (1, 1)
			  ○ Rich pictures (2, 2), Rich Picture (1, 1)
			  ○ SSM (2, 3), SSM (root definitions & conceptual activity modelling) (1, 1)
			Total: 2 clusters

SYSTEMS THINKING • Boundary Critique (Midgley) • Critical Systems Heuristics (Ulrich) • System Dynamics (Forrester) • Total Systems Intervention (TSI) (Jackson & Flood) / System of Systems Methodologies (Jackson & Keys) • Viable Systems Model (VSM) (Beer)	***SYSTEMS THINKING*** • Influence diagrams/mapping (1) [responses to q1 SD, SODA] • **Systems context diagram (both for owned system and unowned system), concept mapping (not SSM), ladder of abstraction, Pig model (Gareth Morgan)** We also use thinking tools to check that we are thinking systemically e.g. Iceberg model (but we add a "container" layer below the mental model layer), model of how purposeful complex adaptive system learns and adapts, Gareth Morgan's metaphors for organisations (1) • Systems Thinking/Systems Engineering (I'm not sure if this is one of the options on Q1 but under a different name?) (1) [3 participants]	***SYSTEMS THINKING*** • **Causal loop analysis (1)** • **Causal loop diagrams (which usually do not lead to system dynamics models) (1)** • **Systems context diagrams (1)** [2 participants]	***SYSTEMS THINKING* (7, 13, 20)** • **Causal loop modelling (1, 1)** • **context mapping (2, 2)** • **Gareth Morgan's metaphors (1, 1)** • **Iceberg model (1, 1)** • **Ladder of abstraction (1, 2)** • System Dynamics (1, 1) • **Systems Analysis** (1, 2) • VSM (6, 10) Total: 8 clusters

Methods in question 1 ***BY CATEGORY***	**Other methods – Use regularly** Responses to question 2i (number of participants) ***BY CATEGORY***	**Other methods – Use, but not regularly** Responses to question 2ii (number of participants) ***BY CATEGORY***	**Methods in recent decision support projects** Responses to question 4 (numbers of participants, project examples, method listings) ***BY REVISED CATEGORIES***

QUALITATIVE/SOFT OR
• Morphological Analysis (Zwicky)
• Nominal Group Technique (NGT) (Delbecq)
• Team Syntegrity (Beer)
• Theory of Constraints (TOC) / Current and Future Reality Trees / Transition Tree / Evaporating Cloud or Conflict Resolution Diagram / Prerequisite Trees / Five Focusing Steps (Goldratt)
	QUALITATIVE/SOFT OR
	• Balanced judgement approaches (1)
	• The 6 questions - 1) What are you trying to achieve? 2) What do you think you need to do to achieve it? 3) Who's going to do it? 4) Who benefits or is impacted by it? 5) Who owns it (can start/stop it)? 6) What constraints apply? (1)
	• Use of expert/stakeholder advisors (1)
	[3 participants]
		QUALITATIVE/SOFT OR
		• A collaborative approach to post Normal Scientific problems (problems where the nature of the problem is part of the focus of the analysis) has been developed and trialled, which for now we describe by the term 'sandpit'. This involved a mix of [stakeholders]. At the time of the sandpit trial a key customer who made time to come to the first of two events on a key issue then current found so much value to the approach that they made time to support both. In a review 6 months later I reflected that all of the issues we became aware of during the two part sandpit had become part of common perception, the issue was that the importance of all of the perspectives surfaced was not recognised at the time (1)
		[1 participant]
			***QUALITATIVE/SOFT OR* (11, 19, 19)**
			• **Bespoke qualitative analysis method to compare capabilities (piloted first) (1, 1)**
			• {SME/Stakeholder/Team Judgement/Assessment (5, 8)]
			  ○ **Expert judgement / stakeholder judgement (1, 4), SME and other stakeholder judgment (1, 1), SME judgement (1, 1), SME subjective/objective assessment (1, 1),** Team **judgement (1, 1)** [format, such as workshop, not specified]
			• **Expert/stakeholder advisors** (1, 1) [format not specified]
			• **Mapping (needs to objectives) (1, 1)**
			• [Morphological Analysis (3, 3)]
			  ○ Morphological Analysis (2, 2), **Morphological box (1, 1)**
			• **Problem structuring with "6 questions" (1, 1)**
			• **SME 'So What?' (1, 4)**
			Total: 7 clusters

• Stakeholder Analysis/Mapping / Power-Interest Grids	• **Pig approach** for stakeholder analysis (1) [Gareth Morgan] • Stakeholder analysis (power/interest grid) (1) [2 participants]	• Personality profiling - who is the real customer? What do they think? What outcome do they wish to achieve? What is their most positive and most negative possible outcome? Where is their focus and when do they need to show impact? Etc... (1) [1 participant]	***STAKEHOLDER ANALYSIS* (12, 16, 17)** • Stakeholder (1, 1), Stakeholder Analysis (7, 9), Stakeholder analysis mapping (1, 1), Stakeholder mapping (2, 3), **Pig** (1, 1), power vs interest (1, 1), **Stakeholder perspectives/profiling** (1, 1) Total: 1 cluster
	SOFT/CONSULTING SKILLS • Soft skills (1) • Red teaming (1) [2 participants]	***SOFT/CONSULTING SKILLS*** -	***CONSULTING SKILLS* (4, 7, 7)** • Output summary, Presentation of findings (1, 2) • problem solving (1, 1) • **Stakeholder engagement** (2, 4) Total: 3 clusters

Methods in question 1 ***BY CATEGORY***	**Other methods – Use regularly** Responses to question 2i (number of participants) ***BY CATEGORY***	**Other methods – Use, but not regularly** Responses to question 2ii (number of participants) ***BY CATEGORY***	**Methods in recent decision support projects** Responses to question 4 (numbers of participants, project examples, method listings) ***BY REVISED CATEGORIES***

• Expert Workshops[52]	• Facilitated workshops designed around specific challenges using a variety of **prompting techniques** to **stimulate 'thinking differently'**. Outputs used to develop greater understanding of issues in minds of participants. (2)
	• Facilitated structured workshops (1)
	• Facilitated workshops (1)
	• Workshop (1)
	[4 participants]
	
	FACILITATED WORKSHOP TECHNIQUES
	• A range of **elicitation techniques** (1)
	• A variety of other **simple decision support tools**, for example: **Force Field Analysis**, **Probability - Impact grids (Risk analysis)**, Backwards planning (working back from the goal), Impact - Feasibility grids, **pre-mortem** (often to examine project risks), bespoke frameworks (e.g. like PESTLE, but developed for the specific issue), sticky dot voting. I often use such techniques in a 'mix and match' way in workshop settings. **Ideas mapping (Concept mapping, mind mapping, ishikawa diagrams)** (1)
	• Bespoke workshop exercises (1)
	• Facilitation methods, 'mini-techniques' within workshops (1)
	• **Laddering** [facilitation technique] (1)
	• **Pre-mortem** (1)
	• Workshop facilitation (e.g. **6 hats technique**) (1)
	[7 participants]
	
	OTHER TOOLS
	• Italian flag uncertainty assessment (1)
	• Kipling (1)
	• RAG assessment [Red Amber Green] (1)
	[1 participant]
	
	[8 participants]
		• Workshopping. Structured SME **elicitation** (not sure what it's called, but basically asking experts to distribute probability estimates into bins, combining them all, and then discussing the results with the experts) (1)
		• SME/facilitated workshops (1)
		[2 participants]
		
		FACILITATED WORKSHOP TECHNIQUES
		• **Fish-bone Diagram for mapping** relevant factors and their contributory components (1)
		[1 participant]
		
		[3 participants]
			WORKSHOPS/ELICITATION/FACILITATION, TOOLS
			(23, 40, 45)
			• [Expert Workshop (16, 27)]
			  • Expert Workshop (**8**, 13), Expert Workshops (7, 10), SME workshops (1, 1), Expert judgement (1, 1), SME judgement [in workshop] (1, 1), Workshopping [with Structured SME elicitation] (1, 1)
			• [**Facilitated Workshop** (9, 13)]
			  • Facilitated workshop (1, 2), Facilitated workshop with customers (1, 1), Facilitated workshop with key subject matter experts [qualitative] (1, 1), Facilitated Workshops (1, 1), facilitation (1, 1), Facilitated discussion and voting on options (1, 1), structured workshops (1, 1), stakeholder engagement tools - structured workshops (1, 1), Strategic roadmapping workshop (1, 1), Workshop (2, 2), Workshops (1, 1)
			• [**Elicitation** (3, 3)]
			  • [With Workshopping] Structured SME elicitation to generate some data (1, 1), [With Facilitated discussion], Stakeholder elicitation (1, 1), [With Delphi] Bespoke framework [for capturing information] (1, 1)
			• Italian flag (1, 1)
			• Pre-mortem (1, 1)
			Total: 5 clusters

[52] Cf. Howick and Ackermann (2011), who categorize workshops, interviews and meetings as 'forms of intervention' (Table 7), while 'facilitated discussion' is a qualitative method (Appendix B) used with discrete event simulation in one of the papers they review (Table 1).

Methods in question 1 ***BY CATEGORY***	**Other methods – Use regularly** Responses to question 2i (number of participants) ***BY CATEGORY***	**Other methods – Use, but not regularly** Responses to question 2ii (number of participants) ***BY CATEGORY***	**Methods in recent decision support projects** Responses to question 4 (numbers of participants, project examples, method listings) ***BY REVISED CATEGORIES***

OR LESS EASILY CATEGORIZED
• Analytical Hierarchy Process (AHP) (Saaty) / Analytical Network Process (ANP)
• Delphi Technique (RAND)
• Game Theory (von Neumann & Morgenstern) / Metagame Analysis / Drama Theory (Howard) / Hypergame Theory (Bennett)
• Gaming
• Multi-Criteria Decision Analysis (MCDA) / Decision Analysis (DA) / Decision Tree
	OR LESS EASILY CATEGORIZED
	• Benefits mapping and Benefits Analysis (1)
	• **Cynefin model for conducting analysis estimates (1)**
	• Effectiveness assessment (1)
	• MCDA (1)
	• Metagaming (1)
	• **Pathways analysis (1)**
	[5 participants]
		OR LESS EASILY CATEGORIZED
		• **Cynefin (1)**
		• Delphi (1)
		• **Pathways analysis (similar to other techniques) (1)**
		• Role-play gaming (1)
		[4 participants]
			***OR LESS EASILY CATEGORIZED* (26, 38, 53)**
			• AHP (3, 5)
			• [**Benefits analysis/mapping/modelling**]
			  ○ Benefits Analysis (1, 1)
			  ○ Benefits mapping (3,3)
			  ○ Benefits model (1, 1), Benefits modelling (4,6)
			  ○ Effectiveness analysis (1, 1)
			• **Causal Mapping** (2, 2)
			• [Delphi (4, 6)]
			  ○ Delphi (2, 3), Delphi Technique (RAND) (1, 2), Elements of Delphi, Elements of Delphi (eliciting information individually first) (1, 1)
			• **Fuzzy Cognitive Modelling** (1, 1)
			• Game theory (1, 1)
			• [Gaming (9, 11)]
			  ○ Gaming (7, 9), Gaming – within a training context (1, 1), Scenario gaming (bespoke approach (1, 1)
			• Metagaming (1, 1)
			• [MCDA (10, 12)]
			  ○ MCDA (8, 9), MCDMA [Multiple Criteria Decision Making Analysis] (1, 1), Multi-Criteria Decision Analysis (MCDA) / Decision Analysis (DA) / Decision Tree (1, 2)
			• **Pathways** (1, 1)
			Total: 13 clusters

Methods in question 1 ***BY CATEGORY***	**Other methods – Use regularly** Responses to question 2i (number of participants) ***BY CATEGORY***	**Other methods – Use, but not regularly** Responses to question 2ii (number of participants) ***BY CATEGORY***	**Methods in recent decision support projects** Responses to question 4 (numbers of participants, project examples, method listings) ***BY REVISED CATEGORIES***

MANAGEMENT/STRATEGY
• Balanced Scorecard (BSC)
• Brainstorming (Osborn)
• PESTLE (Political Economic Social Technological Legal Environmental Analysis)
• Scenario Building/Planning/Analysis
• SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis
	MANAGEMENT/STRATEGY
	• [**Activity modelling (2)**]
	  ○ Activity modelling, gap analysis (1)
	  ○ Business Analysis and Business Process techniques (e.g. Logical Activity Modelling, Business Activity Modelling (1)
	• Chaining, **appreciative enquiry**, reframing, GROW, circles of excellence (1)
	• COSO (Committee of sponsoring organisations of the Treadway commission) model ... **Risk based approaches**, **Force Field Analysis**, ISO31000 (1)
	• [**Futures techniques/methods (2)**]
	  ○ A wide range of futures techniques and ways of measuring uncertainty e.g. various scenario planning techniques, Robust Decision Making, use of regret to measure, etc. ... [some of this might be considered quantitative OR] (1)
	  ○ Strategic Futures Methods. E.g.: Cone of Plausibility, Matrix method, etc. (1)
	• Maturity Modelling (1)
	• Other world [innovation/facilitation technique] (1)
	• **Process modelling** and data flow diagrams (1)
	• **RACI - establishing who is Responsible, Accountable, Consulted and Informed at each step of a process (2)**
	• Scenario assessment (1)
	• Swimlanes (1)
	[11 participants]
		MANAGEMENT/STRATEGY
		• [**Appreciative inquiry (2)**]
		  ○ Appreciative Enquiry Method (1)
		  ○ Appreciative inquiry (1)
		• **DE Bono's 6 hats** (1)
		• **Force Field Analysis**, listing forces with and against the desired direction of progress (1)
		• Hambrick & Fredrickson's strategy diamond (1)
		• Logistics modelling (1)
		• **Process modelling** (1)
		• **RACI analysis** (1)
		• Day-After scenario gaming. Other **futures methods**, roadmapping.(1)
		• PROSCI-ADKAR (1)
		• Structured judgement techniques such as a revised HAZOP/HAZAN process (1)
		[6 participants]
			***MANAGEMENT/STRATEGY* (32, 56, 84)**
			• [Activity modelling (2, 2, 3)]
			  ○ **Activity modelling** (1, 1), Business Activity Modelling (1, 1), Logical Activity Modelling (1, 1)
			• Balanced Scorecard (2, 2)
			• **Benchmarking** (1, 1), Technical benchmarking (1, 1)
			• Brainstorm, Brainstorming, Brain-storming, Brainstorming (Osborn) (12, 21)
			• **Cone of Plausibility** (1, 1)
			• **COSO** (1, 1)
			• **Feasibility & Impact Grids** (1, 1)
			• **Market analysis** (1, 1)
			• **Maturity Models** (1, 1)
			• PEST, PESTLE (7, 9)
			• **Process Mapping** (1, 1)
			• **RACI, RACI analysis** (2, 2)
			• [Scenarios (13, 21)]
			  ○ Scenario (1, 2), Scenario Analysis (4, 5), Scenario assessment (1, 1), Scenario building (1, 4), Scenario Building and Planning (1, 2), Scenario Building/Planning/Analysis (1, 2), Scenario construction and analysis (1, 1), Scenario development (1, 1), Scenario Planning (2, 3)
			• **Strategy diamond** (1, 1)
			• **Swimlane analysis** (1, 1)
			• SWOT Analysis (10, 14)
			• **Trials (operations)** (1, 1)
			• **Vision and Strategic Analysis** (1, 1)
			Total: 18 clusters

Methods in question 1 ***BY CATEGORY***	**Other methods – Use regularly** Responses to question 2i (number of participants) ***BY CATEGORY***	**Other methods – Use, but not regularly** Responses to question 2ii (number of participants) ***BY CATEGORY***	**Methods in recent decision support projects** Responses to question 4 (numbers of participants, project examples, method listings) ***BY REVISED CATEGORIES***
OTHER, INCLUDING OTHER DISCIPLINES • Diagramming Techniques / Structured Analysis and Design Technique (SADT) (Ross) • Historical Analysis	***ENGINEERING*** • Functional Modelling (1) • Hierarchical Process Modelling (1) ***POLICY ANALYSIS*** • Policy analysis (1) • Policy tools: E.g. **Mind-mapping**, Wind Tunnelling (1) ***OTHER DISCIPLINES*** • Knowledge management techniques, collaboration techniques (1) ***OTHER*** • Back of the envelope comparators, as used by the 1950's rocket scientists (there is a technical term for this which I have currently forgotten) • Un-named methods 'made up' as the need arises [7 participants]	***OTHER DISCIPLINES*** • Engineering models (1) • Historical Trend Analysis (1) • Sometimes (maybe often) borrowed from other fields e.g. Communities of Practice (Wenger) (1) ***OTHER*** • Entity relationship diagrams (1) • Techniques to remove bias during decision making (1) [5 participants]	***HISTORICAL ANALYSIS* (9, 17)** • Historical Analysis (8, 16), HA / Literature search (1, 1) Total: 1 cluster ***OTHER, INCLUDING OTHER DISCIPLINES* (10, 15, 19)** • **Assumption Testing** (1, 3) • **Basic Excel tool constructed through systems thinking/engineering approach** (1, 1) • **collaboration** (1, 1), **Community of practice** (1, 1), **Academic engagement** (1, 1) • **Engineering simulations** (1, 1) • **Functional Modelling** (1, 1) • **Future estimation/prediction** (1, 1) • **HPM** [Hierarchical Process Modelling] (1, 2) • **Lab based experiments** (1, 1) • **Policy Analysis** (1, 1), **Mind-mapping** (1, 1), **Wind Tunnelling** (1, 1) • **Psychological analysis** (1, 1) • **SoS [System of Systems] Analysis** (1, 1) • **System modelling** (1, 1) Total: 12 clusters

Methods in question 1 ***BY CATEGORY***	**Other methods – Use regularly** Responses to question 2i (number of participants) ***BY CATEGORY***	**Other methods – Use, but not regularly** Responses to question 2ii (number of participants) ***BY CATEGORY***	**Methods in recent decision support projects** Responses to question 4 (numbers of participants, project examples, method listings) ***BY REVISED CATEGORIES***

	GENERAL RESEARCH
	• Customised Microsoft Word-based structured outliner and **mind mapping** tools (1)
	• Grounded Theory: An inductive methodology, although considered a qualitative method, it is not. It is a general method; the systematic generation of theory from systematic research. It is a set of rigorous research procedures leading to the emergence of conceptual categories. Ref: www.groundedtheory.com/what-is-gt.aspx (1)
	• Identification of **themes** and common perspectives/opinions within certain groups to summarise for decision makers the "feeling" around an issue (1)
	• **[Interviews (3)]**
	  ○ Structured interviews [elicitation technique] (1)
	  ○ Interviews (2)
	• Literature searches/summaries (1)
	• Observation (1)
	• Q Method (Differing stakeholder issues analysis) (1)
	• Q-Methodology for assessing choice among a number of competing options. (1)
	[8 participants]
		GENERAL RESEARCH
		• Case study development and write up (1)
		• **Interviewing** subject matter experts around structured questions to subsequently analyse patterns, trends and insights (1)
		• **[Text analysis (2)]**
		  ○ Coding text data into a database to enable a more holistic analysis (1)
		  ○ Text analysis techniques (automated and manual). (1)
		• **Thematic Analysis** (1)
		• Surveys and focus groups. (1)
		[5 participants]
			***GENERAL RESEARCH* (13, 22, 30)**
			• **Coding data into a database to analyse** (1, 1)**, Qualitative data in spreadsheet** (1, 1)**, Simple tabulation** (1, 2)
			• **Electronic voting** (1, 1)
			• **Focus Groups** (1, 2)
			• [Interviewing (7, 9)]
			  ○ **Interviewing** (1, 1)**, Structured interviews** (3, 3)**, Semi-Structured interviews** (1, 1)**, Interviews with stakeholders** (1, 1)**, SME interviews** (1, 1)**, User interviews (1, 2)**
			• **Literature review** (1, 1)**, Literature search** (1, 2)
			• **Manual and automated text analysis** (1, 1)**, manual text analysis** (1, 1)
			• **Q Method** (1, 1)**, Q-method** (1, 1)
			• **Survey** (1, 1)**, Survey / questionnaire** (1, 1)**, Questionnaire** (1, 1)
			• **Seminars and website info** (1, 1)
			• **Thematic Analysis** (1, 1)**, Thematic analysis - wants and needs, Thematic analysis of perspectives** (1, 2)
			Total: 10 clusters

DOMAIN-SPECIFIC [5 methods]	***DOMAIN-SPECIFIC*** • [8 methods] [6 participants]	***DOMAIN-SPECIFIC*** • [6 methods] [5 participants]	***DOMAIN-SPECIFIC*** • [5 methods] [2 participants]
Total: 47 clusters / methodologies			**Total: 111 clusters/methods**

Table 38: Awareness of methods (question 1) compared with previous surveys, by category

[REDACTED]

[REDACTED]

Appendix O Survey: Descriptive statistics

Table 39: Descriptive statistics for practitioners' frequencies of combining methods (question 3; Figure 12 refers)

	How frequently do you combine methods (0-10)?
Mean	7.78
Median	8
Mode	**10**
Minimum	0
Maximum	10
N	**50**

Table 40: Descriptive statistics for methods per project (question 4), compared with previous surveys (Figure 18 refers)

Survey	**This survey**	**OB**	**MM**
Total method listings (all projects)	**456**	**125**	**77**
Mean	4.4	2.4	2.5
Median	4	2	2
Mode	3	2	2
Minimum	2	2	2
Maximum	10 *(Note 1)*	6	4
Project examples	**104**	**53**	**31**
Number of different methods	111 *following clustering* (Table 37, Appendix N)	26 (Table 6)	26 *including SWOT/PEST as one method* (Table 5)
Participants providing examples	46	<53 *(across all OR/MS practitioner respondents)*	22 *NAPs*

Green = Consistent results across surveys *Yellow = Higher in this survey compared with previous survey(s)*
Note 1: Respondents could list up to 10 methods per project.
Note 2: RFH did not collect data on single projects, so no results are included in the table.

Table 41: Descriptive statistics for method categories per project (question 4), compared with previous surveys (Figure 19 refers)

Survey	**This survey** *(Note 2)*	**OB**
Mean	3.4	1.8
Median	3	2
Mode	3	2
Minimum	1	1
Maximum	7	4
Project examples	**104**	**53**
Participants providing examples	46	<53 *OR/MS practitioners*

Yellow = Higher in this survey compared with previous survey(s)
Note 1: Full details of method categories are in Table 37, Appendix N. The final number of method categories developed during data analysis in this study was 16.
Note 2: Respondents could list up to 10 methods per project.
Note 3: MM did not list method combinations for NAPs, and RFH did not collect data on single projects, so no results are included in the table.

Table 42: Descriptive statistics for method choice themes per practitioner (Figure 22 refers)

Mean	2.07
Median	1.5
Mode	1
Minimum	1
Maximum	6
Participants	**42**

Note: The total number of final method choice themes was 8 (see Table 48, Appendix R).

Appendix P Survey: Regular use of pairs of methods

Table 43: Pairs of method categories and methods practitioners were more (or less) likely to report they use regularly (question 1; Table 44 refers)

Practitioners using method(s) in this method category regularly...	**...were more likely than average also to report regular use of method(s) within these categories** *(Note)*
Management/Strategy	**OR less easily categorized** **Expert workshops** **Quantitative OR** **Project management** **Historical analysis**
OR less easily categorized	**Management/Strategy** **Expert workshops** **Quantitative OR** **Project management** **Historical analysis**
Expert workshops	**Management/Strategy** (particularly SWOT [18], Scenarios [17], Brainstorming [13], PESTLE [8]) **OR less easily categorized** (particularly Gaming [13], MCDA/DA [10]) **Project management** **Historical Analysis**
Quantitative OR (particularly Statistical Analysis, Data Mining/Analytics/Visualisation, and with OR less easily categorized and Project Management, CBA, and, with OR less easily categorized, DES)	**OR less easily categorized** (particularly Gaming [12], MCDA/DA [9]) **Management/Strategy** (particularly SWOT [15], Scenarios [15], Brainstorming [11], PESTLE [9]) **Project management** **Historical analysis**
PSMs (Rosenhead, 1996) (primarily SODA and SSM)	**Project management** **Stakeholder analysis** **Systems thinking** (primarily VSM [7]) ***And less likely to report regular use of*** Historical Analysis
Project management	**Management/Strategy** (particularly SWOT [14], Scenarios [10], Brainstorming [10], PESTLE [5]) **OR less easily categorized** (particularly MCDA/DA [8], Gaming [6]) **Quantitative OR** (particularly Statistical Analysis [6], Data Mining/Analytics/Visualisation [6], CBA/NPV/Financial Modelling [5]) **Expert workshops** **PSMs** (Rosenhead, 1996; particularly SSM [7], SODA [6]) **Stakeholder analysis** **Historical analysis** **Systems thinking** (primarily VSM [4])
Stakeholder analysis	**PSMs** (primarily SODA [8], SSM [7]) **Project management** **Systems thinking** (primarily VSM [5])
Historical analysis	**Management/Strategy** (particularly Scenarios [8], SWOT [7]) **OR less easily categorized** (particularly Gaming [9]) **Expert workshops** **Quantitative OR** (particularly Statistical Analysis [6], Data Mining/Analytics/Visualisation [6]) **Project management** ***And less likely to report regular use of*** PSMs (Rosenhead, 1996)
Systems thinking (primarily VSM)	**PSMs** (primarily SODA [8], SSM [6]) **Stakeholder analysis** **Project management**

Note 1: Numbers in the second column are numbers of participants reporting regular use with the method(s) in the first column
Note 2: Full details of method categories are in Table 37, Appendix N.

Table 44: Pairwise comparison of regular use of methods (question 1), by category (Table 43 refers)

Method category *(see Table 37, Appendix N)*	Number of methods in survey	Regular use of at least one method within category (Survey question 1)		% of participants reporting regular use of method(s) within category who also reported regular use of... (Survey question 1)										
		Ppts	% of 54 ppts	Management/ Strategy	OR less easily categorized	Expert workshops	Quantitative OR	PSMs (Rosenhead 1996)	Project Management	Stakeholder Analysis	Historical Analysis	Systems Thinking	Qualitative/ Soft OR	Diagramming/ SADT
Management/ Strategy	5	36	67%	n/a	**69%**	**69%**	**64%**	36%	**47%**	33%	**31%**	22%	6%	6%
OR less easily categorized	7	31	57%	**81%**	n/a	**77%**	**77%**	35%	**45%**	23%	**35%**	19%	6%	6%
Expert workshops	1	31	57%	**81%**	**77%**	n/a	61%	39%	**42%**	29%	**32%**	23%	10%	6%
Quantitative OR	14	29	54%	**79%**	**83%**	66%	n/a	31%	**48%**	28%	**34%**	21%	3%	3%
PSMs (Rosenhead 1996)	4	18	33%	72%	61%	67%	50%	n/a	**44%**	**50%**	**11%**	**44%**	11%	6%
Project Management	1	17	31%	**100%**	**82%**	**76%**	**82%**	**47%**	n/a	**35%**	**35%**	**29%**	12%	6%
Stakeholder Analysis	1	14	26%	86%	50%	64%	57%	**64%**	**43%**	n/a	21%	**43%**	14%	7%
Historical Analysis	1	12	22%	**92%**	**92%**	**83%**	**83%**	**17%**	**50%**	25%	n/a	17%	17%	0%
Systems Thinking	5	10	19%	80%	60%	70%	60%	**80%**	**50%**	**60%**	20%	n/a	20%	0%
Qualitative/ Soft OR	5	3	6%	67%	67%	100%	33%	67%	67%	67%	67%	67%	n/a	0%
Diagramming/ SADT	1	3	6%	67%	67%	67%	33%	33%	33%	33%	0%	0%	0%	n/a
Domain-specific *(Note)*	2	-	0%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total	47	54	100%	67%	57%	57%	54%	33%	31%	26%	22%	19%	6%	6%

Note 1: Two of the five domain-specific methods have been assigned to Quantitative OR, and one to OR less easily categorized. Practitioners did not report regular use of the other two.
Note 2: Full details of method categories are in Table 37, Appendix N.

Appendix Q Survey: Method categories and combinations thereof in project examples

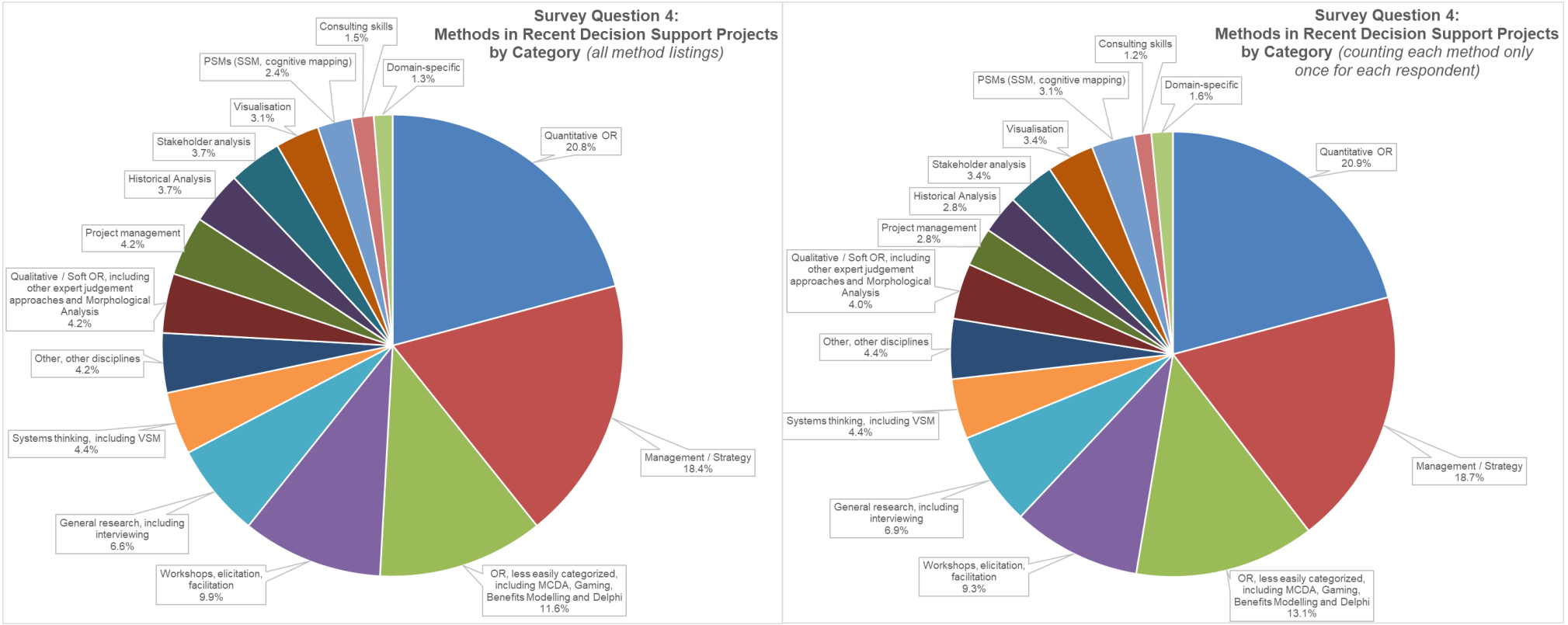
Table 45: Method listings in project examples (question 4), by category, compared with previous surveys

[REDACTED]

Table 46: Method listings in project examples (question 4), by category, counting each method only once for each participant

Category	Quantitative OR	Management/Strategy	OR less easily categorized, including MCDA, Gaming, Benefits Modelling and Delphi	Workshops/ elicitation/ facilitation	General research, including interviewing	Other, other disciplines	Systems Thinking, including VSM	Qualitative/Soft OR, including other expert judgement approaches and Morphological Analysis	Visualization	Stakeholder Analysis	PSMs (SSM, cognitive mapping)	Historical Analysis	Project Management	Domain-specific	Consulting skills	Total /Average
Method listings in examples, counting only the first instance of each different method (cluster) for each participant	67	60	42	30	22	14	14	13	11	11	10	9	9	5	4	321
Percentage of method listings *See pie chart, Figure 50(2) below*	20.9%	18.7%	13.1%	9.3%	6.9%	4.4%	4.4%	4.0%	3.4%	3.4%	3.1%	2.8%	2.8%	1.6%	1.2%	100%
Number of participants with one or more methods in category	34	32	27	23	13	10	7	11	11	11	10	9	8	2	4	212
Proportion of method categories across all project examples, based on number of participants with one or more methods in category *See bar chart, Figure 20 (chapter 5)*	16%	15%	13%	11%	6%	5%	3%	5%	5%	5%	5%	4%	4%	1%	2%	100%
Percentage of participants (all 46 who provided examples) with one or more methods in category	74%	70%	59%	50%	28%	22%	15%	24%	24%	24%	22%	20%	17%	4%	9%	461%
Average number of different methods (clusters) in the (same) category used by participant with method(s) in category	1.97	1.88	1.56	1.30	1.69	1.4	2	1.18	1	1	1	1	1.13	2.5	1	1.51

Note: Full details of method categories are in Table 37, Appendix N.



Note 1: Full details of method categories are in Table 37, Appendix N.
Note 2: Percentages calculated for: (1) all 456 method listings across all 104 project examples (Table 45 above refers); and, (2) for 321 first instances of each method (cluster) for each participant across all 104 project examples (Table 46 above refers).
Note 3: The proportions of methods allocated to each category, and the ordering of categories are very similar. Key differences are for OR less easily categorized (11.6% of all 456 method listings; 13.1% of the total 321 methods counting only the first instance of each method for each participant), Historical Analysis (3.7%; 2.8%), and Project Management (4.2%; 2.8%).

Figure 50: Project examples (question 4): (1) all method listings by category; and, (2) counting only the first instance of each method (cluster) for each participant

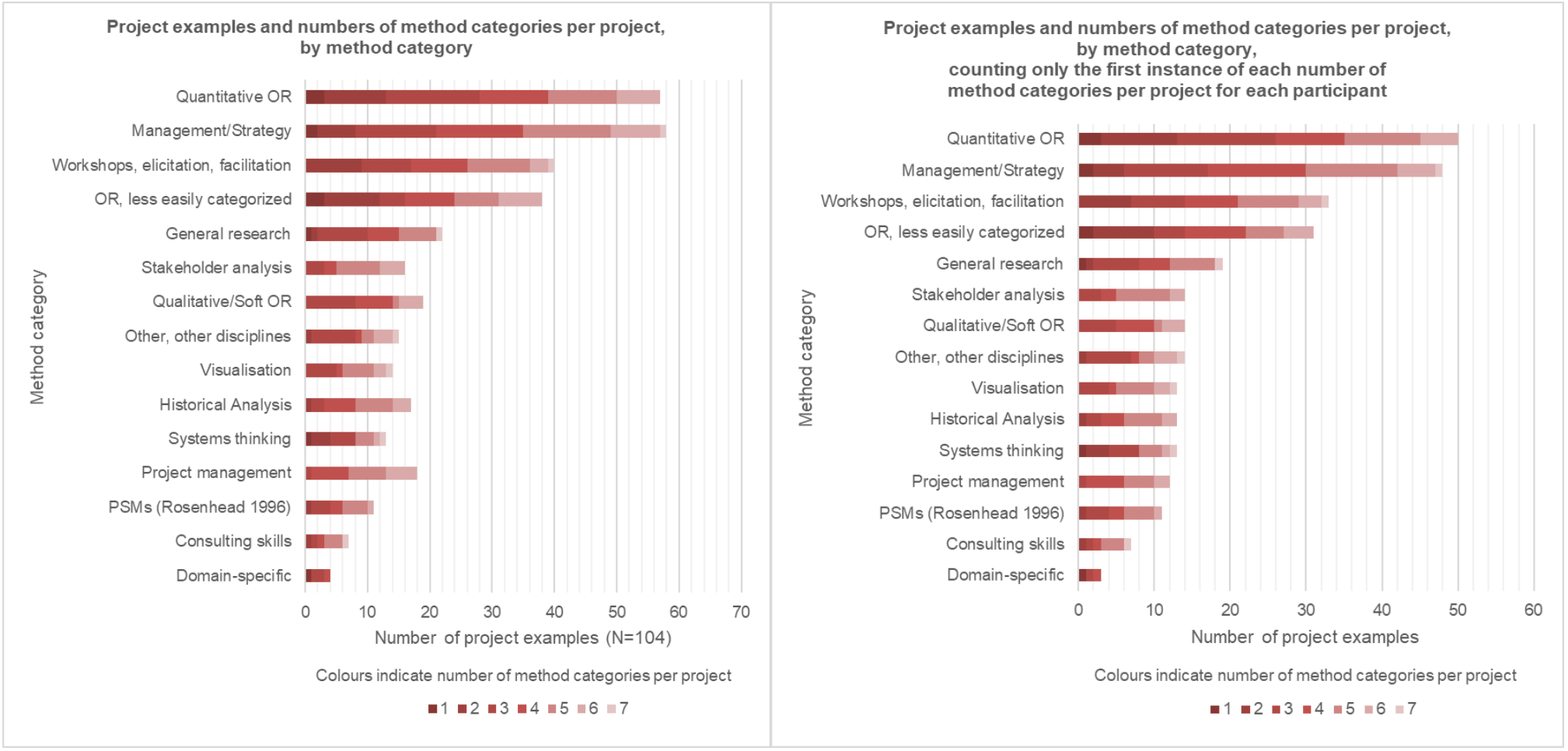


Figure 51: Project examples, and method categories per project (question 4), by method category

Table 47: Expert Workshop, Facilitated Workshop, and/or Subject Matter Expert (SME)/Stakeholder/Team Judgement/Assessment – methods most frequently listed with them in project examples (question 4), by number of participants (following clustering)

Rank	**Methods** (clusters)	**Category**	**Ppts**	**% of ppts** *(N=46)*	**% of ppts listing method** (see Table 17, chapter 5)	**Prjts**	**% of prjts with method** (see Table 17, above 5)	**Project data**
1	Scenarios	Management / Strategy	10	21.74	77%	17	81%	Table 69
2	Statistical Analysis	Quantitative OR	7	15.22	70%	9	60%	Table 55
3	Brainstorming	Management / Strategy	6	13.04	50%	11	52%	Table 70
4	Historical Analysis	Historical Analysis	6	13.04	67%	11	65%	Table 73
5	Visualization	Visualization	6	13.04	55%	6	43%	Table 62, Table 69, Table 65, Table 66
6	Gaming	OR less easily categorized	5	10.87	56%	7	64%	Table 64
7	Stakeholder Analysis	Stakeholder Analysis	5	10.87	45%	7	47%	Table 72
8	Simulation Modelling	Quantitative OR	4	8.70	80%	7	88%	Table 59
9	Cost-Benefit Analysis (CBA)	Quantitative OR	4	8.70	50%	6	46%	Table 56
10	SWOT	Management / Strategy	4	8.70	40%	6	43%	Table 70
11	Interviewing	General research	4	8.70	57%	5	56%	Table 69, Table 72, Table 65
12	MCDA	OR less easily categorized	4	8.70	40%	5	42%	Table 63
13	Delphi	OR less easily categorized	3	6.52	75%	4	67%	Table 63
14	Discrete Event Simulation (DES)	Quantitative OR	3	6.52	50%	4	57%	Table 57
15	Project Management	Project Management	3	6.52	43%	8	44%	Table 69, Table 63
16	AHP	OR less easily categorized	2	4.35	67%	3	60%	Table 63
17	Benefits Modelling	OR less easily categorized	2	4.35	40%	3	50%	Table 63
18	PESTLE	Management / Strategy	2	4.35	29%	3	33%	Table 70
19	Stochastic computer / Monte Carlo modelling	Quantitative OR	2	4.35	100%	3	75%	Table 62, Table 73, Table 63

See Table 37, Appendix N, for full details of the clustering of methods for the purposes of this table.
Ppts = Number of participants including method in at least one project example in which they also listed Expert Workshop(s), Facilitated Workshop(s) and/or Subject Matter Expert (SME)/Stakeholder/Team Judgement/Assessment
% of ppts = % of all participants providing project examples
Prjts = Total number of project examples with method and Expert Workshop(s), Facilitated Workshop(s) and/or Subject Matter Expert (SME)/Stakeholder/Team Judgement/Assessment provided by participants in response to question 4.
Note: Only (clustered) methods combined in three or more projects are included in the table.

Appendix R Survey: Method choice themes

Table 48: Practitioners' reasons for choosing or using particular methods in project examples: Themes and illustrative data

Theme	Illustrative **coded data** with contextual data	**Ppts**
AVAILABLE THEORETICAL AND METHODOLOGICAL APPROACHES		
1. Particular method or multimethod or type of method in order to...	Using Excel + Tableau **to develop understanding of workforce**. Use workshops **for 2-way knowledge transfer**, excel modelling **to conduct what-ifs**, text analysis **to identify functions undertaken by personnel**, benchmarking **to help compare and contrast across multiple organisations within [government department]**. (q5) [...] A range of tools **to analyse data** [pivot tables], **visualise it in a way accessible to stakeholders** [data visualisation means – Tableau], **and allow them to engage with it to develop option spaces** [stakeholder engagement tools - structured workshops] [...] (q 5, [methods (q4)]) [...] The e-voting **allowed them to choose single options and provided quantifiable data**. The questionnaire **allowed them to explain their choices**. The thematic analysis **allowed me to draw out common themes from across a broad sample of delegates, based on those qualitative responses to questionnaires**. (q5) [...] The qualitative analysis methods were used **to scope the non-quantifiable issues** (and in some cases **led to the identification of aspects that could be quantified and used in the "hard" analysis**). (q5) Gaming was used **to produce rapid results early.** 2 discrete event simulations were used. A coarse model was run using output from gaming **to determine which options were best represented in a more detailed model**. Finally, output is analysed using statistics **to check its validity**. (q5) [See Figure 53 below for sub-themes, and Table 49 and Table 50 below for further data and project examples.]	26
INTERVENTION CONTEXT		
2. Project or problem(s) or situation	Difficult to say. **Often it would be based on the requirements of the task which have varied a lot.** [...] (q2i) **The presenting problem** needed methods a) linking strategic outcomes to business processes and b) linking business processes and information structures. (q5) I don't know of any problem that doesn't require a mix of methods if you include softer OR skills/approaches. although **many problems 'major' on a certain method**, they will always need additional skills [...] (q5) [...] I conduct analyses to help people understand their complex problems, this is **usually "soft" analysis as the problems are subjective and not expressed in quantifiable terms**. **I select methods based** on what seems appropriate for me, **the problem** and the customer. [...] (q10) **The choice of method or multi-methods depends on the nature of the situation** and the level of understanding already achieved by the decision makers. It also depends upon the access granted to decision makers and time/money available. (q8) [...] I generally don't use them [toolsets] individually in series [...] but **in combination according to need** - for example, a combined context map and PESTLE to explore the external environment [...] (q8) [...] **I would suggest that an assessment of the type of project is imperative to understand how well methods work.** This is why I use the Cynefin approach as it helps to understand the problem space. For those problems that are more complex or chaotic (Cynefic terms) we should not be using discrete event simulation as the first port of call. (q10)	15
3. Resources, incl. available technology, time and funding, guidance and processes, knowledge, and data, or lack thereof	The fall back option when **rapid progress is required** and it is better to risk being too narrow in outlook than risk being late (q1 [Brainstorming]) A **standard part of the project management process** (q1 [Project Management cluster]) [...] **Context is required (not least to ensure policy compliance and [quality assurance])** thus requiring usage of scenarios. (q5) [...] We have **a process we usually follow** for general capability study questions which will include gaming, simulation, [expert/stakeholder] judgement, scenario building and statistical analysis but the process is flexible and can be amended as studies require. (q5) [...] The hi-fidelity models **take too long to run**. [...] (q5) [...] Some [methods] you are more familiar with and may **have the tools to support the method**, so you will use that until you find you need something more. **Often it comes down to what the customer has access to in terms of supporting tools e.g. what is available on the [system]**? (q8) The choice of method or multi-methods depends on the nature of the situation and the level of understanding already achieved by the decision makers. It also depends upon the access granted to decision makers and **time/money available**. (q8) [...] **Cost and resourcing constraints** are also a consideration. One method may be better than all the others but it may take **too long to run**, or the **data may not be available** to support it. (q8) **Practical and accessible guidance on alternative techniques, and where/when/how to use them would be good, noting that there is often little time or capacity available to practice/deliver events.** (q10)	13
INTERVENERS/PRACTITIONERS		

Theme	Illustrative **coded data** with contextual data	**Ppts**
4. I or we tend to use or most studies or I practice these methods	Most studies involve an element of this, maybe just for me (q1 [Cognitive mapping Causal mapping Oval mapping Journey-Making SODA]) Used within most projects, particularly at initiation (q1 [Brainstorming]) I work in the soft OR area so major on facilitation and consultancy kills, drawing in OR method as a means of structuring or visualising a problem. [...] whatever my problem, I tend to use a mix of these approaches... (q5) I am practising soft OR and rely on methods associated with exploring the problem space (tending to be before hard OR is called upon). (q10) [...] The biggest problem is that many people don't understand the purpose of the analysis that they are applying and tend to be methodologically entrenched. [...] (q10)	9
5. History of use and familiarity of method	The more you use different methods the more you appreciate that they are each more useful for different parts of the problem rather than the whole problem. **Some you are more familiar with** and may have the tools to support the method, **so you will use that until you find you need something more**. [...] (q8) **Despite having successfully been doing OR for 10 years, as an Engineer by degree I have not been trained in any of the techniques in Q1, and use a very limited selection of them**. I use common sense to answer questions, backed up by Excel based calculations. (q10) [...] **Many folk are familiar with some approaches, usually the same ones - we struggle to throw in new approaches** and the need for delivery often discourages risk taking in this regard. [...] (q10) I realise **we rely on 'tried-and-tested' methods that seem to work**. Practical and accessible guidance on alternative techniques, and where/when/how to use them would be good, noting that there is often little time or capacity available to practice/deliver events. (q8) The **fall back option when rapid progress is required** and it is better to risk being too narrow in outlook than risk being late (q1 [Brainstorming])	9
6. Appropriate	Used when appropriate to the question being examined (q1 [PESTLE]) [...] I select methods based on what seems appropriate for me, the problem and the customer. [...] (q10) [...] I use common sense to answer questions, backed up by Excel based calculations. Given the varied nature of the questions I answer, I just chose an appropriate technique to answer each element. [...] (q10)	6
7. Name or source of method	[...] might use similar techniques **without knowing origin** (q1 Diagramming Techniques SADT) [...] in [my organization], **quite often we don't think about precise sources of methods or exact names**. ... (q2i) [...] Typically use **un-named methods 'made up' as the need arises**. (q2i)	3
RELATIONSHIPS WITH STAKEHOLDERS		
8. Stakeholders	The choice of method or multi-methods depends on the nature of the situation and **the level of understanding already achieved by the decision makers**. It also depends upon the **access granted to decision makers** and time/money available. (q8) [...] I must admit that I often use methods in a very light touch manner to aid thinking and insight around a problem **rather than to produce products for the customer or address specific problems and generate solutions**. (q8) [...] **I select methods based on what seems appropriate for me, the problem and the customer.**[...] (q10) [Government departmental] decision making concerns situations where **opponents are actively seeking to change the rules. The assumption of continuity of process in this method** is a good way to achieve future failure (q1 [DEA])	6
TOTAL		**42**

Ppts = Number of participants providing data that contributed to theme

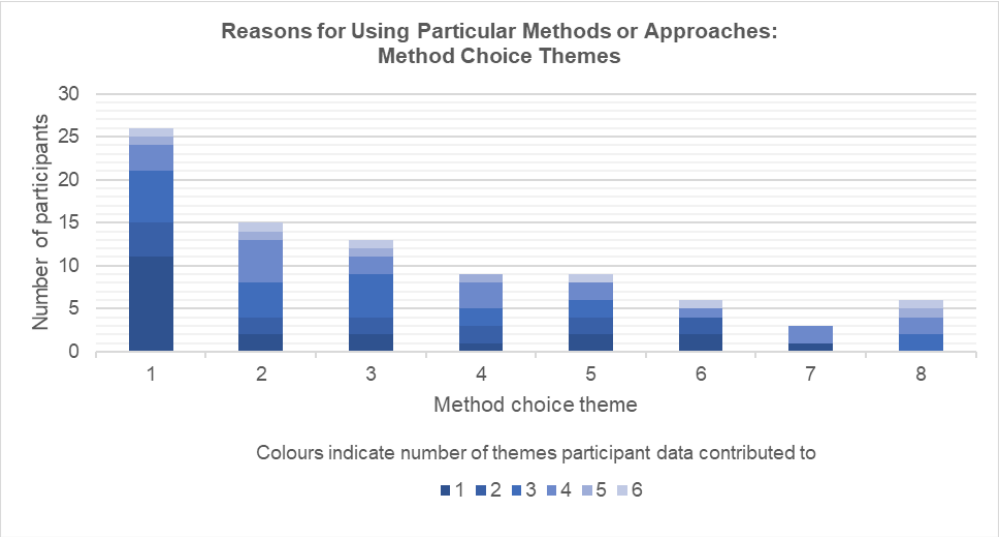


Figure 52: Contribution of participants' data to method choice themes (N=42)

TO UNDERSTAND OR CONSIDER OR DEFINE PROJECT SCOPE AND/OR REQUIREMENTS, OR ISSUES FOR ANALYSIS AND/OR METHODS
(AT OUTSET OR DURING PROJECT)
[5 participants]

Understand project requirements and scope
- **Problem structuring methods**

Consider project scope and/or methods [2 ppts]
- **Brainstorming**
- **Cynefin model**

Scope/identify issues for qualitative or quantitative analysis [1 prjt]
- **Causal mapping**
- **Morphological box**
- **PESTLE**
- **Scenario analysis**

Define scope or issues for model or analysis activity [2 ppts]
- **Discrete event simulation** (coarse model)
- **Expert workshops**

TO IDENTIFY, GATHER, AND GENERATE DATA NEEDED FOR ANALYSIS
[6 participants]

- **Data Mining**
- **Electronic voting** (quantifiable, single responses)
- **Financial modelling/ prediction**
- **Historical Analysis**
- **Questionnaire** (qualitative explanations)
- **Rich Picture** (SSM)
- **SME interviews**
- **Stakeholder analysis**
- **Statistical Analysis**
- **Structured SME elicitation**
- **Structured interviews**

TO VISUALISE AND ENGAGE WITH STAKEHOLDERS
[4 participants]

- **Data visualisation means – Tableau**
- **Diagrams (**to describe processes)
- **Graphical Display Methods**
- **Rich Picture**
- **Stakeholder engagement tools - structured workshops**
- **Visualisation (sun ray diagram)**

TO MANAGE PROJECT PROGRESS OR BUDGET OR RISK
[4 participants]

Progress [1 ppt]
- **Gaming**

Budget [1 ppt]
- **Project management**

Risk [2 ppts]
- **Pre-mortem**
- **Stakeholder profiling**
- **Stakeholder engagement**
- **Visualisation**

TO ANALYSE DATA
[14 participants]

- **Benchmarking**
- **Coding text data into a database / Qualitative data in spreadsheet** (for more holistic analysis)
- **Data Mining**
- **Descriptive/visual/ regression analysis**
- **Engineering modelling**
- **Historical Analysis**
- **pivot tables**
- **Policy Analysis** (risks and benefits)
- **Effectiveness analysis**
- **Spreadsheet modelling** (what-ifs)
- **Statistical Analysis** (e.g., dealing with uncertainty, hypothesis testing)
- **Thematic analysis**

To represent system or options [3 ppts]
- **Discrete event simulation**
- **Gaming**
- **RACI** (Responsible, Accountable, Consulted, Interested)
- **VSM** (Viable System Model)

To describe or understand or assess capability or policy or future organisational health or resilience or context [3 ppts]
- **Scenario building**
- **Scenario development**
- **Scenario Planning**

To validate options / output [3 ppts]
- **Data Mining**
- **Historical Analysis**
- **Human-in-the-loop experimental design and gaming** (for rigour and repeatability)
- **Statistical Analysis**

TO EXPLORE OR STRUCTURE A/THE PROBLEM / PROBLEM SPACE
(WITH GROUP OF STAKEHOLDERS, OR OTHERWISE)
[7 participants]

- **Causal loop modelling**
- **Consultancy skills**
- **Context mapping**
- **Elements of cognitive mapping**
- **Facilitation**
- **Ladder of abstraction**
- **Soft OR**
- **Soft Systems Methodology** (SSM), root definitions & conceptual activity modelling, SSM questions
- **Visualisation**

In a very light touch manner to aid thinking and insight around a problem [1 ppt]
- **Problem structuring methods**, e.g., Problem structuring with "6 questions", SWOT

As thinking tools to inquire of the group [when facilitating] [1 ppt]
- **SSM** (Soft Systems Methodology)
- **VSM** (Viable System Model)
- **CSH** (Critical Systems Heuristics)
- **Metaphor**
- **Iceberg model**

TO DEVELOP UNDERSTANDING
(WITH, WITHOUT, AMONGST, AND OF PROJECT STAKEHOLDERS)
[9 participants]

- **Context mapping**
- **Diagrams** of processes
- **Domain-specific analysis**
- **Excel** spreadsheet + **Tableau** visualisation
- **Manual and automated text analysis** (to identify functions)
- **PESTLE**
- **Pig** (Gareth Morgan)
- **Power vs interest**
- **Robustness Analysis** (Rosenhead)
- **Stakeholder mapping**
- **Strategy diamond**
- **Structured interviews**
- **SWOT**
- **System dynamics**
- **VSM (Viable System Model)**

Getting the stakeholder community to a degree of shared problems understanding [1 ppt]
- **Rich pictures** (SSM)

To think through why people are behaving in a particular way when doing rich pictures [1 ppt]
- **Eternal triangle** (CSH)

To develop greater understanding of issues in minds of participants [1 ppt]
- **Outputs from facilitated workshops** (using a variety of prompting techniques)

TO ELICIT INFORMATION / EXPERTISE / UNDERSTANDING / IDEAS FROM EXPERTS / STAKEHOLDERS
[6 participants]

- **Bespoke framework**
- **Elements of Delphi**
- **Expert or stakeholder judgement**
- **Expert/SME workshops**
- **Feasibility & Impact Grids**
- **Italian flag scoring**
- **Q-Methodology (**to assess choice)
- **Simpler decision tools,** 'for example: Force Field Analysis, Probability - Impact grids (Risk analysis), Backwards planning (working back from the goal), Impact - Feasibility grids, pre-mortem (often to examine project risks), bespoke frameworks (e.g. like PESTLE, but developed for the specific issue), sticky dot voting. I often use such techniques in a 'mix and match' way in workshop settings.' (q2i)
- **Structured stakeholder workshops**
- **Workshops**

To stimulate 'thinking differently' [1 ppt]
- **Facilitated workshops** using a variety of prompting techniques

Note: Illustrative and full coded data with related project examples are in Table 49 and Table 50, respectively (Appendix R).

Figure 53: Practitioners' reasons for using particular methods in project examples – sub-themes and methods for the most common theme, 'Particular method or multimethod or type of method in order to…'

Table 49: Theme, 'Particular method or multimethod or type of method in order to...' – illustrative data, by sub-theme

SUB-THEME	Methods used	Illustrative **coded data** with contextual data	**Subject matter(s)** of related project example(s) (time available)
TO UNDERSTAND OR CONSIDER OR DEFINE PROJECT SCOPE AND/OR REQUIREMENTS, OR ISSUES FOR ANALYSIS AND/OR METHODS (AT OUTSET OR DURING PROJECT)	• Brainstorming • Causal mapping • Cynefin model • Discrete event simulation (coarse model) • Expert workshops • Morphological box • PESTLE • Problem structuring methods • Scenario analysis	Brainstorm with other team members for longer-term studies to **consider options and methods and potential case studies etc**. [...] (q5) Gaming was used to produce rapid results early. 2 discrete event simulations were used. A coarse model was run using output from gaming **to determine which options were best represented in a more detailed model**. **[...]** [...] In addition some of the methods are used to narrow down options for other methods, e.g. some expert workshops are used **to define the scope of a simulation activity or a gaming event**. (q5) [...] Many of the above **cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope**. Consequently many studies involved phases in which PSM were employed followed by more focused analysis. [...] (q5) [...] The qualitative analysis methods [Causal mapping, Scenario analysis Brainstorming, PESTLE, Morphological box] were used **to scope the non-quantifiable issues** (and in some cases **led to the identification of aspects that could be quantified and used in the "hard" analysis**). (q5) Cynefin model **for conducting analysis estimates.** (2i)	Strategic Planning (4 months); Strategic Planning (3 months) Baselining for future requirement (1 year) Equipment Procurement (months); Operational Planning (months) Portfolio appraisal (6 months); Domain Capability Audit (6 months); National capability analysis (18 months); Option Assessment (8 months) Cost-benefit analysis (a little over a year)
TO EXPLORE OR STRUCTURE A/THE PROBLEM / PROBLEM SPACE (WITH GROUP OF STAKEHOLDERS, OR OTHERWISE)	• Causal loop modelling • Consultancy skills • Context mapping • Critical Systems Heuristics (CSH) • Elements of cognitive mapping • Iceberg model • Facilitation • Ladder of abstraction • Metaphor, Gareth Morgan's metaphors • Problem structuring methods, e.g., Problem structuring with "6 questions", SWOT • Soft OR • Soft Systems Methodology (SSM), root definitions & conceptual activity modelling, SSM questions • Visualisation • Viable System Model (VSM)	[...] I work in the soft OR area so major on facilitation and consultancy kills, **drawing in OR method as a means of structuring or visualising a problem** [...] (q5) [...] e.g. Laddering [Ladder of abstraction] and SSM questions help you **to identify whether you are studying the right problem to start off with** [...] when I facilitate a group I will use SSM, VSM, CSH, metaphor, iceberg .... **as thinking tools to inquire of the group** (q5) Cognitive mapping [elements of] **to develop goals and constituent activities** [...] (q5) I needed something **to 'unpack' the problem** and SSM fitted the bill well for this. [...] (q5) [...] I must admit that I often use methods [e.g., Problem structuring with "6 questions", SWOT] **in a very light touch manner to aid thinking and insight around a problem** rather than to produce products for the customer or address specific problems and generate solutions. (q8)	Organisational change (2 years) Reorganisation of team in central government department (6 months, part time) Requirements setting (6 hours) Organisational assessment and design (3 months) The potential of a process to provide benefit in a government department (4 months)

SUB-THEME	Methods used	Illustrative **coded data** with contextual data	**Subject matter(s)** of related project example(s) (time available)
TO DEVELOP UNDERSTANDING (WITH, WITHOUT, AMONGST, AND OF PROJECT STAKEHOLDERS)	• Context mapping • Diagrams • Domain-specific analysis • Eternal triangle (CSH) • Excel spreadsheet + Tableau visualisation • Manual and automated text analysis • Outputs from facilitated workshops (using a variety of prompting techniques) • PESTLE • Pig (Gareth Morgan) • Power vs interest • Rich pictures (SSM) • Robustness Analysis (Rosenhead) • Stakeholder mapping • Strategy diamond • Structured interviews • SWOT • System Dynamics • Viable System Model (VSM)	Using Excel + Tableau **to develop understanding of workforce** [...] text analysis **to identify functions undertaken by personnel [...]** (q5)	Strategic Workforce planning (6 months)
		I tried system dynamics **to understand some of the key flows between parts of the system (money was one) - this was interesting in shaping the extent of the system we were interesting in** but it didn't get us towards a solution. [...] (q5)	National Capability Planning (3 months (which became 2 years))
		Range of methods [VSM, Strategy diamond, context mapping, PESTLE, SWOT, Pig, power vs interest] **to understand the system in focus, the external environment, freedoms and constraints, opportunities to shape potential strategic choices** [...] (q5)	Strategy development (ca 5 days)
		C**apture of understanding of the system** through iterative stakeholder mapping and 1-1 engagement through interview [...] (q5)	System health (3 months)
		[...] Most of my problems are multi-stakeholder so part of the approach is about **getting the stakeholder community to a degree of shared problems understanding** so we build rich pictures [...] (q5)	Reorganisation of Departmental Agency (12 months)
		Note that tend to use the eternal triangle **to think through why people are behaving in a particular way when doing rich pictures and brain storms but do not use full question set regularly** (q1 CSH)	
		Facilitated workshops designed around specific challenges using a variety of prompting techniques to stimulate 'thinking differently'. Outputs used **to develop greater understanding of issues in minds of participants** (q2i)	Future policy awareness (2 days prep, 1 day delivery); Future technical direction (3 days prep, 1 day delivery)
		I use diagrams **to describe/ understand how processes work**, but don't think that is as formal as SADT (q1 SADT)	
		This is being used by a task within my project as a part of our work seeking **to understand the Deep Uncertainty under which many of [the department's] decisions are taken** (q1 RA)	
		[...] Something else entirely, and it might fit in the list on the previous page (I'm not sure) is [domain-specific] analysis, where **we might seem to understand the issues of a [domain-specific] capability** [...] (q2ii)	OR to inform future equipment requirement and strategy (Several Months)

SUB-THEME	Methods used	Illustrative **coded data** with contextual data	**Subject matter(s)** of related project example(s) (time available)
TO ELICIT INFORMATION / EXPERTISE / UNDERSTANDING / IDEAS FROM EXPERTS / STAKEHOLDERS	• Bespoke framework • Elements of Delphi (eliciting information individually first) • Expert or stakeholder judgement • Expert/SME workshops • Facilitated workshops using a variety of prompting techniques • Feasibility & Impact Grids • Italian flag scoring • Q-Methodology • Simpler decision tools, 'for example: Force Field Analysis, Probability - Impact grids (Risk analysis), Backwards planning (working back from the goal), Impact - Feasibility grids, pre-mortem (often to examine project risks), bespoke frameworks (e.g. like PESTLE, but developed for the specific issue), sticky dot voting. I often use such techniques in a 'mix and match' way in workshop settings.' (q2i) • Structured stakeholder workshops • Workshops	[...] Delphi style elicitation of ideas **to generate ideas from individuals,** bespoke framework - **to capture information in the desired format,** bespoke framework - **to capture information in the desired format**, feasibility impact grids **to assess options**. (q5)	Requirements setting (6 hours)
		[...] **health scoring** through structured stakeholder workshops, Italian flag scoring, elicitation and capture of rationale for scoring. (q5)	System health (3 months)
		[...] I often (initially) do not have the depth of **knowledge or expertise required to answer the problem or properly formulate a methodology**. As such, I will use expert or [stakeholder] judgement **to properly understand the issues**. [...] (q5)	Capability people requirements (3 months); National Capability Development (6 months); Implications of Policy Analysis (3 years); Strategic operations (3 years)
		Scenario gaming often involves activities **to elicit information from individuals**, so can use some of the simpler decision tools to support this. (q5)	Multi-actor scenario gaming (2 months)
		[...] Use workshops **for 2-way knowledge transfer** [...] (q5)	Strategic Workforce planning (6 months)
		[My organization] may not hold all of the expertise hence need for [expert workshop]s in some cases. [...] (q5)	Requirements Capture (4 months) Operations Policy (9 months)
		[...] In the end we used some scenario planning and a series of workshops **to build pictures of supply, demand, gaps** and health (ability to sustain the current position) [...] (q5)	National Capability Planning (3 months (which became 2 years))
		Facilitated workshops designed **around specific challenges using a variety of prompting techniques to stimulate 'thinking differently'**. Outputs used to develop greater understanding of issues in minds of participants (q2i)	Future policy awareness (2 days prep, 1 day delivery); Future technical direction (3 days prep, 1 day delivery)
		Q-Methodology **for assessing choice among a number of competing options.** (2i)	Equipment Procurement (months)
TO IDENTIFY, GATHER, AND GENERATE DATA NEEDED FOR ANALYSIS	• Data Mining • Electronic voting • Financial modelling/ prediction • Historical Analysis • Questionnaire • Rich Picture (SSM) • SME interviews • Stakeholder analysis • Statistical Analysis • Structured SME elicitation • Structured interviews	[...] Often historical analysis or data mining is **necessary to gather data**. **[...] (q5)**	Capability people requirements (3 months); National Capability Development (6 months); Implications of Policy Analysis (3 years); Strategic operations (3 years)
		[...] Data mining, HA [Historical Analysis} and Stats used **to identify-locate data** [...] (q5)	Strategic Planning (4 months); Strategic Planning (3 months); Operational Planning (1 month)
		To gain further insight into delegate opinions. The e-voting **allowed them to choose single options and provided quantifiable data.** The questionnaire **allowed them to explain their choices**. [...] (q5)	Collecting delegate feedback (3 months)
		[...]. For senior stakeholders there was also a need to draw in a variety of different visualisations to engage with them - this means that **many different methods are needed to generate the data.** (q5 [methods: SME interviews; Financial modelling/ prediction; Stakeholder analysis; Rich Picture])	Requirements Setting study (8 months + 6 month follow on)
		Interviewing subject matter experts around structured questions **to subsequently analyse patterns, trends and insights**. (q2ii)	Organisational best practice (Intermittently over 9 months)
		Structured SME elicitation **to generate some data** (q4)	Operational assessment of national capability effectiveness (about a month (not full time))

SUB-THEME	Methods used	Illustrative **coded data** with contextual data	**Subject matter(s)** of related project example(s) (time available)
TO ANALYSE DATA	• Benchmarking • Coding text data into a database / Qualitative data in spreadsheet • Data Mining • Descriptive/visual/regression analysis • Engineering modelling • Historical Analysis • Pivot tables • Policy Analysis • Effectiveness analysis • Spreadsheet modelling • Statistical Analysis • Thematic analysis	[...] excel modelling **to conduct what-ifs**, benchmarking **to help compare and contrast across multiple organisations within [government department]**. [...] (q5) [...] [pivot tables] **to analyse data** [...] (q5) [...] Data mining, HA and Stats used **to** identify-locate data and **process**/validate. **[...]** (q5) Descriptive/visual/regression **analysis of the results** (q4) Statistical Analysis **for hypothesis testing** (q4) [...] Coding text data into a database **to enable a more holistic analysis.** (q2ii) [...] The thematic analysis **allowed me to draw out common themes from across a broad sample of delegates, based on those qualitative responses to questionnaires**. (q5) Regular use of what I would call 'policy analysis' **to establish/identify the risks and benefits of taking different courses of action or pursuing different policy options**. [...] (q2i) We also use non-OR techniques to inform our work. These would typically be classed as performance models (i.e., we're **looking at absolute performance [of equipment] to then combine with the relative effectiveness in OR)**. [...]. It might be that the output from these [engineering] models feeds into the OR [simulation] models, or we simply use it to inform our study. [...] (q2ii) [...] I am in the process of extending how I use cost-benefit analysis methods to i**nclude simple statistical analysis to be able to deal with uncertainty in cost and benefit estimation data.** (q10)	Strategic Workforce planning (6 months) Workforce understanding (3 months) Strategic Planning (4 months); Strategic Planning (3 months); Operational Planning (1 month) Operational assessment of national capability effectiveness (about a month (not full time)) Assessing factors which impact on national capability (4 months) Identifying and prioritising investment options (Team of 4 for 6 months/ ongoing) Collecting delegate feedback (3 months) Policy Analysis (6 months)
To represent system or options	• *Discrete event simulation* • *Gaming* • *RACI (Responsible, Accountable, Consulted, Informed)* • *Viable System Model (VSM)*	[...] **system representation** through VSM and RACI [...] (q5) Gaming was used **to produce rapid results early.** 2 discrete event simulations were used. A coarse model was run using output from gaming **to determine which options were best represented in a more detailed model**. [...] (q5) [...]. I then needed **a way of representing the problems in a recursive hierarchy** which suited VSM. What I really needed after this was a good range of solution options, which was difficult to find based on just the VSM outputs (q5)	System health (3 months) Baselining for future requirement (1 year) Organisational assessment and design (3 months)
To describe or understand or assess capability or policy or future organisational health or resilience or context	• *Scenario building* • *Scenario development* • *Scenario Planning*	[...] In the end we used some scenario planning and a series of workshops **to build pictures of supply, demand, gaps and health (ability to sustain the current position)** [...] (q5) [...] **Context is required (not least to ensure policy compliance and [quality assurance])** thus requiring usage of scenarios. (q5) [...] and scenarios **to understand the resilience of the future organisation against potential future challenges**.	National Capability Planning (3 months (which became 2 years)) Capability people requirements (3 months); National Capability Development (6 months); Implications of Policy Analysis (3 years); Strategic operations (3 years) Strategy development (ca 5 days)

SUB-THEME	**Methods used**	Illustrative **coded data** with contextual data	**Subject matter(s)** of related project example(s) (time available)
To validate options / output	• *Data Mining* • *Historical Analysis* • *Human-in-the-loop experimental design and gaming* • *Statistical Analysis*	[...] Finally, output is analysed using statistics **to check its validity**. (q5) [...] Data mining, HA and Stats used **to** identify-locate data and process/**validate**. [...] (q5) In the past - human-in-the-loop experimental design and gaming; **more rigorous and repeatable** than table top gaming, also **uses psychological wrapping to 'immerse' participants.** (q2ii)	Baselining for future requirement (1 year) Strategic Planning (4 months); Strategic Planning (3 months); Operational Planning (1 month)
TO VISUALISE AND ENGAGE WITH STAKEHOLDERS	• Data visualisation means – Tableau • Diagrams • Graphical Display Methods • Rich Picture (SSM) • Stakeholder engagement tools - structured workshops • Visualisation (sun ray diagram)	[...] A range of tools **to analyse data**, **visualise it in a way accessible to stakeholders, and allow them to engage with it to develop option spaces** [...] (q5) Complexity - it was not possible to address the issues with a single method because there was a lot of connectivity between issues, uncertainty in terms of need. **For senior stakeholders there was also a need to draw in a variety of different visualisations to engage with them** - this means that many different methods are needed to generate the data. (q5; [q4 methods include Rich Picture and Visualisation (sun ray diagram)]) By taking a view of the desired outcome and the types of input that would be needed to deliver this outcome. It is then possible to consider what type of tool is needed (**graphical representation for discussion** or a hard display of supply against demand etc etc) (q10)	Workforce understanding (3 months) Requirements Setting study (8 months + 6 month follow on) National Capability Planning (3 months (which became 2 years))
TO MANAGE PROJECT PROGRESS OR BUDGET OR RISK	• Gaming • Project management • Pre-mortem • Stakeholder profiling • Stakeholder engagement • Visualisation	Gaming was used **to produce rapid results early.** 2 discrete event simulations were used. A coarse model was run using output from gaming to determine which options were best represented in a more detailed model. [...] (q5) [...] Some methods act **as risk mitigations e.g. stakeholder engagement and profiling are to try and understand who might be impacted by my proposals so that I can encourage engagement or adjust plans, and visualisations are often part of attempts to manage expectations/clarify problems and show how my proposal presents a solution to that problem.** (q5) [...] PM **to maintain personal oversight of budget allocated spend**. (q5) [...] Also use of 'pre-mortem' **to identify where piece of work may go awry**. **(2i)**	Baselining for future requirement (1 year) The potential of a process to provide benefit in a government department (4 months); Designing a process pilot (4 months) Strategic Planning (4 months); Strategic Planning (3 months); Operational Planning (1 month) Improved Evidence-Based Policy Making (3 years)

Table 50: Theme, 'Particular method or multimethod or type of method in order to…' – full data, with responses and full project examples grouped by participant

Sub-theme	**Reason**	**Method(s) used**	**Coded data** (with contextual data)	**Question**	**Methods in project** (q4)	**Subject matter** (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**
explore (problem space)	exploring the problem space (tending to be before hard OR is called upon)	[soft OR]	I am practising soft OR and rely on methods associated with **exploring the problem space (tending to be before hard OR is called upon).**	10	VSM Causal loop modelling SSM (root definitions & conceptual activity modelling) Visualisation	Setting strategic goals (3)	SCS3 Government Department Business Unit (2)	1 year
explore or structure (problem)	for structuring or visualising a problem	[soft] OR method[s]	[…] I work in the soft OR area so major on facilitation and consultancy kills, **drawing in OR method as a means of structuring or visualising a problem** […]	5	VSM Facilitation Context mapping Interviewing Brainstorming Collaboration Visualisation Problem solving	Organisational change (7)	Government Department Capabilities, programme level (3)	6 months to first draft, 2 years to IOC [initial operating capability]
explore (problem space)	to help elucidate a problem space	[Soft Systems Methodology (SSM) / Rich Pictures / CATWOE / Root Definitions / Conceptual Mapping / 3E's (Checkland)]	Used **where it helps to elucidate a problem space**, cognisant of the limitations on the freedom of expression and freedom of action of the actors analysed and hence the limitations of these perspectives	1 (SSM)				
understand (uncertainty)	as part of work seeking to understand deep uncertainty	Robustness Analysis (Rosenhead)	This is being used by a task within my project as a part of our work seeking **to understand the Deep Uncertainty under which many of [the department's] decisions are taken**	1 (RA)				
explore or structure (problem)	to aid thinking and insight around a problem	[see examples included in this row and the two rows immediately below this one]	I must admit that I often use methods **in a very light touch manner to aid thinking and insight around a problem** rather than to produce products for the customer or address specific problems and generate solutions.	8	Structured interviews Data visualisation Thematic analysis - wants and needs Mapping (needs to objectives)	Ensuring research programme aligned to and achieves strategic objectives in Personnel area (2)	Assistant Head Government Department Function (3)	2 months

Sub-theme	**Reason**	**Method(s) used**	**Coded data** (with contextual data)	**Question**	**Methods in project** (q4)	**Subject matter** (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**
manage project (risk)	as risk mitigation – to understand impacted so I can encourage engagement or adjust plans	Stakeholder profiling Stakeholder engagement	[...] Some methods act **as risk mitigations e.g. stakeholder engagement and profiling are to try and understand who might be impacted by my proposals so that I can encourage engagement or adjust plans, and visualisations are often part of attempts to manage expectations/clarify problems and show how my proposal presents a solution to that problem.**	5	Workshop Thematic analysis of perspectives SWOT Stakeholder perspectives/profiling Stakeholder engagement	The potential of a process to provide benefit in a government department (2)	Head of Function, Government Department Head Office (2)	4 months
manage project (risk)	as risk mitigation – to manage expectations/clarify problems and show how my proposal presents a solution to that problem	Visualisation			Stakeholder engagement Problem structuring with "6 questions" Visualisation	Designing a process pilot (2)	Head of Function, Government Department Head Office (2)	4 months
understand (stakeholder behaviour)	to think why people are behaving in a particular way when using particular method and tool	eternal triangle	Note that tend to use the eternal triangle **to think through why people are behaving in a particular way when doing rich pictures and brain storms** but do not use full question set regularly	1 (CSH)				
structure (problem) (group of stakeholders)	as thinking tools to inquire of the group	SSM, VSM, CSH, metaphor, iceberg	The methods can be complimentary and help you look at a problem through a different lenses to discover different aspects or cover different parts of the problem space e.g.as consultants we are seeking to understand the problem, structure it so that we can reflect it back to our customer in some sort of order and then identify a way forward. Thus we use different tools in different parts of that process but often iterate. e.g. Laddering and SSM questions help you **to identify whether you are studying the right problem to start off with**. Most of my problems are multi-stakeholder so part of the approach is about **getting the stakeholder community to a degree of shared problems understanding** so we build rich pictures but so when I facilitate a group I will use SSM, VSM, CSH, metaphor, iceberg.... **as thinking tools to inquire of the group**	5	VSM Ladder of abstraction	Review of cross org governance structure for addressing risks to animal and plant health in UK (7)	Pan-organisations (7)	3 month study (which included other aspects)
develop understanding (of problems) (share amongst stakeholders)	getting the stakeholder community to a degree of shared problems understanding	rich pictures			VSM Rich pictures Brainstorming Activity modelling	Reorganisation of Departmental Agency (7)	Corporate centre Departmental Agency (2)	Seconded into transformation team for 12 months
structure (problem)	to identify whether you are studying the right problem	Laddering, SSM questions			VSM Gareth Morgan's metaphors Iceberg model Ladder of abstraction Brainstorming	Reorganisation of team in central government department (7)	Government Department Business Unit (SEO) (4)	I was embedded part time with team for 6 months

Sub-theme	**Reason**	**Method(s) used**	**Coded data** (with contextual data)	**Question**	**Methods in project** (q4)	**Subject matter** (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**
to elicit ideas (from stakeholders)	to stimulate 'thinking differently'	Facilitated workshops using a variety of prompting techniques	Facilitated workshops designed around specific challenges **using a variety of prompting techniques to stimulate 'thinking differently'**. Outputs used **to develop greater understanding of issues in minds of participants**	2i	Facilitated workshop Expert workshop Output summary	Future policy awareness (10)	Experienced official, Departmental Agency (3)	2 days prep, 1 day delivery
develop understanding (participants')	to develop greater understanding of issues in minds of participants				Facilitated workshop Expert workshop Numerical analysis Data visualisation	Future technical direction (10)	Government Department Business Unit, SEO (4)	3 days prep, 1 day delivery
elicit (information)	to elicit information from individuals, so can use some of the simpler decision tools to support this	simpler decision tools ['for example: Force Field Analysis, Probability - Impact grids (Risk analysis), Backwards planning (working back from the goal), Impact - Feasibility grids, pre-mortem (often to examine project risks), bespoke frameworks (e.g. like PESTLE, but developed for the specific issue), sticky dot voting. I often use such techniques in a 'mix and match' way in workshop settings.' (q2i)]	Scenario gaming often involves activities **to elicit information from individuals**, so can use some of the simpler decision tools to support this.	5	Scenario gaming (bespoke approach) Elements of Delphi	Multi-actor scenario gaming (10)	Senior government stakeholders (2)	2 months
structure	to develop goals and constituent activities	Cognitive mapping (elements of)	Cognitive mapping **to develop goals and constituent activities**, Delphi style elicitation of ideas **to generate ideas from individuals**, bespoke framework - **to capture information in the desired format**, feasibility impact grids **to assess options**.	5	Elements of cognitive mapping Feasibility & Impact Grids Elements of Delphi (eliciting information individually first) Bespoke framework	Requirements setting (8)	Working level Departmental Agency (5)	6 hours
elicit (ideas)	to generate ideas from individuals	Elements of Delphi (eliciting information individually first)						
elicit (information)	to capture information in the desired format	Bespoke framework						
elicit (information) (assess options)	to assess options	Feasibility & Impact Grids						
develop understanding	to develop understanding of workforce	Excel + Tableau	Using Excel + Tableau **to develop understanding of workforce**. Use workshops **for 2-way knowledge transfer**, excel modelling **to conduct what-ifs**, text analysis **to identify functions undertaken by personnel**, benchmarking **to help compare and contrast across multiple organisations within [government department]**.	5	Visualisation (graphs and geographic) Spreadsheet modelling SME workshops Manual and automated text analysis Benchmarking	Strategic Workforce planning (1)	SCS3 Government Department stakeholders (2)	6 months
elicit (information) (2-way)	for 2-way knowledge transfer	SME workshops						
analyse	to conduct what-ifs	Spreadsheet modelling						
develop understanding	to identify functions undertaken by personnel	text analysis						

Sub-theme	**Reason**	**Method(s) used**	**Coded data** (with contextual data)	**Question**	**Methods in project** (q4)	**Subject matter** (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**
analyse	to help compare and contrast across multiple organisations within [government department]	Benchmarking						
develop understanding	to understand some of the key flows between parts of the system (money was one) - this was interesting in shaping the extent of the system we were interested in	System Dynamics	I tried system dynamics **to understand some of the key flows between parts of the system (money was one) - this was interesting in shaping the extent of the system we were interested in** but it didn't **get us towards a solution**. I tried SSM which took things one step further. The problem boiled down to understanding supply and demand across a national capability - multiple suppliers and multiple demanders. In the end we used some scenario planning and a series of workshops **to build pictures of supply, demand, gaps and health (ability to sustain the current position)**	5	System Dynamics SSM Scenario Planning Workshops Graphical Display Methods	National Capability Planning (1)	SCSI Head Office Government Department + Other Government Departments (2)	3 months (which became 2 years)
[solve problem]	to get us towards a solution	SSM						
elicit information analyse – to describe capability health	to build pictures of supply, demand, gaps and health (ability to sustain the current position)	scenario planning and a series of workshops						
explore or structure (problem)	to 'unpack' the problem	SSM	I needed something **to 'unpack' the problem** and SSM fitted the bill well for this. I then needed **a way of representing the problems in a recursive hierarchy** which suited VSM. What I really needed after this was a good range of solution options, which was difficult to find based on just the VSM outputs	5	SSM VSM	Organisational assessment and design (7)	SCSI Government Department Head Office (2)	3 months
analyse – represent system	a way of representing the problems in a recursive hierarchy	VSM						
-	help perform a diagnosis and offer a solution	tools such as VSM, sometimes	Some complex problems need structuring and shaping before any attempt can be made to solve them. Sometimes tools such as VSM **help perform a diagnosis and also offer a solution**, other tools and methods do not lend themselves to application alone	8				

Sub-theme	**Reason**	**Method(s) used**	**Coded data** (with contextual data)	**Question**	**Methods in project** (q4)	**Subject matter** (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**
visualise and engage (discussion)	graphical representation for discussion	Graphical Display Methods	By taking a view of the desired outcome and the types of input that would be needed to deliver this outcome. It is then possible to consider what type of tool is needed (**graphical representation for discussion** or a hard display of supply against demand etc etc)	10	System Dynamics SSM Scenario Planning Workshops Graphical Display Methods	National Capability Planning (1)	SCSI Head Office Government Department + Other Government Departments (2)	3 months (which became 2 years)
elicit (expertise)	expertise	Expert Workshops	**[My organization] may not hold all of the expertise** hence need for [expert workshop]s in some cases. [...]	5	Expert Workshop Scenario	Requirements Capture (8)	N/A (8)	4 Months
					Scenario Expert Workshops Discrete Event Simulation	Operations (5)	Policy (Government Department) (6)	9 Months
elicit (expertise)	to properly understand the issues	expert or stakeholder judgement	The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. I often (initially) do not have the depth of knowledge or expertise required to answer the problem or properly formulate a methodology. As such, I will use expert or [stakeholder] judgement **to properly understand the issues**. Often historical analysis or data mining is **necessary to gather data**. **Context is required (not least to ensure policy compliance and [quality assurance]**) thus requiring usage of scenarios.	5 (four examples)	Deterministic modelling **Expert judgement / stakeholder judgement** Project management / Gantt charts **Scenario building** **Historical analysis** Cost benefit analysis	Capability people requirements (8)	Government Department Business Units, officers (5)	3 months
gather data	to gather data	historical analysis data mining			**Expert judgement / stakeholder judgement** Project management / Gantt charts Stakeholder mapping **Scenario building** **Historical analysis** AHP Benefits modelling Brainstorming	National Capability Development (1)	Government Department Business Unit, SCSI (2)	6 months
analyse – to assess capability or policy (context)	Context is required (not least to ensure policy compliance and [quality assurance])	Scenario building			**Expert judgement / stakeholder judgement** Project management / Gantt charts Stakeholder mapping **Scenario building** AHP Benefits modelling Brainstorming Stochastic computer modelling	Implications of Policy Analysis (1)	Government Department Business Unit, SCSI (2)	3 years

Sub-theme	**Reason**	**Method(s) used**	**Coded data** (with contextual data)	**Question**	**Methods in project** (q4)	**Subject matter** (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**
					Expert judgement / stakeholder judgement Project management / Gantt charts **Scenario building** Brainstorming Stochastic computer modelling Statistical analysis MCDA **Historical analysis** Response surface modelling **Data mining / analytics**	Strategic operations (5)	Government Department Business Unit, SCSI (2)	3 years
develop understanding	to understand the system in focus, the external environment, freedoms and constraints, opportunities to shape potential strategic choices	VSM Strategy diamond context mapping PESTLE SWOT Pig power vs interest	Range of methods **to understand the system in focus, the external environment, freedoms and constraints, opportunities to shape potential strategic choices**, and scenarios **to understand the resilience of the future organisation against potential future challenges**.	5	VSM Strategy diamond Context mapping PESTLE SWOT Scenario development Pig Power vs interest	Strategy development (3)	Departmental Agency, divisional senior management team (3)	ca 5 days
analyse – understand future organisational resilience	to understand the resilience of the future organisation against potential future challenges	Scenario development						
analyse	to analyse data	pivot tables	[...] A range of tools **to analyse data**, **visualise it in a way accessible to stakeholders, and allow them to engage with it to develop option spaces** [...]	5	Pivot tables Data visualisation means – Tableau Stakeholder engagement tools - structured workshops	Workforce understanding (1)	Government Department, SCS3 downwards (2)	3 months
visualise and engage	to visualise data in a way accessible to stakeholders	data visualisation means – Tableau						
visualise and engage	to allow stakeholders to engage with data to develop option spaces	stakeholder engagement tools - structured workshops						
understanding (system)	capture of understanding of the system	iterative stakeholder mapping and 1-1 engagement through interview	**Capture of understanding of the system** through iterative stakeholder mapping and 1-1 engagement through interview; **system representation** through VSM and RACI; **health scoring** through structured stakeholder workshops, Italian flag scoring, elicitation and capture of rationale for scoring.	5	VSM Italian flag Structured interviews Structured workshops Stakeholder mapping RACI	System health (6)	Government Department, SCS3 downwards (2)	3 months
analyse – to represent system	system representation	VSM and RACI						
elicit information (from stakeholders) (scoring)	health scoring	structured stakeholder workshops, Italian flag scoring, elicitation and capture of rationale for scoring						

Sub-theme	**Reason**	**Method(s) used**	**Coded data** (with contextual data)	**Question**	**Methods in project** (q4)	**Subject matter** (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**
consider project scope and methods	to consider options and methods and potential case studies etc.	Brainstorm	Brainstorm with other team members for longer-term studies to **consider options and methods and potential case studies etc**. Data mining, HA and Stats used **to identify-locate data and process/validate**. PM **to maintain personal oversight of budget allocated spend**.	5	Brainstorm Data Mining Historical Analysis Statistical Analysis Project Mgt	Strategic Planning (1)	Government Department (SCS1) (2)	4 months
identify data	to identify-locate data	Data mining, HA and Stats			Brainstorm Data Mining Historical Analysis Statistical Analysis Project Mgt	Strategic Planning (1)	Government Department Business Unit (SCS1) (2)	3 months
analyse (process) analyse - validate	to process/validate data				Data Mining Historical Analysis Statistical Analysis Project Mgt	Operational Planning (5)	Government Department Business Unit (SCS1) (2)	1 month
manage project (budget)	to maintain personal oversight of budget allocated spend	Project Mgt						
generate data (choose single options)	allowed them to choose single options	Electronic voting	To gain further insight into delegate opinions. The e-voting **allowed them to choose single options and provided quantifiable data.** The questionnaire **allowed them to explain their choices**. The thematic analysis **allowed me to draw out common themes from across a broad sample of delegates, based on those qualitative responses to questionnaires**.	5	Questionnaire Electronic voting Thematic Analysis	Collecting delegate feedback (2)	Internal Government Department (6)	3 months
generate data (quantitative)	provided quantifiable data							
generate data (qualitative explanation)	allowed them to explain their choices	Questionnaire						
analyse (themes)	allowed me to draw out common themes from across a broad sample of delegates, based on those qualitative responses to questionnaires	Thematic analysis						
generate data visualise and engage	to generate the data for variety of different visualisations to engage with senior stakeholders	SME interviews Financial modelling/ prediction Stakeholder analysis Rich Picture Visualisation (sun ray diagram)	Complexity - it was not possible to address the issues with a single method because there was a lot of connectivity between issues, uncertainty in terms of need. **For senior stakeholders there was also a need to draw in a variety of different visualisations to engage with them - this means that many different methods are needed to generate the data.**	5	SME interviews Financial modelling/ prediction Stakeholder analysis Rich Picture Visualisation (sun ray diagram) Financial modelling/ prediction (outsourced)	Requirements Setting study (8)	SCS2 and SCS3 (2)	8 months + 6 month follow on

Sub-theme	**Reason**	**Method(s) used**	**Coded data** (with contextual data)	**Question**	**Methods in project** (q4)	**Subject matter** (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**
generate data	to subsequently analyse patterns, trends and insights	Interviewing subject matter experts around structured questions **to subsequently analyse patterns, trends and insights**.	Interviewing subject matter experts around structured questions **to subsequently analyse patterns, trends and insights**.	2ii	**Structured interviews** Numerical analysis Stakeholder analysis Data visualisation Presentation of findings	Organisational best practice (2)	Civil servant, Programme Leader (3)	Intermittently over 9 months
generate data	to generate some data	Structured SME elicitation	Structured SME elicitation **to generate some data**	4	Workshopping Structured SME elicitation to generate some data Descriptive/visual/regression analysis of the results	Operational assessment of national capability effectiveness (6)	Government customer (8)	about a month (not full time)
analyse	analysis of the results	Descriptive/visual/regression analysis	Descriptive/visual/regression **analysis of the results**					
analyse (hypothesis testing)	for hypothesis testing	Statistical Analysis	Statistical Analysis **for hypothesis testing**	4	Simulation modelling Gaming (computer-based) Expert Workshops Statistical Analysis for hypothesis testing Statistical Forecasting Scenario Building and Planning Historical Analysis	Assessing factors which impact on national capability (6)	Departmental Agency Programme manager (Grade 6/7) and national capability stakeholders (Grades 6/7) (3)	4 months
analyse (holistic)	to enable a more holistic analysis	Coding text data into a database / Qualitative data in spreadsheet	[...] Coding text data into a database **to enable a more holistic analysis.**	2ii	Stakeholder analysis Semi-Structured interviews **Qualitative data in spreadsheet** Team judgement Facilitated workshop with customers Potentially more	Identifying and prioritising investment options (4)	SCS2, Government Department Head Office (2)	Team of 4 for 6 months/ongoing
analyse (risks and benefits)	to establish~identify the risks and benefits of taking different courses of action or pursuing different policy options	Policy Analysis	Regular use of what I would call 'policy analysis' **to establish/identify the risks and benefits of taking different courses of action or pursuing different policy options**. Also use of 'pre-mortem' **to identify where piece of work may go awry**.	2i	SWOT Brainstorm Stakeholder Policy Analysis Systems Analysis Risk Analysis	Policy Analysis (12)	Minister (1)	6 months
manage project (risk)	to identify where piece of work may go awry	'pre-mortem'			Gaming - within a training context SWOT Visualisation Pre-mortem	Improved Evidence-Based Policy Making (2)	Government Department Chief Scientist (2)	3 years
analyse - validate	uses psychological wrapping to 'immerse' participants	human-in-the-loop experimental design and gaming	In the past - human-in-the-loop experimental design and gaming; **more rigorous and repeatable** than table top	2ii				

Sub-theme	**Reason**	**Method(s) used**	**Coded data** (with contextual data)	**Question**	**Methods in project** (q4)	**Subject matter** (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**
[analyse - validate]	more rigorous and repeatable		gaming, also **uses psychological wrapping to 'immerse' participants.**					
analyse – represent system manage project (progress)	to produce rapid results early	Gaming	Gaming was used **to produce rapid results early.** 2 discrete event simulations were used. A coarse model was run using output from gaming **to determine which options were best represented in a more detailed model**. Finally, output is analysed using statistics **to check its validity**.	5	Gaming Discrete event simulation Statistical analysis	Baselining for future requirement (8)	Government Department Business Unit SCS2 (2)	1 year
refine scope analyse – represent options	to determine which options were best represented in a more detailed model	discrete event simulation (coarse model)						
validate	to check its validity	statistical analysis						
consider methods (conduct analysis estimates)	for conducting analysis estimates	Cynefin model	Cynefin model **for conducting analysis estimates.**	2i				
define scope or issues for analysis (during project)	to define the scope of a simulation activity or a gaming event	expert workshops	To ensure multiple perspectives on a problem are derived and therefore to increase the evidence base. In addition some of the methods are used to narrow down options for other methods, e.g. some expert workshops are used **to define the scope of a simulation activity or a gaming event**.	5	Discrete event simulation Q-method Expert Workshops Statistical Analysis Historical Analysis	Equipment Procurement (9)	Government Department Procurement (6)	months
					ABM Discrete Event Simulation Expert Workshops Statistical Analysis Historical Analysis Gaming	Operational Planning (5	CSA [Chief Scientific Adviser] (2)	months
elicit information (assess choice)	for assessing choice among a number of competing options	Q-Methodology	Q-Methodology **for assessing choice among a number of competing options.**	2i	Discrete event simulation Q-method Expert Workshops Statistical Analysis Historical Analysis	Equipment Procurement (9)	Government Department Procurement (6)	months
understand project scope and requirements	to understand key requirements and scope with stakeholders	[PSMs]	Three main reasons: 1. Many of the above **cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope**. Consequently many studies	5	MCDA Graph Theory/ Network Analysis Causal Mapping	Portfolio appraisal (4)	Government Department Business Unit, Middle m'gmt (3)	6 months

Sub-theme	**Reason**	**Method(s) used**	**Coded data** (with contextual data)	**Question**	**Methods in project** (q4)	**Subject matter** (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**
			involved phases in which PSM were employed followed by more focused analysis. 2. The above cases are typically very broad with several areas of interest for stakeholders ranging from e.g. "optimal" solutions, relative strengths and weaknesses, overall costs, current risks etc. 3. Some of the above cases used a range of methods as an understanding of the problem area emerged, in order **to pull out more fidelity in specific areas**		Expert Workshops Graph Theory/ Network Analysis Balanced Scorecard	Domain Capability Audit (6)	Government Department Business Unit, Middle m'gmt (3)	6 months
develop understanding (specific areas)	analyse to pull out more fidelity in specific areas	[range of methods]			Expert Workshops Brainstorming Morphological Analysis Cost-benefit analysis Mathematical Programming	National capability analysis (1)	Government Department Business Unit, Senior m'gmt (2)	18 months
					Statistical Analysis Discrete Event Simulation Brainstorming Expert Workshops Cost-Benefit Analysis SWOT	Option Assessment (4)	Government Department Business Unit, Middle m'gmt (3)	8 months
define issues for analysis and methods	to scope non-quantifiable issues (and in some cases led to the identification of aspects that could be quantified and used in the "hard" analysis)	Causal mapping Scenario analysis Brainstorming PESTLE Morphological box	[...] The qualitative analysis methods were used **to scope the non-quantifiable issues** (and in some cases **led to the identification of aspects that could be quantified and used in the "hard" analysis**).	5	Discrete event simulation Causal mapping Scenario analysis Brainstorming PESTLE Morphological box Linear programming	Cost-benefit analysis (4)	(8)	A little over a year
analyse (uncertainty)	to deal with uncertainty in cost and benefit estimation data	statistical analysis	[...] I am in the process of extending how I use cost-benefit analysis methods to i**nclude simple statistical analysis to be able to deal with uncertainty in cost and benefit estimation data.**	10				
analyse (quantify uncertainty)	ways of measuring uncertainty	e.g. various scenario planning techniques, Robust Decision Making, use of regret to measure, etc. ...	A wide range of futures techniques and **ways of measuring uncertainty** e.g. various scenario planning techniques, Robust Decision Making, use of regret to measure, etc. ...	2i	e.g. various scenario planning techniques, Robust Decision Making, use of regret to measure, etc. ...			
develop understanding visualise and engage	to describe/ understand how processes work	diagrams	I use diagrams **to describe/ understand how processes work**, but don't think that is as formal as SADT	1 (DT, SADT)				
analyse		[engineering modelling]		2ii				

Sub-theme	**Reason**	**Method(s) used**	**Coded data** (with contextual data)	**Question**	**Methods in project** (q4)	**Subject matter** (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**
	looking at absolute performance [of equipment] to then combine with the relative effectiveness in OR	[relative effectiveness analysis]	We also use non-OR techniques to inform our work. These would typically be classed as performance models (i.e., we're **looking at absolute performance [of equipment] to then combine with the relative effectiveness in OR**). [...]. It might be that the output from these [engineering] models feeds into the OR [simulation] models, or we simply use it to inform our study. [...]					
develop understanding	we might seem to understand the issues of a [domain-specific] capability [...]	[domain-specific] analysis	Something else entirely, and it might fit in the list on the previous page (I'm not sure) is [domain-specific] analysis, where **we might seem to understand the issues of a [domain-specific] capability [...]**		Scenario analysis User interviews Cost analysis Isochrone analysis [Domain-specific method]	OR to inform future equipment requirement and strategy (3)	Government Department Business Unit HEO (4)	Several Months

Table 51: Practitioners' use of aspects of theoretical frameworks

Clusters / Methods / (Aspects of) Theoretical Frameworks	**Use and Awareness of Methods in Question 1** (N=54)								
	Use regularly		**Use, total**		Familiar with, not used		**Not heard of**		**Participants' comments**
Total Systems Intervention (TSI) (Jackson & Flood) / System of Systems Methodologies (Jackson & Keys) (TSI/SOSM)	1	2%	3	**6%**	6	11%	32	**59%**	• 'An approach which maps situational context to methodology. Most [domain] issues are coercive in nature with complex information to assess and appropriately understand and characterise within the timescales that are available.' **(q1, familiar with TSI/SOSM, not used)**
Boundary Critique (Midgley) [BC]	3	6%	7	**13%**	2	4%	38	**70%**	• Discussing challenges of using another methodology to develop models with senior decision makers, one participant commented that, '[...] Boundary critique [...] could also assist [when using a particular domain-specific method], but the dysfunctional nature of groups (particularly busy groups) for surfacing and recognising the value of less commonly held perceptions is likely to [act] against much improvement being achieved. [...]' **(q1, regular user of BC)**
Critical Systems Heuristics (Ulrich) [CSH]	1	2%	4	**7%**	10	19%	25	**46%**	• 'Central to the improvements we are currently making to assessing [departmental] requirements as we work to engage with the Deep Uncertainty in the [departmental] Decision making space' **(q1, regular user of CSH)** • 'Note that tend to use the eternal triangle to think through why people are behaving in a particular way when doing rich pictures and brain storms but do not use full question set regularly' **(q1, non-regular user)** • 'We arranged a course a while ago' **(q1, familiar with CSH, not used)**
Cynefin *[responses from 3 participants]*	Comment on Interactive Planning (Ackoff): • 'Ideas used in the sense that Cynefin and the Future Backwards technique draws upon them' **(q1)** Comment on Nominal Group Technique (Delbecq): • 'Generally applicable to quick responses to complicated problems in the Cynefin sense, not the complex or apparently chaotic problems that I usually deal with. [...]' **(q1)**								
	Use regularly (q2i): 'Cynefin model for conducting analysis estimates.' [1 participant] • 'I think to be able to assess the value of methods you need to have an indication of the complexity of a project. Many combinations of methods are often a response to the complexity of a project, i.e., the problems are often wicked by nature. I would suggest that an assessment of the type of project is imperative to understand how well methods work. This is why I use the Cynefin approach as it helps to understand the problem space. For those problems that are more complex or chaotic (Cynefic terms) we should not be using discrete event simulation as the first port of call' **(q10, regular user from q2i)**								
	Use, not regularly (q2ii): 'Cynefin' [1 participant]								

Appendix S Survey: Multimethodology – reasons for using, frameworks used, forms

Table 52: Practitioners' reasons for using more than one method in a project – themes with illustrative data, and counts of participants, question responses, project examples, and data fragments

Theme	Illustrative data (**Coded data** with relevant contextual data)	Participants (N=54)	Question responses	Project examples (N=104)	Data fragments
RELATIONSHIPS WITH STAKEHOLDERS **1. To respond to stakeholder questions or project requirements, or produce a range of outputs or activities**	***[General responses: customer/project requirements, questions, outputs, outcomes, breadth]*** One method would not have been **sufficient to meet the customer requirement** (q5) [...] **one method cannot provide the answer to all aspects of a complex question.** (q5) **The overall project has a very large scope. No one method is appropriate to answer the breadth of the study.** (q5) ***[More specific responses: strands of analysis, ill-defined cases, stakeholder interests, problem areas, stakeholder understanding, multiple perspectives]*** **In all cases questions are quite nebulous and require the generation of a portfolio of evidence which cover various factors from costs and numbers down to stakeholder influence analysis.** (q5) **I rarely have to deal with questions that require only one strand of analysis** (q8) Three main reasons: 1. **Many of the above cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope**. Consequently many studies involved phases in which PSM were employed followed by more focused analysis. 2. The above **cases are typically very broad with several areas of interest for stakeholders** ranging from e.g. "optimal" solutions, relative strengths and weaknesses, overall costs, current risks etc. 3. Some of the above cases used a range of methods as an understanding of the problem area emerged, **in order to pull out more fidelity in specific areas** (q5) The problems I deal with are messy, complex and often conceptual/strategic rather than specific capability-based [...] **One method alone does not provide sufficient insight into these problems and often does not present solutions but instead provides greater knowledge that can be used to generate possible options or bring stakeholders together in their understanding and agreed forward direction**. (q8) ***[Particular method/combination: policy requirement]*** Combination of cost benefit and OR effectiveness analysis, required for business case support (q5) The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. I often (initially) do not have the depth of knowledge or expertise required to answer the problem or properly formulate a methodology. As such, I will use expert or [stakeholder] judgement to properly understand the issues. Often historical analysis or data mining is necessary to gather data. **Context is required (not least to ensure policy compliance and [quality assurance]) thus requiring usage of scenarios.** (q5) ***[Other methods did not correspond to outputs or activities on a one-to-one basis, for example where practitioners used methods together]*** **To tailor the method**[s] **to the** [stakeholders'] **problem [...]** (q5) These answers are **question related**. [...] Most [domain] oriented OR has to address complex (if not chaotic) questions - hence the need to adopt a multi-disciplinary approach (that needs to include some form of empirical activity, whether data from [training] or [experiments]) in order to enable a culmination method (e.g. metagaming) to represent [domain] capability sufficiently. (q8) *[see also examples of multimethodological interventions where constituent methods were each used for different questions/requirements/outputs/activities (q5)]*	**23**	q2ii: 1 q5: 17 q8: 11 q10: 1 **Total: 30**	**36**	**37**
2. For broad, in-depth understanding, and well-rounded, rich and complete answers	[...] A single method was not sufficient **to fully explore the rich problem space**. (q5) Tasks are by nature complex and require multiple methods to develop understanding of alternative factors, alternative viewpoints and due to complex nature often require breaking elements down into area where single methods can then be used. **But to provide an answer requires the combination of techniques to provide a balanced thorough response.** (q5) [...] **Rarely are tasks broken down into a simple area where a single method would ever be suitable for providing the robustness.** [...] (q8)	**17**	q5: 11 q8: 7	**24**	**20**

Theme	Illustrative data (**Coded data** with relevant contextual data)	**Participants** (N=54)	**Question responses**	**Project examples** (N=104)	**Data fragments**
	One method does not guarantee the most useful and fully thought through answer/options. Using multiple methods adds extra layers of detail and perspectives that supports the customer in making a more robust decision or forward plan. Some methods act as risk mitigations e.g. stakeholder engagement and profiling are to try and understand who might be impacted by my proposals so that I can encourage engagement or adjust plans, and visualisations are often part of attempts to manage expectations/clarify problems and show how my proposal presents a solution to that problem. (q5) To ensure multiple perspectives on a problem are derived and therefore to increase the evidence base. In addition some of the methods are used to narrow down options for other methods, e.g. some expert workshops are used to define the scope of a simulation activity or a gaming event. (q5) It is not possible to generate credible evidence in support of [National Capability] Development decisions (i.e., [across all aspects of a departmental capability]) unless a multi-disciplinary approach is adopted. (q5) To gain an in depth understanding of a subjectively problematic situation as a means of providing actionable intelligence to the customer. (q5) To balance the hypothetical qualitative discussions with quantitative analysis, hopefully leading to more balanced insights. (q5) [...] a purely quantitative study will fall down if there is no use of experts to filter the output and pick up on the other things that need considering, [...] (q8) **To gather more information than using one technique and to see if different techniques might yield different answers** (q5) [...] Most HA [Historical Analysis] studies now combine a mix of quantitative HA plus qualitative HA (case study research, comparative analysis [grounded theory] and write-up) and provide for a broader understanding of the problem/question at hand. (q8) Combining methods usually works better as it allows different facets of the same 'thing' to be considered in different ways. **Complimentary methods, particularly using hard and soft OR techniques, allows a sort of 'triangulation' and a broader picture to be gathered.** (q8) [...] need to include soft skills if you want well-rounded, rich and complete answers (q10)		q10: 2 **Total: 20**		
3. For stakeholder engagement or interest or relevance or buy-in	Tools in and of themselves rarely in my experience 'work', and definitely not in isolation. **It is important to use an approach that will work in the circumstances and achieves buy-in from customers/end users. This I would class as a soft systems approach.** (q5) To access diversity of viewpoints, **keep audience interested/engaged**, challenge problem from different perspectives, **make outputs more relevant to customers**. (q5) **To enable the most effective approach to the problem at hand, taking into account the data available and the stakeholder views**. (q5) [...] A range of tools to analyse data, visualise it in a way accessible to stakeholders, and allow them to engage with it to develop option spaces [...] (q5)	**7**	q5: 7 q10: 1 **Total: 8**	**19**	**9**
INTERVENTION CONTEXT **4. Multidimensional, complex problem or problem space, project or analysis**	***[Complexity]*** Complexity - it was not possible to address the issues with a single method because there was a lot of connectivity between issues, uncertainty in terms of need. [...] (q5) Dimension reduction. (q5) The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. [...] (q5) ***[Different parts to analysis / factors to analyse / multilevel analysis]*** This was a **complex analysis project** and numerous methods were used in different parts of the analysis. [...] (q5) In all cases questions are quite nebulous and require the generation of a portfolio of evidence which cover various factors from costs and numbers down to stakeholder influence analysis. (q5) The presenting problem needed methods a) linking strategic outcomes to business processes and b) linking business processes and information structures. (q5) **The solution space to our problems is inhomogeneous. Therefore, typically, not one method is able to span the full solution space.** (q5) **The problem space is typically non-homogeneous and complex. Different methods are needed to either (i) address different sub-problems,** or (ii) the methods complement each other to give a more robust solution, but reducing variability in confidence. (q8) **Complex and non-routine problems typically benefit from a multi-method approach to problem-solving.** [...] (q10) ***[Complex / multilevel / multidisciplinary subject matters / analysis]*** [The subject matter is] so complex it is impossible to cover with one method, multiple uses of multiple methods are required (q5)	**28**	q5: 22 q8: 11 q10: 3 **Total: 36**	**48**	**40**

Theme	Illustrative data (**Coded data** with relevant contextual data)	**Participants** (N=54)	**Question responses**	**Project examples** (N=104)	**Data fragments**
	Complex and Uncertain Operational Environments; Integrated and Multidisciplinary Human-System Environments (q5) No one method can represent the complexity of [capability] representation and various level of resolutions required [...] (q8) **Complexity of the problem and at multiple levels** (where should the facility be located, what is the impact on currently-shared staffing). (q5) [...] **Most [domain] oriented OR has to address complex (if not chaotic) questions - hence the need to adopt a multi-disciplinary approach (that needs to include some form of empirical activity, whether data from [training] or [experiments]) in order to enable a culmination method (e.g. metagaming) to represent [domain] capability sufficiently.** (q8) ***[Qualitative and quantitative analysis]*** **To gain further insight into delegate opinions. The e-voting allowed them to choose single options and provided quantifiable data. The questionnaire allowed them to explain their choices.** The thematic analysis allowed me to draw out common themes from across a broad sample of delegates, based on those qualitative responses to questionnaires. (q5) ***[Problem structuring / Successive project steps]*** **Some complex problems need structuring and shaping before any attempt can be made to solve them.** Sometimes tools such as VSM help perform a diagnosis and also offer a solution, other tools and methods do not lend themselves to application alone (q8) Routinely use multiple methods - work on **complex problems** that frequently require a succession of approaches to move from initial customer expression of issue through to provision of advice. [...] (q5) ***[Type of problems – messy, complex, wicked, conceptual, strategic, systems level]*** [...] The problems I deal with are messy, complex and often conceptual/strategic rather than specific capability-based [...] One method alone does not provide sufficient insight into these problems and often does not present solutions but instead provides greater knowledge that can be used to generate possible options or bring stakeholders together in their understanding and agreed forward direction. [...] (q8) Tasks are by nature complex and require multiple methods to develop understanding of alternative factors, alternative viewpoints [...] (q5) Most questions are at a strategic level where one method is not suitable. [...] all decisions at a multi-million pound+ level require looking backwards, consideration of today and forecasting forward. (q8) All projects I am asked to lead/support are looking at systems level questions so it is important we consider many factors before delivering insights and analysis output to our customers. [...] (q5) R**ange of methods to understand the system in focus, the external environment, freedoms and constraints, opportunities to shape potential strategic choices, and scenarios to understand the resilience of the future organisation** against potential future challenges. [...] (q5) [...] As a consultant, my primary focus is helping my client develop a better understanding of their problem and the routes to address it. **Such problem spaces are complex or wicked, and require viewing from multiple angles, through multiple lenses, to understand them and potential responses.** Single tools do not have the breadth, range or specificity necessary. [...] (q8)				
5. Intervention dynamics – project phases, or parts of analysis project, or iterative or emergent approach; project management	***[Project dynamics]*** Necessary to get from start point to end point... (q5) I don't know of any problem that doesn't require a mix of methods if you include softer OR skills/approaches. Although many problems 'major' on a certain method, they will always need additional skills (as above). I work in the soft OR area so major on facilitation and consultancy kills, **drawing in OR method as a means of structuring or visualising a problem**. (q5) One method would not get us to all the outputs and outcomes we needed, or would not get us to the final outputs/outcomes. We needed to complete **several steps** to reach the end result. (q5) Routinely use multiple methods - work on complex problems that frequently require a succession of **approaches to move from initial customer expression of issue through to provision of advice. Never been asked to do something that was a single shot activity**. [...] (q5) Methods are combined because there are usually multiple strands to the problem. This is **not optional or to get synergies between methods,** it's because it's **essential to working through the problem**. (q10) ***[Project examples]***	**25**	q5: 19 q8: 7 q10: 2 **Total: 28**	**58**	**33**

Theme	Illustrative data (**Coded data** with relevant contextual data)	**Participants** (N=54)	**Question responses**	**Project examples** (N=104)	**Data fragments**
	Brainstorm with other team members for longer-term studies to consider options and methods and potential case studies etc. Data mining, HA and Stats used to identify-locate data and process/validate. PM to maintain personal oversight of budget allocated spend. (q5) This was a complex analysis project and numerous methods were used in **different parts of the analysis**. Linear programming was used to inform and populate one of the simulation models. The outputs of two simulation models were used as inputs to the causal mapping and benefits analysis. The qualitative analysis methods were used to scope the non-quantifiable issues (and in some cases led to the identification of aspects that could be quantified and used in the "hard" analysis). (q5) (1) I needed something to 'unpack' the problem and SSM fitted the bill well for this. I then needed a way of representing the problems in a recursive hierarchy which suited VSM. What I really needed after this was a good range of solution options, which was difficult to find based on just the VSM outputs (2) I tried system dynamics to understand some of the key flows between parts of the system (money was one) - this was interesting in shaping the extent of the system we were interested in but it didn't get us towards a solution. I tried SSM which took things one step further. The problem boiled down to understanding supply and demand across a national capability - multiple suppliers and multiple demanders. In the end we used some scenario planning and a series of workshops to build pictures of supply, demand, gaps and health (ability to sustain the current position) (q5) Some complex problems need structuring and shaping before any attempt can be made to solve them. [...] (q8) Three main reasons: 1. **Many of the above cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope. Consequently many studies involved phases in which PSM were employed followed by more focused analysis.** 2. The above cases are typically very broad with **several areas of interest for stakeholders** ranging from e.g. "optimal" solutions, relative strengths and weaknesses, overall costs, current risks etc. 3. Some of the above cases **used a range of methods as an understanding of the problem area emerged**, in order to pull out more fidelity in specific areas (q5) ***[Iteration]*** The methods can be complimentary and help you look at a problem through a different lenses to discover different aspects or cover different parts of the problem space e.g.as consultants we are seeking to understand the problem, structure it so that we can reflect it back to our customer in some sort of order and then identify a way forward. Thus **we use different tools in different parts of that process but often iterate.** e.g. Laddering and SSM questions help you to identify whether you are studying the right problem to start off with. (q5) ***[Project steps / phases / layers]*** We often go through several steps, such as generating ideas and then analysing or rating them in some way, before trying to come up with agreed ways forward. Different tools and methods have strengths in each of these steps. (q5) Projects often have multiple phases or layers, where different techniques allow you to build up, filter and present evidence before analysing it. (q5) Most OR techniques are either context specific and/ or a small step in a wider process. Also, when you are dealing with lots of uncertainty (especially) then one method might elicit understanding and knowledge that then allows you to redo the analysis with a better OR technique. [...] (q8) ***[Divergence / convergence]*** To ensure multiple perspectives on a problem are derived and therefore to increase the evidence base. **In addition some of the methods are used to narrow down options for other methods**, e.g. some expert workshops are used to define the scope of a simulation activity or a gaming event. (q5)				
6. Available resources (or lack thereof), including technology, time, budget, and data	***[Technology]*** [...] There are however **boundary issues with the current art of the possible** concerning this combinations of methods which led us to reject using this combination of approaches in our research at present (q1) **AHP could be done in a spreadsheet but MCDA required a bespoke application** [...] (q5) The more you use different methods the more you appreciate that they are each more useful for different parts of the problem rather than the whole problem. Some you are more familiar with and may have the tools to support the method, so you will use that until you find you need something more. [...] (q8) **The move is of greater on-line real time analysis with live feeds for decision support. This required a [domain-specific method] with faster than real-time predictive analysis.** Big Data and Analytics technologies for visualisation decision aids to [customer] is increasing needed. (q10) ***[Time]*** Engineering models cannot model the complexity of all the interactions. **The hi-fidelity models take too long to run.** All models have to be validated against trails, operations and experiments. (q5)	**6**	q1: 1 q5: 4 q10: 1 **Total: 6**	**14**	**6**

Theme	Illustrative data (**Coded data** with relevant contextual data)	**Participants** (N=54)	**Question responses**	**Project examples** (N=104)	**Data fragments**
	[Budget] Brainstorm with other team members for longer-term studies to consider options and methods and potential case studies etc. Data mining, HA and Stats used to identify-locate data and process/validate. PM **to maintain personal oversight of budget allocated spend**. (q5) ***[Data]*** To enable the most effective approach to the problem at hand, **taking into account the data available** and the stakeholder views. (q5)				
AVAILABLE THEORETICAL AND METHODOLOGICAL APPROACHES **7. Strengths and weaknesses of different methods and tools**	***[Specific strengths and weaknesses]*** I needed something to 'unpack' the problem and SSM fitted the bill well for this. I then needed a way of representing the problems in a recursive hierarchy which suited VSM. What I really needed after this was a good range of solution options, which was difficult to find based on just the VSM outputs (q5) Gaming was used to produce rapid results early. 2 discrete event simulations were used. A coarse model was run using output from gaming to determine which options were best represented in a more detailed model. Finally, output is analysed using statistics to check its validity. (q5) Benefits realisation needed to combine quantitative management information and more qualitative assessment of benefits. (q5) Engineering models cannot model the complexity of all the interactions. The hi-fidelity models take too long to run. All models have to be validated against trails, operations and experiments. (q5) ***[Strengths and weaknesses more generally]*** We do not have a method that covers the entire spectrum we need to explore. (q5) To analyse the problem we needed to investigate multiple strands of inquiry and there is not "one size of analysis that fits all" (q8) Because **each individual method has strengths and weaknesses** (q5) **Dimension reduction.** (q5) **The methods can be complimentary** and help you look at a problem through a different lenses to discover different aspects or cover different parts of the problem space [...] (q5) We often go through several steps, such as generating ideas and then analysing or rating them in some way, before trying to come up with agreed ways forward. **Different tools and methods have strengths in each of these steps.** (q5) [...] when you are dealing with lots of uncertainty (especially) then **one method might elicit understanding and knowledge that then allows you to redo the analysis with a better OR technique**. ... (q8) *[NB: See also other data within the next theme below.]*	**18**	q5: 16 q8: 6 **Total: 22**	**32**	**23**
8. To explore and challenge different perspectives (triangulate), and to test insights (for validity), for balance, sufficient representation, rigour and robustness	***[To test / validate]*** [...] Scenarios (of varying detail with appropriate range of circumstances covered) frame the problems that are most likely/dangerous to draw insights from and **other techniques can be used to test these insights**. [...] (q5) [...] Gaming was used to produce rapid results early. 2 discrete event simulations were used. A coarse model was run using output from gaming to determine which options were best represented in a more detailed model. Finally, **output is analysed using statistics to check its validity**. (q5) Engineering models cannot model the complexity of all the interactions. The hi-fidelity models take too long to run. **All models have to be validated against trials, operations and experiments.** (q5) ***[Explore / challenge different perspectives (triangulate)]*** [...] **Using multiple methods adds extra layers of detail and perspectives that supports the customer in making a more robust decision or forward plan.** Some methods act as risk mitigations e.g. stakeholder engagement and profiling are to try and understand who might be impacted by my proposals so that I can encourage engagement or adjust plans, and visualisations are often part of attempts to manage expectations/clarify problems and show how my proposal presents a solution to that problem. (q5) [...] **there is always a need to 'triangulate' and hence to generate views from differently founded perspectives**, remembering that all models (was that methods in the detail of their application are in at least some senses) are wrong but some are useful. [...] (q5)	**17**	q5: 12 q8: 7 q10: 1 **Total: 20**	**31**	**20**

Theme	Illustrative data (**Coded data** with relevant contextual data)	Participants (N=54)	Question responses	Project examples (N=104)	Data fragments
	Projects often have multiple phases or layers, where different techniques allow you **to build up, filter and present evidence before analysing it**. (q5) ***[To balance/broaden quantitative and qualitative insights]*** To balance the hypothetical qualitative discussions with quantitative analysis, hopefully leading to more balanced insights. (q5) [...] a purely quantitative study will fall down if there is no use of experts to filter the output and pick up on the other things that need considering, i.e., that [workers] may need to eat, sleep, drink, clean, rather than just [work]. (q8) Combining methods usually works better as it allows different facets of the same 'thing' to be considered in different ways. **Complementary methods, particularly using hard and soft OR techniques, allows a sort of 'triangulation' and a broader picture to be gathered**. (q8) ***[Sufficient representation]*** [...] Most [domain] oriented OR has to address complex (if not chaotic) questions - hence the need to adopt a multi-disciplinary approach (that **needs to include some form of empirical activity, whether data from [training] or [experiments]) in order to enable a culmination method (e.g. metagaming) to represent [the] capability sufficiently**. (q8) ***[Rigour / robustness]*** The problem space is typically non-homogeneous and complex. Different methods are needed to either (i) address different sub-problems, or **(ii) the methods complement each other to give a more robust solution, but reducing variability in confidence**. (q8) **Depth and rigour** associated with undertaking cost and scenario analysis is linked to the business requirement basis [...] they are heavily bound with need for uncertainty/risk analysis [...] (q10) [...] Multi method studies allow a problem space to be viewed from multiple angles and consequently it allows a more thorough understanding of the problem space and **makes generalisation slightly easier and less prone to error**. (q8)				
PRACTITIONERS ***9. Roles of practitioners, including their ways of working, histories, tendencies, and specific methodological approaches***	***[Tendency to use a particular combination of methods]*** I don't know of any problem that doesn't require a mix of methods if you include softer OR skills/approaches. Although many problems 'major' on a certain method, they will always need additional skills (as above). I work in the soft OR area so major on facilitation and consultancy kills, drawing in OR method as a means of structuring or visualising a problem. [...] **whatever my problem, I tend to use a mix of these approaches** [...] (q5) [...] **when I facilitate a group I will use SSM, VSM, CSH, metaphor, iceberg** .... as thinking tools to inquire of the group (q5) [...] **We have a process we usually follow for general capability study questions** which will include gaming, simulation, [expert/stakeholder] judgement, scenario building and statistical analysis but the process is flexible and can be amended as studies require. (q5) HA is quantitative in nature and providing sufficient data/data points can be readily identified or collected and has proven very successful in the past. **Most HA studies now combine a mix of quantitative HA plus qualitative HA (case study research, comparative analysis [grounded theory] and write-up)** and provide for a broader understanding of the problem/question at hand. (q8) Only to note that whilst I work as part of a historical analysis team, I am primarily a historian [...] more so than a statistical analyst. My stats background and knowledge is more on the use of Excel formulae than 'proper' statistics methodologies etc. (q10) Despite having successfully been doing OR for 10 years, as an Engineer by degree I have not been trained in any of the techniques in Q1, and use a very limited selection of them [Expert Workshops, MCDA and SWOT]. I use common sense to answer questions, backed up by Excel based calculations. Given the varied nature of the questions I answer, I just chose an appropriate technique to answer each element. **Therefore I'm uncertain why the focus is on combining techniques.** (q10) ***[Experience of previous projects or problems, and what methods or tools or approaches 'work' and are 'more useful']*** Requests answered in weeks - **built on years of experience**. (q4) Engineering models cannot model the complexity of all the interactions. The hi-fidelity models take too long to run. All models have to be validated against trails, operations and experiments. (q5) Tools in and of themselves rarely in my experience 'work', and definitely not in isolation. **It's important to use** an approach that will work in the circumstances and achieves buy-in from customers/end users. This I would class as **a soft systems approach**. (q5) AHP could be done in a spreadsheet but MCDA required a bespoke application [...] (q5) **The more you use different methods** the more you appreciate that they are each more useful for different parts of the problem rather than the whole problem. Some you are more familiar with and may have the tools to support the method, so you will use that until you find you need something more. [...] (q8)	**20**	q4: 1 q5: 7 q8: 11 q10: 3 **Total: 22**	**45**	**23**

Theme	Illustrative data (**Coded data** with relevant contextual data)	Participants (N=54)	Question responses	Project examples (N=104)	Data fragments
	Complex and non-routine problems typically benefit from a multi-method approach to problem-solving. However, it is usually the interface between the methods that poses the biggest challenges to the OR practitioner. (q10) ***['routinely' / 'natural']*** The overall project has a very large scope. No one method is appropriate to answer the breadth of the study. For [quick turnaround projects] it may sometimes be appropriate to use a single established method but this is generally by exception as **more often than not it is natural to use several even if in making the decision as to which to purse for the core analysis**. (q5) **Routinely use multiple methods** - work on complex problems that frequently require a succession of approaches to move from initial customer expression of issue through to provision of advice. Never been asked to do something that was a single shot activity. (q5) ***[Always use multiple methods, or nearly always, given the type of work, or not trying or able to do job otherwise]*** **I have always used multiple methods.** If only one method was to be used, I suspect the answer would be incomplete or lacking depth. (q8) **Could not do my job without** using multiple methods. [...] (q8) **I don't attempt projects using only one method so can't answer the above.** [...] I must admit that I often use methods in a very light touch manner to aid thinking and insight around a problem rather than to produce products for the customer or address specific problems and generate solutions. (q8) **I have never used just one method in my 30 year** career so I cannot answer the question that pose here **(q8)** **Not sure that I can recall working on a project using only one method, ever!** Always worked on projects that have taken a multi-disciplinary and thus multi-methodology approach. (q8) Generally **use a combination of methods by default**, depending upon the stage of the project. There may be a principle method but, especially in the project definition, a number of methods are considered and (some) used. (q8)				

Table 53: Comparison of themes with theoretical rationales for using more than one method

INTERVENTION ELEMENT	**Theoretical rationales for using more than one method** *(Note 1)*	**Howick and Ackermann (2011, p. 508)** and **Ackermann and Howick (2022)**		**This survey**	
		Themes from papers (2011) or **interview responses** (2022) *(Note 2)*	***Papers** (2011) or **ppts** (2022)*	**Themes**	***Ppts***
STAKEHOLDERS (S)	To facilitate achievement of a practical goal	• 'test a framework' (2011)	*1*	1. To respond to stakeholder questions or project requirements, or produce a range of outputs or activities	*23*
		• support project management – one method "used as a recording device" and "mapping for the clarification of project objectives" (2022, p. 1913)	*2 (1 non-academic)*		
	To increase variety in results or improve decision-making process for better decision-making			2. For broad, in-depth understanding, and well-rounded, rich and complete answers	*17*
	To enhance intervention process or output for stakeholders to achieve their acceptance and possibly action	• 'gain decision maker involvement and thus model confidence and ownership' (2011)	*2*	3. For stakeholder engagement or interest or relevance or buy-in	*7*
		• buy-in from "multiple key stakeholders", including through demonstrating understanding of complexity of "their world" (2022, p. 1913)	*2 (both academic)*		
		• empowerment from Soft OR/mapping with scientific procedural rationality from MCDA (2022)	*1 (academic)*		
	To include and facilitate achievement of social justice				
INTERVENTION CONTEXT (C)	To view different aspect(s) of a situation and in different way(s)	• 'deal with a complex situation' (2011)	*2*	4. Multidimensional, complex problem or problem space, project or analysis	*28*
	To intervene more comprehensively or holistically across intervention activities or aspects, or stakeholder purposes	• 'gain particular benefits from specific methods' (2011)	*6*	5. Intervention dynamics – project phases, or parts of analysis project, or iterative or emergent approach	*25*
		• 'support different stages of a project' (2011)	*4*		
		• 'consider a wider system' (2011)	*2*		
		• 'attending to different aspects of the problem' (2022, pp. 1909-1910)	*[not reported]*		
		• "'One thing [method] did this, fulfilled a particular objective. This other thing [method] fulfilled another objective."' (2022, p. 1914)	*1 (academic)*		
	To save money			6. Available resources (or lack thereof), including technology, time, budget, and data	*6*
AVAILABLE METHODOLOGIES AND METHODS (M)	To address an intervention need not addressed by another method	• 'methods chosen to complement each other' (2011)	*1*	7. Strengths and weaknesses of different methods and tools	*18*
		• 'overcome weaknesses of the individual methods' (2011)	*8*		
		• "'the value was in having these two things talk to one another ... the output of the optimisation would not be there unless the simulation was there"' (2022, p. 1914)	*1 (academic)*		

INTERVENTION ELEMENT	**Theoretical rationales for using more than one method** *(Note 1)*	**Howick and Ackermann (2011, p. 508)** and **Ackermann and Howick (2022)**		**This survey**	
		Themes from papers (2011) or **interview responses** (2022) *(Note 2)*	***Papers** (2011) or **ppts** (2022)*	**Themes**	***Ppts***
	To compare results across methods for validity	• 'more robust outcomes' (2022)	*[not reported]*	8. To explore and challenge different perspectives (triangulate), and to test insights (for validity), for balance, sufficient representation, rigour and robustness	*17*
PRACTITIONERS (P)	The approach evolved	• 'recognise that simply the approach evolved' (2011)	*2*	9. Roles of practitioners, including their ways of working, histories, tendencies, and specific methodological approaches	*20*
	To build on previous interventions	• 'capitalise on something that worked well previously' (2011)	*1*		
	To facilitate transference of skills between practitioners and clients, learning, innovation, and renewal, enabling practitioners to address new problem areas and promote OR	• 'try something different' (2011)	*1*		
		• 'training opportunities' (2022, p. 1914)	*[not reported]*		
		• "academic' benefits – learning and trying out new methods' (2022, p. 1914)	*1 (non-academic)*		

Ppts = Participants
Note 1: Source: Compilation and analysis by author
Note 2: Allocation of rationales to theoretical rationales by author

Table 54: Practitioners' use of methods sequentially, or in different project stages or steps – interrelated sub-themes

Sub-theme	Ppts	Illustrative data	Example method(s)	Other insights
Exploring problem space early in studies	5	'[...] Many of the above cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope. Consequently many studies involved phases in which PSM were employed followed by more focused analysis. [...]' (q5)	PSMs [broadly defined]	
Selecting methods to use	2	'[...] I would suggest that an assessment of the type of project is imperative to understand how well methods work. This is why I use the Cynefin approach as it helps to understand the problem space. For those problems that are more complex or chaotic (Cynefic terms) we should not be using discrete event simulation as the first port of call.' (q10)	Cynefin	
Generating data for analysis	3	'Interviewing subject matter experts around structured questions to subsequently analyse patterns, trends and insights.' (q2ii)	Structured SME interviews	
Using data from one method in another method/model	5	'This was a complex analysis project and numerous methods were used in different parts of the analysis. Linear programming was used *to inform and populate* one of the simulation models. The *outputs of two simulation models were used as inputs* to the causal mapping and benefits analysis. The qualitative analysis methods were used *to scope the non-quantifiable issues* (and in some cases led to the identification of aspects that could be quantified and used in the "hard" analysis).' (q5, *emphasis added*)	Outputs of simulation models used in causal mapping and benefits analysis	Inputs may be produced by other practitioners, e.g., 'someone else applied the method, I imported the output' (q5)
To inform modelling	3		Linear programming to inform simulation models	Data suggests some parts of project/methods may be undertaken/used in parallel (Kotiadis & Mingers, 2006; Schultz & Hatch, 1996)
To frame problem / scope subsequent analysis	3		Qualitative analysis methods [Causal mapping, Scenario analysis Brainstorming, PESTLE, Morphological box]	
Series of steps required for outputs and outcomes (including testing/validation and visualisation of model outputs)	12	'One method would not get us to all the outputs and outcomes we needed, or would not get us to the final outputs/outcomes. We needed to complete several steps to reach the end result.' (q5) '[...] Gaming was used to produce rapid results early. [...] Finally, output is analysed using statistics to check its validity' (q5) '[...] Some of the above cases used a range of methods as an understanding of the problem area emerged, in order to pull out more fidelity in specific areas' (q5) '[...] need to adopt a multi-disciplinary approach [...] in order to enable a culmination method (e.g. metagaming) to represent [...] [a particular] capability sufficiently' (q8) 'Routinely use multiple methods - work on complex problems that frequently require a succession of approaches to move from initial customer expression of issue through to provision of advice. [...]' (q5)	[Various]	
Trying different methods over time to build understanding and move towards a solution	1	'I tried system dynamics to understand some of the key flows between parts of the system (money was one) - this was interesting in shaping the extent of the system we were interested in but it didn't get us towards a solution. I tried SSM which took things one step further. The problem boiled down to understanding supply and demand across a national capability - multiple suppliers and multiple demanders. In the end we used some scenario planning and a series of workshops to build pictures of supply, demand, gaps and health (ability to sustain the current position)' (q5)	SD, SSM, Scenarios, Workshops	
Total	**23**			

Ppts = number of survey participants whose data contributed to sub-theme
Further examples are in Table 48, Table 49 and Table 50 (Appendix R).

Appendix T Survey: 104 examples of multimethod projects

Table 18: Project examples in Appendix T by category and method

Category	Table	Title	Examples	Page
Quantitative OR	Table 55	Project examples with statistical analysis	15	383
	Table 56	Project examples with CBA (cost-benefit analysis)	13 [+ 1]	385
	Table 57	Project examples with DES (discrete event simulation)	7	387
	Table 58	Project examples with graph theory / network analysis	6	388
	Table 59	Project examples with simulation modelling	8	389
	Table 60	Project examples with NPV / financial / cost modelling / analysis	5	391
	Table 61	Project examples with data mining / analytics	8	392
	Table 62	Other project examples with Quantitative OR methods	14	393
OR methods less easily categorized	Table 63	Project examples with OR methods less easily categorized, including MCDA, benefits analysis/mapping/modelling, Delphi, and causal mapping	28	395
	Table 64	Project examples with gaming	11	398
Systems thinking	Table 65	Project examples with VSM (viable system model; including context mapping, ladder of abstraction, causal loop modelling, iceberg model and metaphors)	10	400
	Table 66	Project examples with other systems thinking methods (system dynamics and systems analysis)	3	402
PSMs	Table 67	Project examples with SSM (soft systems methodology)	8	403
	Table 68	Project examples with cognitive mapping (SODA)	3	404
Management/ Strategy	Table 69	Project examples with scenarios	21	405
	Table 70	Project examples with brainstorming, SWOT, PESTLE *[includes Morphological Analysis examples]*	32	408
	Table 71	Other project examples with Management/Strategy methods	12	413
Stakeholder Analysis	Table 72	Project examples with Stakeholder Analysis	16	415
Historical Analysis	Table 73	Project examples with Historical Analysis	17	417
Qualitative/ Soft OR	Table 74	Other project examples (not in other tables), including with other Qualitative/Soft OR methods	7	420

Note 1: The above tables together include all 104 project examples provided by 46 questionnaire respondents.
Note 2: The tables for each one of the categories listed in the first column together include all method listings for that category across the 104 project examples with the exception of the Qualitative/Soft OR category.

Table 55: Project examples with statistical analysis

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**							**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	
Method Improvement (2)	Practitioner organization (6)	months	2	Facilitated Workshops	Statistical Analysis					To ensure multiple perspectives on a problem are derived and therefore to increase the evidence base.
Policy effectiveness measurement (12)	Government Department Business Unit Officer (5)	Multiple 1-2 week iterations	3	Statistical Analysis	Expert Workshop	Graph Analysis				No one method would meet the range of project requirements
Operational assessment of national capability effectiveness (6)	Government customer (8)	about a month (not full time)	3	Workshopping	Structured SME elicitation to generate some data	Descriptive/ visual/ regression analysis of the results				Necessary to get from start point to end point...
Research (13)	(8)	2 years	3	Machine learning	Statistical analysis	Statistical forecasting				Dimension reduction.
Baselining for future requirement (8)	Government Department Business Unit SCS2 (2)	1 year	3	Gaming	Discrete event simulation	Statistical analysis				Gaming was used to produce rapid results early. 2 discrete event simulations were used. A coarse model was run using output from gaming to determine which options were best represented in a more detailed model. Finally, output is analysed using statistics to check its validity.
Operational Planning (5)	Government Department Business Unit (SCS1) (2)	1 month	4	Data Mining	Historical Analysis	Statistical Analysis	Project Mgt			Brainstorm with other team members for longer-term studies to consider options and methods and potential case studies etc. Data mining, HA and Stats used to identify-locate data and process/validate. PM to maintain personal oversight of budget allocated spend.
Strategic Planning (1)	Government Department (SCS1) (2)	4 months	5	Brainstorm	Data Mining	Historical Analysis	Statistical Analysis	Project Mgt		
Strategic Planning (1)	Government Department Business Unit (SCS1) (2)	3 months	5	Brainstorm	Data Mining	Historical Analysis	Statistical Analysis	Project Mgt		
Equipment Procurement (9)	Government Department Procurement (6)	months	5	Discrete event simulation	Q-method	Expert Workshops	Statistical Analysis	Historical Analysis		To ensure multiple perspectives on a problem are derived and therefore to increase the evidence base. In addition some of the methods are used to narrow down options for other methods, e.g. some expert workshops are used to define the scope of a simulation activity or a gaming event.
Operational Planning (5)	CSA [Chief Scientific Adviser] (2)	months	6	ABM	Discrete Event Simulation	Expert Workshops	Statistical Analysis	Historical Analysis	Gaming	
Option Assessment (4)	Government Department Business Unit, Middle m'gmt (3)	8 months	6	Statistical Analysis	Discrete Event Simulation	Brainstorming	Expert Workshops	Cost-Benefit Analysis	SWOT	Three main reasons: 1. Many of the above cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope. Consequently many studies involved phases in which PSM [broadly defined] were employed followed by more focused analysis. 2. The above cases are typically very broad with several areas of interest for stakeholders ranging from e.g. "optimal" solutions, relative strengths and weaknesses, overall costs, current risks etc. 3. Some of the above cases used a range of methods as an understanding of the problem area emerged, in order to pull out more fidelity in specific areas

Subject matter (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**	**Methods**											**Why did you use more than one method...?**
			Σ	**1**	2	3	4	**5**	**6**	7	8	9	**10**	
Assessing factors which impact on national capability (6)	Departmental Agency Programme manager (Grade 6/7) and national capability stakeholders (Grades 6/7) (3)	4 months	7	Simulation modelling	Gaming (computer-based)	Expert Workshops	Statistical Analysis for hypothesis testing	Statistical Forecasting	Scenario Building and Planning	Historical Analysis				All projects I am asked to lead/support are looking at systems level questions so it is important we consider many factors before delivering insights and analysis output to our customers. Single method studies are never suitable for these types of question hence we use a variety of techniques to ensure we can answer the customer's questions. We have a process we usually follow for general capability study questions which will include gaming, simulation, [expert] judgement, scenario building and statistical analysis but the process is flexible and can be amended as studies require.
Procurement planning (9)	SCSI (2)	6 mths	9	Cost-Benefit Analysis	Stakeholder analysis	Statistical Analysis	Statistical Forecasting	PESTLE	Critical Path Analysis	Delphi	Benefits Modelling	Expert Workshop		Tasks are by nature complex and require multiple methods to develop understanding of alternative factors, alternative viewpoints and due to complex nature often require breaking elements down into area where single methods can then be used. But to provide an answer requires the combination of techniques to provide a balanced thorough response.
Strategic decision (departmental policy) making (3)	SCSI-SCS3 (2)	1 year	10	Cost-Benefit Analysis	Stakeholder analysis	Statistical Analysis	Statistical Forecasting	PESTLE	Critical Path Analysis	Delphi	Benefits Modelling	Historical Analysis	MCDA	
Strategic operations (5)	Government Department Business Unit, SCSI (2)	3 years	10	Expert judgement / stakeholder judgement	Project management / Gantt charts	Scenario building	Brainstorming	Stochastic computer modelling	Statistical analysis	MCDA	Historical analysis	Response surface modelling	Data mining / analytics	The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. I often (initially) do not have the depth of knowledge or expertise required to answer the problem or properly formulate a methodology. As such, I will use expert or [stakeholder] judgement to properly understand the issues. Often historical analysis or data mining is necessary to gather data. Context is required (not least to ensure policy compliance and [quality assurance]) thus requiring usage of scenarios.

Table 56: Project examples with CBA (cost-benefit analysis)

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**							**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	
Business Case Submissions (4)	Govt Dept (6)	between 1 - 2 mths and 2 - 6mths	2	Scenario Analysis	Cost benefit analysis					Combination of cost benefit and OR effectiveness analysis, required for business case support
New modelling services (2)	Intergovernmental organization (7)	3 yrs	3	CBA	SoS [System of Systems] Analysis	[Domain-specific method]				Complex and Uncertain Operational Environments; Integrated and Multidisciplinary Human-System Environments
Domain strategic goals (3)	Government Department Business Unit Leadership (2)	1 year	4	Vision and Strategic Analysis	PEST	[Domain-specific method]	CBA			
Engineering decision making (11)	Chief Engineer (2)	<1month	4	SWOT	Critical Path	Stakeholder Analysis	Cost-Benefit Analysis			Tasks are by nature complex and require multiple methods to develop understanding of alternative factors, alternative viewpoints and due to complex nature often require breaking elements down into area where single methods can then be used. But to provide an answer requires the combination of techniques to provide a balanced thorough response.
Review of governance and operating models used with Departmental Agency to enable transformation and realisation of costs savings (7)	Departmental Agency Executive level (2)	6 months	5	COSO [Committee of sponsoring organisations of the Treadway commission]	Benefits Mapping	Cost Benefit	Prince II concepts	Managing Successful Programmes		Tools in and of themselves rarely in my experience 'work', and definitely not in isolation. It is important to use an approach that will work in the circumstances and achieves buy-in from customers/end users. This I would class as a soft systems approach.
National capability analysis (1)	Government Department Business Unit, Senior m'gmt (2)	18 months	5	Expert Workshops	Brainstorming	Morphological Analysis	Cost-benefit analysis	Mathematical Programming		Three main reasons: 1. Many of the above cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope. Consequently many studies involved phases in which PSM [broadly defined] were employed followed by more focused analysis. 2. The above cases are typically very broad with several areas of interest for stakeholders ranging from e.g. "optimal" solutions, relative strengths and weaknesses, overall costs, current risks etc. 3. Some of the above cases used a range of methods as an understanding of the problem area emerged, in order to pull out more fidelity in specific areas
Capability people requirements (8)	Government Department Business Units, officers (5)	3 months	6	Deterministic modelling	Expert judgement / stakeholder judgement	Project management / Gantt charts	Scenario building	Historical analysis	Cost benefit analysis	The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. I often (initially) do not have the depth of knowledge or expertise required to answer the problem or properly formulate a methodology. As such, I will use expert or [stakeholder] judgement to properly understand the issues. Often historical analysis or data mining is necessary to gather data. Context is required (not least to ensure policy compliance and [quality assurance]) thus requiring usage of scenarios.

Subject matter (Figure 15 category)	**Customer** and organizational level or equivalent (Figure 16 category)	**Time available**	**Methods**											**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Option Assessment (4)	Government Department Business Unit, Middle m'gmt (3)	8 months	6	Statistical Analysis	Discrete Event Simulation	Brainstorming	Expert Workshops	Cost-Benefit Analysis	SWOT					Three main reasons: [...] [as above]
Strategic capability planning (1)	Government Department Head Office Director (2)	18 months	7	Benefits mapping	Benefits Analysis	MCDA	Cost benefit Analysis	Sensitivity analysis	(Cost modelling)	(Effectiveness analysis)				Because each individual method has strengths and weaknesses () = someone else applied the method, I imported the output
Procurement planning (9)	SCS1 (2)	6 mths	9	Cost-Benefit Analysis	Stakeholder analysis	Statistical Analysis	Statistical Forecasting	PESTLE	Critical Path Analysis	Delphi	Benefits Modelling	Expert Workshop		Tasks are by nature complex and [...] [as above]
Procurement (9)	SCS1 sometimes ministers (2)	Variable	9	Simulation modelling	Brainstorming (Osborn)	Cost-Benefit Analysis / Net Present Value / Financial Modelling	Delphi Technique (RAND)	Expert Workshops	MCDA / DA / Decision Tree	Project Management / Project Networks / Gantt Charts / Critical Path Analysis	Scenario Building/ Planning/ Analysis	SWOT Analysis		Questions are quite nebulous and require the generation of a portfolio of evidence which cover various factors from costs and numbers down to stakeholder influence analysis.
Capability development (1)	SCS1 and SCS2 (2)	Variable	9	Simulation modelling	Brainstorming (Osborn)	Cost-Benefit Analysis / Net Present Value / Financial Modelling	Delphi Technique (RAND)	Expert Workshops	MCDA / DA / Decision Tree	Project Management / Project Networks / Gantt Charts / Critical Path Analysis	Scenario Building/ Planning/ Analysis	SWOT Analysis		
Strategic decision (departmental policy) making (3)	SCS1-SCS3 (2)	1 year	10	Cost-Benefit Analysis	Stakeholder analysis	Statistical Analysis	Statistical Forecasting	PESTLE	Critical Path Analysis	Delphi	Benefits Modelling	Historical Analysis	MCDA	Tasks are by nature complex and [...] [as above]

Note: See also from Table 57: Project examples with DES (discrete event simulation):

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**								**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Cost-benefit analysis (4)	(8)	A little over a year	7	Discrete event simulation	Causal mapping	Scenario analysis	Brainstorming	PESTLE	Morphological box	Linear programming	This was a complex analysis project and numerous methods were used in different parts of the analysis. Linear programming was used to inform and populate one of the simulation models. The outputs of two simulation models were used as inputs to the causal mapping and benefits analysis. The qualitative analysis methods were used to scope the non-quantifiable issues (and in some cases led to the identification of aspects that could be quantified and used in the "hard" analysis).

Table 57: Project examples with DES (discrete event simulation)

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**								**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Support to domain capability management (1)	SCS1 / Experienced official (2)	Ongoing (repeated yearly)	2	Benefits Modelling	Discrete Event Simulation						Complexity - it was not possible to address the issues with a single method because there was a lot of connectivity between issues, uncertainty in terms of need.
Operations (5)	Policy (Government Department) (6)	9 Months	3	Scenarios	Expert Workshops	Discrete Event Simulation					[My organization] may not hold all of the expertise hence need for [expert workshop]s in some cases. Scenarios (of varying detail with appropriate range of circumstances covered) frame the problems that are most likely/[impactful] to draw insights from and other techniques can be used to test these insights. At other times, one method cannot provide the answer to all aspects of a complex question.
Baselining for future requirement (8)	Government Department Business Unit SCS2 (2)	1 year	3	Gaming	Discrete event simulation	Statistical analysis					Gaming was used to produce rapid results early. 2 discrete event simulations were used. A coarse model was run using output from gaming to determine which options were best represented in a more detailed model. Finally, output is analysed using statistics to check its validity.
Equipment Procurement (9)	Government Department Procurement (6)	months	5	Discrete event simulation	Q-method	Expert Workshops	Statistical Analysis	Historical Analysis			To ensure multiple perspectives on a problem are derived and therefore to increase the evidence base. In addition some of the methods are used to narrow down options for other methods, e.g. some expert workshops are used to define the scope of a simulation activity or a gaming event.
Operational Planning (5)	CSA [Chief Scientific Adviser] (2)	months	6	ABM	Discrete Event Simulation	Expert Workshops	Statistical Analysis	Historical Analysis	Gaming		
Option Assessment (4)	Government Department Business Unit, Middle m'gmt (3)	8 months	6	Statistical Analysis	Discrete Event Simulation	Brainstorming	Expert Workshops	Cost-Benefit Analysis	SWOT		Three main reasons: 1. Many of the above cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope. Consequently many studies involved phases in which PSM [broadly defined] were employed followed by more focused analysis. 2. The above cases are typically very broad with several areas of interest for stakeholders ranging from e.g. "optimal" solutions, relative strengths and weaknesses, overall costs, current risks etc. 3. Some of the above cases used a range of methods as an understanding of the problem area emerged, in order to pull out more fidelity in specific areas
Cost-benefit analysis (4)	(8)	A little over a year	7	Discrete event simulation	Causal mapping	Scenario analysis	Brainstorming	PESTLE	Morphological box	Linear programming	This was a complex analysis project and numerous methods were used in different parts of the analysis. Linear programming was used to inform and populate one of the simulation models. The outputs of two simulation models were used as inputs to the causal mapping and benefits analysis. The qualitative analysis methods were used to scope the non-quantifiable issues (and in some cases led to the identification of aspects that could be quantified and used in the "hard" analysis).

Table 58: Project examples with graph theory / network analysis

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**						**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	
Policy effectiveness measurement (12)	Government Department Business Unit Officer (5)	Multiple 1-2 week iterations	3	Statistical Analysis	Expert Workshop	Graph Analysis			No one method would meet the range of project requirements
Strategic - understanding the problem space (3)	Research councils - Research integrators (7)	2 weeks	3	Stakeholder analysis mapping	Network analysis	CATWOE / concept mapping			A single method was not sufficient to fully explore the rich problem space.
Portfolio appraisal (4)	Government Department Business Unit, Middle m'gmt (3)	6 months	3	MCDA	Graph Theory/ Network Analysis	Causal Mapping			Three main reasons: 1. Many of the above cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope. Consequently many studies involved phases in which PSM [broadly defined] were employed followed by more focused analysis. 2. The above cases are typically very broad with several areas of interest for stakeholders ranging from e.g. "optimal" solutions, relative strengths and weaknesses, overall costs, current risks etc. 3. Some of the above cases used a range of methods as an understanding of the problem area emerged, in order to pull out more fidelity in specific areas
Domain Capability Audit (6)	Government Department Business Unit, Middle m'gmt (3)	6 months	3	Expert Workshops	Graph Theory/ Network Analysis	Balanced Scorecard			
Operations portfolio appraisal (4)	Government Department Business Unit Leadership (2)	1 yr	4	Optimisation	Networks	Graph Theory	Bespoke Modelling		The solution space to our problems is inhomogeneous. Therefore, typically, not one method is able to span the full solution space.
OR to inform future equipment requirement and strategy (3)	Government Department Business Unit HEO (4)	Several Months	5	Scenario analysis	User interviews	Cost analysis	Isochrone analysis	[Domain-specific method]	To gather more information than using one technique and to see if different techniques might yield different answers

Table 59: Project examples with simulation modelling

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**										**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Strat Planning (1)	Government Department Head Office (6)	6 months	3	Simulation modelling	Gaming	SME and other stakeholder judgment							[Operations] are so complex it is impossible to cover with one method, multiple uses of multiple methods are required
Future national capability operating concepts (3)	Government Department Business Unit Head Office (6)	Ongoing project	3	Scenario planning	Simulation modelling	Expert workshops							To balance the hypothetical qualitative discussions with quantitative analysis, hopefully leading to more balanced insights.
Setting requirements for future national capability (8)	Government Department Head Office (6)	Ongoing project	5	Scenario planning	Historical analysis	Simulation modelling	Gaming	Expert workshops					
Domain assessments (6)	Government Department (Grade 6) (3)	3 months	5	Simulation modelling	Gaming (computer-based)	Expert Workshops	Historical Analysis	Scenario Building and Planning					All projects I am asked to lead/support are looking at systems level questions so it is important we consider many factors before delivering insights and analysis output to our customers. Single method studies are never suitable for these types of question hence we use a variety of techniques to ensure we can answer the customer's questions. We have a process we usually follow for general capability study questions which will include gaming, simulation, [expert] judgement, scenario building and statistical analysis but the process is flexible and can be amended as studies require.
Assessing factors which impact on national capability (6)	Departmental Agency Programme manager (Grade 6/7) and national capability stakeholders (Grades 6/7) (3)	4 months	7	Simulation modelling	Gaming (computer-based)	Expert Workshops	Statistical Analysis for hypothesis testing	Statistical Forecasting	Scenario Building and Planning	Historical Analysis			
National Capability Development (1)	Government Department Business Unit Head Office, typically SCS1 and above (2)	ranges from months to 2 years	7	SSM	Stakeholder analysis	HA / Literature search	Data analysis (data from training)	Simulation modelling	Gaming	Metagaming			It is not possible to generate credible evidence in support of [National Capability] Development decisions (i.e., [across all aspects of a departmental capability]) unless a multi-disciplinary approach is adopted.
Procurement (9)	SCS1 sometimes ministers (2)	Variable	9	Simulation modelling	Brainstorming (Osborn)	Cost-Benefit Analysis / Net Present Value / Financial Modelling	Delphi Technique (RAND)	Expert Workshops	MCDA / DA / Decision Tree	Project Management / Project Networks / Gantt Charts / Critical Path Analysis	Scenario Building/ Planning/ Analysis	SWOT Analysis	Questions are quite nebulous and require the generation of a portfolio of evidence which cover various factors from costs and numbers down to stakeholder influence analysis.

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**										**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Capability development (1)	SCS1 and SCS2 (2)	Variable	9	Simulation modelling	Brainstorming (Osborn)	Cost-Benefit Analysis / Net Present Value / Financial Modelling	Delphi Technique (RAND)	Expert Workshops	MCDA / DA / Decision Tree	Project Management / Project Networks / Gantt Charts / Critical Path Analysis	Scenario Building/ Planning/ Analysis	SWOT Analysis	

Table 60: Project examples with NPV / financial / cost modelling / analysis

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**								**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Review of the process used within government department to ensure humans are appropriately protected if they are taking part in research sponsored by department (2)	SCS2 (2)	3 months	5	NPV /Financial Modelling	Process Mapping	Data Visualisation	Project Management	Stakeholder Analysis			Tools in and of themselves rarely in my experience 'work', and definitely not in isolation. It is important to use an approach that will work in the circumstances and achieves buy-in from customers/end users. This I would class as a soft systems approach.
OR to inform future equipment requirement and strategy (3)	Government Department Business Unit HEO (4)	Several Months	5	Scenario analysis	User interviews	Cost analysis	Isochrone analysis	[Domain-specific method]			To gather more information than using one technique and to see if different techniques might yield different answers
Training Facilities (location, staffing, impact) (5)	SCSl+, Government Department and Business Units (2)	6 months	6	PESTLE	SWOT	MCDA	Financial Modelling	Project Management	Mathematical Programming		Complexity of the problem and at multiple levels (where should the facility be located, what is the impact on currently-shared staffing).
Requirements Setting study (8)	SCS2 and SCS3 (2)	8 months + 6 month follow on	6	SME interviews	Financial modelling/prediction	Stakeholder analysis	Rich Picture	Visualisation (sun ray diagram)	Financial modelling/prediction (outsourced)		Complexity - it was not possible to address the issues with a single method because there was a lot of connectivity between issues, uncertainty in terms of need. For senior stakeholders there was also a need to draw in a variety of different visualisations to engage with them - this means that many different methods are needed to generate the data.
Strategic capability planning (1)	Government Department Head Office Director (2)	18 months	7	Benefits mapping	Benefits Analysis	MCDA	Cost benefit Analysis	Sensitivity analysis	(Cost modelling)	(Effectiveness analysis)	Because each individual method has strengths and weaknesses () = someone else applied the method, I imported the output

Table 61: Project examples with data mining / analytics

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**											**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Operational Planning (5)	Government Department (SCSI) (2)	1 week	2	Data Mining	Historical Analysis									Data mining, HA [...] used to identify-locate data and process/validate.
Operational Planning (5)	(8)	Months	2	Game theory	Pattern recognition									Dimension reduction.
Research (12)	(8)	2 years	3	Machine learning	Statistical analysis	Statistical forecasting								
Operational Planning (5)	Government Department Business Unit (SCSI) (2)	1 month	4	Data Mining	Historical Analysis	Statistical Analysis	Project Mgt							Brainstorm with other team members for longer-term studies to consider options and methods and potential case studies etc. Data mining, HA and Stats used to identify-locate data and process/validate. PM to maintain personal oversight of budget allocated spend.
Strategic Planning (1)	Government Department (SCSI) (2)	4 months	5	Brainstorm	Data Mining	Historical Analysis	Statistical Analysis	Project Mgt						
Strategic Planning (1)	Government Department Business Unit (SCSI) (2)	3 months	5	Brainstorm	Data Mining	Historical Analysis	Statistical Analysis	Project Mgt						
Major change to departmental structure and management (7)	Minister (1)	4 months	6	Data analytics	Psychological analysis	Market analysis	Systems analysis	Rich pictures	Data visualisation					To enable the most effective approach to the problem at hand, taking into account the data available and the stakeholder views.
Strategic operations (5)	Government Department Business Unit, SCSI (2)	3 years	10	Expert judgement / stakeholder judgement	Project management / Gantt charts	Scenario building	Brainstorming	Stochastic computer modelling	Statistical analysis	MCDA	Historical analysis	Response surface modelling	Data mining / analytics	The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. I often (initially) do not have the depth of knowledge or expertise required to answer the problem or properly formulate a methodology. As such, I will use expert or [stakeholder] judgement to properly understand the issues. Often historical analysis or data mining is necessary to gather data. Context is required (not least to ensure policy compliance and [quality assurance]) thus requiring usage of scenarios.

Table 62: Other project examples with Quantitative OR methods

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**									**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Domain equipment (11)	Government Department (6)	months/years	2	Monte Carlo	Deterministic modelling							To cover different aspects of the problem space
Futures (10)	Government Department, SCS3 (2)	6 months	3	Risk Matrix	Literature review	MCDMA						Projects often have multiple phases or layers, where different techniques allow you to build up, filter and present evidence before analysing it.
Workforce understanding (1)	Government Department, SCS3 downwards (2)	3 months	3	Pivot tables	Data visualisation means - Tableau	Stakeholder engagement tools - structured workshops						A range of tools to analyse data, visualise it in a way accessible to stakeholders, and allow them to engage with it to develop option spaces
Strategic use of national capability (1)	Government Department Business Unit Leadership (2)	Months	4	Deterministic modelling	Monte Carlo modelling	Historical Analysis	SME subjective/ objective assessment					To cover different aspects of the problem space
Future technical direction (10)	Government Department Business Unit, SEO (4)	3 days prep, 1 day delivery	4	Facilitated workshop	Expert workshop	Numerical analysis	Data visualisation					To access diversity of viewpoints, keep audience interested/engaged, challenge problem from different perspectives, make outputs more relevant to customers.
Benefits realisation (6)	Departmental Agency Executive (2)	6 months	4	Benefits model	Graphs	Survey	Manual text analysis					Benefits realisation needed to combine quantitative management information and more qualitative assessment of benefits.
Damage Estimation (11)	Government Department Business Unit (6)	Requests answered in weeks - built on years of experience	4	Engineering simulations	Hi-Fidelity simulations	Trials (operations)	Lab based experiments					Engineering models cannot model the complexity of all the interactions. The hi-fidelity models take too long to run. All models have to be validated against trails, operations and experiments.
Organisational best practice (2)	Civil servant, Programme Leader (3)	Intermittently over 9 months	5	Structured interviews	Numerical analysis	Stakeholder analysis	Data visualisation	Presentation of findings				To access diversity of viewpoints, keep audience interested/engaged, challenge problem from different perspectives, make outputs more relevant to customers.
Strategic Workforce planning (1)	SCS3 Government Department stakeholders (2)	6 months	5	Visualisation (graphs and geographic)	Spreadsheet modelling	SME workshops	Manual and automated text analysis	Benchmarking				Using Excel + Tableau to develop understanding of workforce. Use workshops for 2-way knowledge transfer, excel modelling to conduct what-ifs, text analysis to identify functions undertaken by personnel, benchmarking to help compare and contrast across multiple organisations within [government department].
Project planning (13)	Government Department, SCS1 downwards (2)	few hours	5	Brainstorm	Cognitive mapping	Swimlane analysis	Spreadsheet	Gantt chart				Exploration of the necessary steps needed to deliver against a high level requirement, constraints, freedoms, options, interfaces, delivery options, development of delivery plan
Equipment business case support (4)	(8)	1 year	6	Expert Workshops	Scenario analysis	Optimisation	System modelling	Data visualisation	Benefits mapping			We do not have a method that covers the entire spectrum we need to explore.

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**									**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Domain equipment capability analysis (11)	Government Department Procurement, Capability (6)	1 year (and ongoing for another 6+)	6	MCDA	Expert/ stakeholder advisors	Basic Excel tool constructed through systems thinking/ engineering approach	Complex bespoke models	Expert workshops	Scenario construction and analysis			The overall project has a very large scope. No one method is appropriate to answer the breadth of the study. For [quick turnaround projects] it may sometimes be appropriate to use a single established method but this is generally by exception as more often than not it is natural to use several even if in making the decision as to which to purse for the core analysis.
Policy Analysis (12)	Minister (1)	6 months	6	SWOT	Brainstorm	Stakeholder [Analysis]	Policy Analysis	Systems Analysis	Risk Analysis			To enable the most effective approach to the problem at hand, taking into account the data available and the stakeholder views.
Implications of Policy Analysis (1)	Government Department Business Unit, SCS1 (2)	3 years	8	Expert judgement / stakeholder judgement	Project management / Gantt charts	Stakeholder mapping	Scenario building	AHP	Benefits modelling	Brainstorming	Stochastic computer modelling	The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. I often (initially) do not have the depth of knowledge or expertise required to answer the problem or properly formulate a methodology. As such, I will use expert or [stakeholder] judgement to properly understand the issues. Often historical analysis or data mining is necessary to gather data. Context is required (not least to ensure policy compliance and [quality assurance]) thus requiring usage of scenarios.

Table 63: Project examples with OR methods less easily categorized, including MCDA, benefits analysis/mapping/modelling, Delphi, and causal mapping

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**					**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	
Equipment procurement appraisal (9)	Government Department Procurement (6)	1 year	2	Expert judgement	MCDA			Some aspects of the analysis could only be done through judgement other parts allowed a numerical assessment
Research assessment (6)	Government Department CSA [Chief Scientific Adviser] (2)	1 year	2	AHP	SME judgement			
Capability development (1)	Government Department Business Unit Leadership (2)	1 yr	2	Survey / questionnaire	Fuzzy Cognitive Modelling			The solution space to our problems is inhomogeneous. Therefore, typically, not one method is able to span the full solution space.
Prioritisation (4)	N/A (8)	3 Months	2	Benefits Modelling	Balance Score Card			One method cannot provide the answer to all aspects of a complex question
Portfolio appraisal (4)	Departmental Business Unit Operational Unit Chief Engineer (2)	3 weeks	2	AHP	MCDA			AHP could be done in a spreadsheet but MCDA required a bespoke application
Portfolio appraisal (4)	Government Department Business Unit Leadership (2)	2 weeks	2	AHP	MCDA			
Operational Planning (5)	(8)	Months	2	Game theory	Pattern recognition			Dimension reduction.
Multi-actor scenario gaming (10)	Senior government stakeholders (2)	2 months	2	Scenario gaming (bespoke approach)	Elements of Delphi			Scenario gaming often involves activities to elicit information from individuals, so can use some of the simpler decision tools to support this.
Support to domain capability management (1)	SCSI / Experienced official (2)	Ongoing (repeated yearly)	2	Benefits Modelling	Discrete Event Simulation			Complexity - it was not possible to address the issues with a single method because there was a lot of connectivity between issues, uncertainty in terms of need.
Futures (10)	Government Department, SCS3 (2)	6 months	3	Risk Matrix	Literature review	MCDMA		Projects often have multiple phases or layers, where different techniques allow you to build up, filter and present evidence before analysing it.
Portfolio appraisal (4)	Government Department Business Unit, Middle m'gmt (3)	6 months	3	MCDA	Graph Theory/ Network Analysis	Causal Mapping		Three main reasons: 1. Many of the above cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope. Consequently many studies involved phases in which PSM [broadly defined] were employed followed by more focused analysis. 2. The above cases are typically very broad with several areas of interest for stakeholders ranging from e.g. "optimal" solutions, relative strengths and weaknesses, overall costs, current risks etc. 3. Some of the above cases used a range of methods as an understanding of the problem area emerged, in order to pull out more fidelity in specific areas
Developing information to support a Government Department Strategy (3)	SCSI domain strategy head (2)	Team of 12 for 3 years	4	Delphi	Literature search	Coding data into a database to analyse	Academic engagement	One method would not have been sufficient to meet the customer requirement
Futures (10)	Government Department, SCSI (2)	2 months	4	Pathways	Brainstorming	Morphological analysis	Workshop	Projects often have multiple phases or layers, where different techniques allow you to build up, filter and present evidence before analysing it.
Requirements setting (8)	Working level Departmental Agency (5)	6 hours	4	Elements of cognitive mapping	Feasibility & Impact Grids	Elements of Delphi (eliciting information individually first)	Bespoke framework (to capture information in desired format)	Cognitive mapping to develop goals and constituent activities, Delphi style elicitation of ideas to generate ideas from individuals, bespoke framework - to capture information in the desired format, feasibility impact grids to assess options.
Benefits realisation (6)	Departmental Agency Executive (2)	6 months	4	Benefits model	Graphs	Survey	Manual text analysis	Benefits realisation needed to combine quantitative management information and more qualitative assessment of benefits.

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**									**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Review of governance and operating models used with Departmental Agency to enable transformation and realisation of costs savings (7)	Departmental Agency Executive level (2)	6 months	5	COSO [Committee of sponsoring organisations of the Treadway commission]	Benefits Mapping	Cost Benefit	Prince II concepts	Managing Successful Programmes				Tools in and of themselves rarely in my experience 'work', and definitely not in isolation. It is important to use an approach that will work in the circumstances and achieves buy-in from customers/end users. This I would class as a soft systems approach.
Equipment business case support (4)	(8)	1 year	6	Expert Workshops	Scenario analysis	Optimisation	System modelling	Data visualisation	Benefits mapping			We do not have a method that covers the entire spectrum we need to explore.
Domain equipment capability analysis (11)	Government Department Procurement, Capability (6)	1 year (and ongoing for another 6+)	6	MCDA	Expert/ stakeholder advisors	Basic Excel tool constructed through systems thinking/ engineering approach	Complex bespoke models	Expert workshops	Scenario construction and analysis			The overall project has a very large scope. No one method is appropriate to answer the breadth of the study. For [quick turnaround projects] it may sometimes be appropriate to use a single established method but this is generally by exception as more often than not it is natural to use several even if in making the decision as to which to purse for the core analysis.
Training Facilities (location, staffing impact) (5)	SCSI+, Government Department and Business Units (2)	6 months	6	PESTLE	SWOT	MCDA	Financial Modelling	Project Management	Mathematical Programming			Complexity of the problem and at multiple levels (where should the facility be located, what is the impact on currently-shared staffing).
Cost-benefit analysis (4)	(8)	A little over a year	7	Discrete event simulation	Causal mapping	Scenario analysis	Brainstorming	PESTLE	Morphological box	Linear programming		This was a complex analysis project and numerous methods were used in different parts of the analysis. Linear programming was used to inform and populate one of the simulation models. The outputs of two simulation models were used as inputs to the causal mapping and benefits analysis. The qualitative analysis methods were used to scope the non-quantifiable issues (and in some cases led to the identification of aspects that could be quantified and used in the "hard" analysis).
Strategic capability planning (1)	Government Department Head Office Director (2)	18 months	7	Benefits mapping	Benefits Analysis	MCDA	Cost benefit Analysis	Sensitivity analysis	(Cost modelling)	(Effectiveness analysis)		Because each individual method has strengths and weaknesses () = someone else applied the method, I imported the output
National Capability Development (1)	Government Department Business Unit, SCSI (2)	6 months	8	Expert judgement / stakeholder judgement	Project management / Gantt charts	Stakeholder mapping	Scenario building	Historical analysis	AHP	Benefits modelling	Brainstorming	The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. I often (initially) do not have the depth of knowledge or expertise required to answer the problem or properly formulate a methodology. As such, I will use expert or [stakeholder] judgement to properly understand the issues. Often historical analysis or data mining is necessary to gather data. Context is required (not least to ensure policy compliance and [quality assurance]) thus requiring usage of scenarios.
Implications of Policy Analysis (1)	Government Department Business Unit, SCSI (2)	3 years	8	Expert judgement / stakeholder judgement	Project management / Gantt charts	Stakeholder mapping	Scenario building	AHP	Benefits modelling	Brainstorming	Stochastic computer modelling	

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**											**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Procurement planning (9)	SCSI (2)	6 mths	9	Cost-Benefit Analysis	Stakeholder analysis	Statistical Analysis	Statistical Forecasting	PESTLE	Critical Path Analysis	Delphi	Benefits Modelling	Expert Workshop		Tasks are by nature complex and require multiple methods to develop understanding of alternative factors, alternative viewpoints and due to complex nature often require breaking elements down into area where single methods can then be used. But to provide an answer requires the combination of techniques to provide a balanced thorough response.
Procurement (9)	SCSI sometimes ministers (2)	Variable	9	Simulation modelling	Brainstorming (Osborn)	Cost-Benefit Analysis / Net Present Value / Financial Modelling	Delphi Technique (RAND)	Expert Workshops	MCDA / DA / Decision Tree	Project Management / Project Networks / Gantt Charts / Critical Path Analysis	Scenario Building/ Planning/ Analysis	SWOT Analysis		Questions are quite nebulous and require the generation of a portfolio of evidence which cover various factors from costs and numbers down to stakeholder influence analysis
Capability development (1)	SCSI and SCS2 (2)	Variable	9	Simulation modelling	Brainstorming (Osborn)	Cost-Benefit Analysis / Net Present Value / Financial Modelling	Delphi Technique (RAND)	Expert Workshops	MCDA / DA / Decision Tree	Project Management / Project Networks / Gantt Charts / Critical Path Analysis	Scenario Building/ Planning/ Analysis	SWOT Analysis		
Strategic decision (departmental policy) making (3)	SCS1-SCS3 (2)	1 year	10	Cost-Benefit Analysis	Stakeholder analysis	Statistical Analysis	Statistical Forecasting	PESTLE	Critical Path Analysis	Delphi	Benefits Modelling	Historical Analysis	MCDA	Tasks are by nature complex and require multiple methods [...] [see above]
Strategic operations (5)	Government Department Business Unit, SCSI (2)	3 years	10	Expert judgement / stakeholder judgement	Project management / Gantt charts	Scenario building	Brainstorming	Stochastic computer modelling	Statistical analysis	MCDA	Historical analysis	Response surface modelling	Data mining / analytics	The majority of problems I assess are complex, wide ranging and multi-dimensional. [...] [see above]

Note: For projects with gaming, see Table 64 below.

Table 64: Project examples with gaming

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**								**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Multi-actor scenario gaming (10)	Senior government stakeholders (2)	2 months	2	Scenario gaming (bespoke approach)	Elements of Delphi						Scenario gaming often involves activities to elicit information from individuals, so can use some of the simpler decision tools to support this.
Strat Planning (1)	Government Department Head Office (6)	6 months	3	Simulation modelling	Gaming	SME and other stakeholder judgment					[Operations] are so complex it is impossible to cover with one method, multiple uses of multiple methods are required
Baselining for future requirement (8)	Government Department Business Unit SCS2 (2)	1 year	3	Gaming	Discrete event simulation	Statistical analysis					Gaming was used to produce rapid results early. 2 discrete event simulations were used. A coarse model was run using output from gaming to determine which options were best represented in a more detailed model. Finally, output is analysed using statistics to check its validity.
Improved Evidence-Based Policy Making (2)	Government Department Chief Scientist (2)	3 years	4	Gaming - within a training context	SWOT	Visualisation	Pre-mortem				To enable the most effective approach to the problem at hand, taking into account the data available and the stakeholder views.
Domain assessments (6)	Government Department (Grade 6) (3)	3 months	5	Simulation modelling	Gaming (computer-based)	Expert Workshops	Historical Analysis	Scenario Building and Planning			All projects I am asked to lead/support are looking at systems level questions so it is important we consider many factors before delivering insights and analysis output to our customers. Single method studies are never suitable for these types of question hence we use a variety of techniques to ensure we can answer the customer's questions. We have a process we usually follow for general capability study questions which will include gaming, simulation, [expert] judgement, scenario building and statistical analysis but the process is flexible and can be amended as studies require.
Setting requirements for future national capability (8)	Government Department Head Office (6)	Ongoing project	5	Scenario planning	Historical analysis	Simulation modelling	Gaming	Expert workshops			To balance the hypothetical qualitative discussions with quantitative analysis, hopefully leading to more balanced insights.
National Capability Development (1)	Government Department (Hd SCS1 / DepHd Grade 6/7) (2)	3-4 Months	6	Gaming	PESTLE	Historical Analysis	Expert Workshop	Project Management	SWOT		No one method would meet the range of project requirements
Policy/ strategy development (3)	Government Department (Hd SCS1 / DepHd Grade 6/7) (2)	1-12 Months	6	Gaming	PESTLE	Historical Analysis	Expert Workshop	Project management	SWOT		
Operational Planning (5)	CSA [Chief Scientific Adviser] (2)	months	6	ABM	Discrete Event Simulation	Expert Workshops	Statistical Analysis	Historical Analysis	Gaming		To ensure multiple perspectives on a problem are derived and therefore to increase the evidence base. In addition some of the methods are used to narrow down options for other methods, e.g. some expert workshops are used to define the scope of a simulation activity or a gaming event.

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**								**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
National Capability Development (1)	Government Department Business Unit Head Office, typically SCSI and above (2)	ranges from months to 2 years	7	SSM	Stakeholder analysis	HA / Literature search	Data analysis (data from training)	Simulation modelling	Gaming	Metagaming	It is not possible to generate credible evidence in support of [National Capability] Development decisions (i.e., [across all aspects of a departmental capability]) unless a multi-disciplinary approach is adopted.
Assessing factors which impact on national capability (6)	Departmental Agency Programme manager (Grade 6/7) and national capability stakeholders (Grades 6/7) (3)	4 months	7	Simulation modelling	Gaming (computer-based)	Expert Workshops	Statistical Analysis for hypothesis testing	Statistical Forecasting	Scenario Building and Planning	Historical Analysis	All projects I am asked to lead/support are looking at systems level questions [...] [see above]

Table 65: Project examples with VSM (viable system model; including context mapping, ladder of abstraction, causal loop modelling, iceberg model and metaphors)

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**								**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Organisational assessment and design (7)	SCS1 Government Department Head Office (2)	3 months	2	SSM	VSM							I needed something to 'unpack' the problem and SSM fitted the bill well for this. I then needed a way of representing the problems in a recursive hierarchy which suited VSM. What I really needed after this was a good range of solution options, which was difficult to find based on just the VSM outputs.
Review of cross org governance structure for addressing risks to animal and plant health in UK (7)	Pan-organisations (7)	3 month study (which included other aspects)	2	VSM	Ladder of abstraction							The methods can be complimentary and help you look at a problem through a different lenses to discover different aspects or cover different parts of the problem space e.g.as consultants we are seeking to understand the problem, structure it so that we can reflect it back to our customer in some sort of order and then identify a way forward. Thus we use different tools in different parts of that process but often iterate. e.g. Laddering and SSM questions help you to identify whether you are studying the right problem to start off with. Most of my problems are multi-stakeholder so part of the approach is about getting the stakeholder community to a degree of shared problems understanding so we build rich pictures but so when I facilitate a group I will use SSM, VSM, CSH, metaphor, iceberg.... as thinking tools to inquire of the group
Business Planning (13)	Director General (SCS3) (2)	6 months	2	VSM	HPM [Hierarchical Process Modelling]							To tailor the method to the problem
Business Planning (13)	Director (SCS2) (2)	12 months	3	HPM [Hierarchical Process Modelling]	VSM	Maturity Models						
Setting strategic goals (3)	SCS3 Government Department Business Unit (2)	1 year	4	VSM	Causal loop modelling	SSM (root definitions & conceptual activity modelling)	Visualisation					To gain an in depth understanding of a subjectively problematic situation as a means of providing actionable intelligence to the customer.
Reorganisation of Departmental Agency (7)	Corporate centre Departmental Agency (2)	Seconded into transformation team for 12 months	4	VSM	Rich pictures	Brainstorming	Activity modelling					The methods can be complimentary[...] [as for second example above]

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**								**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Reorganisation of team in central government department (7)	Government Department Business Unit (SEO) (4)	I was embedded part time with team for 6 months	5	VSM	Gareth Morgan's metaphors	Iceberg model	Ladder of abstraction	Brainstorming				
System health (6)	Government Department, SCS3 downwards (2)	3 months	6	VSM	Italian flag	Structured interviews	Structured workshops	Stakeholder mapping	RACI [Responsible, Accountable, Consulted, Informed]			Capture of understanding of the system through iterative stakeholder mapping and 1-1 engagement through interview; system representation through VSM and RACI; health scoring through structured stakeholder workshops, Italian flag scoring, elicitation and capture of rationale for scoring.
Strategy development (3)	Departmental Agency, divisional senior management team (3)	ca 5 days	8	VSM	Strategy diamond	Context mapping	PESTLE	SWOT	Scenario development	Pig [Gareth Morgan]	Power vs interest	Range of methods to understand the system in focus, the external environment, freedoms and constraints, opportunities to shape potential strategic choices, and scenarios to understand the resilience of the future organisation against potential future challenges.
Organisational change (7)	Government Department Capabilities, programme level (3)	6 months to first draft, 2 years to IOC [initial operating capability]	8	VSM	Facilitation	Context mapping	Interviewing	Brainstorming	Collaboration	Visualisation	Problem solving	I don't know of any problem that doesn't require a mix of methods if you include softer OR skills/approaches. Although many problems 'major' on a certain method, they will always need additional skills (as above). I work in the soft OR area so major on facilitation and consultancy [s]kills, drawing in OR method as a means of structuring or visualising a problem. [...] perhaps add an alternative view that is more 'general' i.e., whatever my problem, I tend to use a mix of these approaches.... (more difficult in 'softer' problem solving areas).

Note: For projects with SSM, see Table 67 below.

Table 66: Project examples with other systems thinking methods (system dynamics and systems analysis)

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**							**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	
National Capability Planning (1)	SCSI Head Office Government Department + Other Government Departments (2)	3 months (which became 2 years)	5	System Dynamics	SSM	Scenario Planning	Workshops	Graphical Display Methods		I tried system dynamics to understand some of the key flows between parts of the system (money was one) - this was interesting in shaping the extent of the system we were interested in but it didn't get us towards a solution. I tried SSM which took things one step further. The problem boiled down to understanding supply and demand across a national capability - multiple suppliers and multiple demanders. In the end we used some scenario planning and a series of workshops to build pictures of supply, demand, gaps and health (ability to sustain the current position).
Policy Analysis (12)	Minister (1)	6 months	6	SWOT	Brainstorm	Stakeholder [Analysis]	Policy Analysis	Systems Analysis	Risk Analysis	To enable the most effective approach to the problem at hand, taking into account the data available and the stakeholder views.
Major change to departmental structure and management (7)	Minister (1)	4 months	6	Data analytics	Psychological analysis	Market analysis	Systems analysis	Rich pictures	Data visualisation	

Table 67: Project examples with SSM (soft systems methodology)

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**								**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Organisational assessment and design (7)	SCSI Government Department Head Office (2)	3 months	2	SSM	VSM						I needed something to 'unpack' the problem and SSM fitted the bill well for this. I then needed a way of representing the problems in a recursive hierarchy which suited VSM. What I really needed after this was a good range of solution options, which was difficult to find based on just the VSM outputs.
Strategic - understanding the problem space (3)	Research councils - Research integrators (7)	2 weeks	3	Stakeholder analysis mapping	Network analysis	CATWOE / concept mapping					A single method was not sufficient to fully explore the rich problem space.
Reorganisation of Departmental Agency (7)	Corporate centre Departmental Agency (2)	Seconded into transformation team for 12 months	4	VSM	Rich pictures	Brainstorming	Activity modelling				The methods can be complimentary and help you look at a problem through a different lenses to discover different aspects or cover different parts of the problem space e.g.as consultants we are seeking to understand the problem, structure it so that we can reflect it back to our customer in some sort of order and then identify a way forward. Thus we use different tools in different parts of that process but often iterate. ... Most of my problems are multi-stakeholder so part of the approach is about getting the stakeholder community to a degree of shared problems understanding so we build rich pictures but so when I facilitate a group I will use SSM, VSM, CSH, metaphor, iceberg.... as thinking tools to inquire of the group
Setting strategic goals (3)	SCS3 Government Department Business Unit (2)	1 year	4	VSM	Causal loop modelling	SSM (root definitions & conceptual activity modelling)	Visualisation				To gain an in depth understanding of a subjectively problematic situation as a means of providing actionable intelligence to the customer.
National Capability Planning (1)	SCSI Head Office Government Department + Other Government Departments (2)	3 months (which became 2 years)	5	System Dynamics	SSM	Scenario Planning	Workshops	Graphical Display Methods			I tried system dynamics to understand some of the key flows between parts of the system (money was one) - this was interesting in shaping the extent of the system we were interested in but it didn't get us towards a solution. I tried SSM which took things one step further. The problem boiled down to understanding supply and demand across a national capability - multiple suppliers and multiple demanders. In the end we used some scenario planning and a series of workshops to build pictures of supply, demand, gaps and health (ability to sustain the current position).
Major change to departmental structure and management (7)	Minister (1)	4 months	6	Data analytics	Psychological analysis	Market analysis	Systems analysis	Rich pictures	Data visualisation		To enable the most effective approach to the problem at hand, taking into account the data available and the stakeholder views.

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**								**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Requirements Setting study (8)	SCS2 and SCS3 (2)	8 months + 6 month follow on	6	SME interviews	Financial modelling/ prediction	Stakeholder analysis	Rich Picture	Visualisation (sun ray diagram)	Financial modelling/ prediction (outsourced)		Complexity - it was not possible to address the issues with a single method because there was a lot of connectivity between issues, uncertainty in terms of need. For senior stakeholders there was also a need to draw in a variety of different visualisations to engage with them - this means that many different methods are needed to generate the data.
National Capability Development (1)	Government Department Business Unit Head Office, typically SCSI and above (2)	ranges from months to 2 years	7	SSM	Stakeholder analysis	HA / Literature search	Data analysis (data from training)	Simulation modelling	Gaming	Metagaming	It is not possible to generate credible evidence in support of [National Capability] Development decisions (i.e., [across all aspects of a departmental capability]) unless a multi-disciplinary approach is adopted.

Table 68: Project examples with cognitive mapping (SODA)

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**						**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	
Requirements setting (7)	Working level Departmental Agency (5)	6 hours	4	Elements of cognitive mapping	Feasibility & Impact Grids	Elements of Delphi (eliciting information individually first)	Bespoke framework [to capture information in desired format]		Cognitive mapping to develop goals and constituent activities, Delphi style elicitation of ideas to generate ideas from individuals, bespoke framework - to capture information in the desired format, feasibility impact grids to assess options.
Get more out of departmental professional analysts (2)	Government Department Heads of Analysis (SCSI) (2)	Team of 3 for 18 months	5	Stakeholder engagement	Cognitive map	Technical benchmarking	Community of practice	Seminars and website info	One method would not have been sufficient to meet the customer requirement
Project planning (13)	Government Department, SCSI downwards (2)	few hours	5	Brainstorm	Cognitive mapping	Swimlane analysis	Spreadsheet	Gantt chart	Exploration of the necessary steps needed to deliver against a high level requirement, constraints, freedoms, options, interfaces, delivery options, development of delivery plan

Table 69: Project examples with scenarios

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**						**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	
Business Case Submissions (4)	Govt Dept (6)	between 1 - 2 mths and 2 - 6mths	2	Scenario Analysis	Cost benefit analysis				Combination of cost benefit and OR effectiveness analysis, required for business case support
Requirements Capture (8)	N/A (8)	4 Months	2	Expert Workshop	Scenario				[My organization] may not hold all of the expertise hence need for [expert workshop]s in some cases. Scenarios (of varying detail with appropriate range of circumstances covered) frame the problems that are most likely/[impactful] to draw insights from and other techniques can be used to test these insights. At other times, one method cannot provide the answer to all aspects of a complex question.
Operations (5)	Policy (Government Department) (6)	9 Months	3	Scenario	Expert Workshops	Discrete Event Simulation			
Future national capability operating concepts (3)	Government Department Business Unit Head Office (6)	Ongoing project	3	Scenario planning	Simulation modelling	Expert workshops			To balance the hypothetical qualitative discussions with quantitative analysis, hopefully leading to more balanced insights.
OR to inform future equipment requirement and strategy (3)	Government Department Business Unit HEO (4)	Several Months	3	Scenario analysis	Expert Workshop	User interviews			To gather more information than using one technique and to see if different techniques might yield different answers
Capability investigation for transition of urgent operational facility (5)	Government Department Business Unit, SEO (4)	6 months	4	Scenario assessment	Future estimation/prediction	Functional Modelling	SME judgement		Complexity - it was not possible to address the issues with a single method because there was a lot of connectivity between issues, uncertainty in terms of need.
National Capability Planning (1)	SCSI Head Office Government Department + Other Government Departments (2)	3 months (which became 2 years)	5	System Dynamics	SSM	Scenario Planning	Workshops	Graphical Display Methods	I tried system dynamics to understand some of the key flows between parts of the system (money was one) - this was interesting in shaping the extent of the system we were interested in but it didn't get us towards a solution. I tried SSM which took things one step further. The problem boiled down to understanding supply and demand across a national capability - multiple suppliers and multiple demanders. In the end we used some scenario planning and a series of workshops to build pictures of supply, demand, gaps and health (ability to sustain the current position).
Setting requirements for future national capability (8)	Government Department Head Office (6)	Ongoing project	5	Scenario planning	Historical analysis	Simulation modelling	Gaming	Expert workshops	To balance the hypothetical qualitative discussions with quantitative analysis, hopefully leading to more balanced insights.
Domain assessments (6)	Government Department (Grade 6) (3)	3 months	5	Simulation modelling	Gaming (computer-based)	Expert Workshops	Historical Analysis	Scenario Building and Planning	All projects I am asked to lead/support are looking at systems level questions so it is important we consider many factors before delivering insights and analysis output to our customers. Single method studies are never suitable for these types of question hence we use a variety of techniques to ensure we can answer the customer's questions. We have a process we usually follow for general capability study questions which will include gaming, simulation, [expert] judgement, scenario building and statistical analysis but the process is flexible and can be amended as studies require.
OR to inform future equipment requirement and strategy (3)	Government Department Business Unit HEO (4)	Several Months	5	Scenario analysis	User interviews	Cost analysis	Isochrone analysis	[Domain-specific method]	To gather more information than using one technique and to see if different techniques might yield different answers

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**								**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	
Equipment business case support (4)	(8)	1 year	6	Expert Workshops	Scenario analysis	Optimisation	System modelling	Data visualisation	Benefits mapping		We do not have a method that covers the entire spectrum we need to explore.
Domain equipment capability analysis (11)	Government Department Procurement, Capability (6)	1 year (and ongoing for another 6+)	6	MCDA	Expert/ stakeholder advisors	Basic Excel tool constructed through systems thinking/ engineering approach	Complex bespoke models	Expert workshops	Scenario construction and analysis		The overall project has a very large scope. No one method is appropriate to answer the breadth of the study. For [quick turnaround projects] it may sometimes be appropriate to use a single established method but this is generally by exception as more often than not it is natural to use several even if in making the decision as to which to purse for the core analysis.
Capability people requirements (8)	Government Department Business Units, officers (5)	3 months	6	Deterministic modelling	Expert judgement / stakeholder judgement	Project management / Gantt charts	Scenario building	Historical analysis	Cost benefit analysis		The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. I often (initially) do not have the depth of knowledge or expertise required to answer the problem or properly formulate a methodology. As such, I will use expert or [stakeholder] judgement to properly understand the issues. Often historical analysis or data mining is necessary to gather data. Context is required (not least to ensure policy compliance and [quality assurance]) thus requiring usage of scenarios.
Cost-benefit analysis (4)	(8)	A little over a year	7	Discrete event simulation	Causal mapping	Scenario analysis	Brainstorming	PESTLE	Morphological box	Linear programming	This was a complex analysis project and numerous methods were used in different parts of the analysis. Linear programming was used to inform and populate one of the simulation models. The outputs of two simulation models were used as inputs to the causal mapping and benefits analysis. The qualitative analysis methods were used to scope the non-quantifiable issues (and in some cases led to the identification of aspects that could be quantified and used in the "hard" analysis).
Assessing factors which impact on national capability (6)	Departmental Agency Programme manager (Grade 6/7) and national capability stakeholders (Grades 6/7) (3)	4 months	7	Simulation modelling	Gaming (computer-based)	Expert Workshops	Statistical Analysis for hypothesis testing	Statistical Forecasting	Scenario Building and Planning	Historical Analysis	All projects I am asked to lead/support are looking at systems level questions so it is important we consider many factors before delivering insights and analysis output to our customers. [...] We have a process we usually follow for general capability study questions [...] [see above]

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**											**Why did you use more than one method...?**
			Σ	**1**	2	3	4	**5**	**6**	7	8	9	**10**	
National Capability Development (1)	Government Department Business Unit, SCS1 (2)	6 months	8	Expert judgement / stakeholder judgement	Project management / Gantt charts	Stakeholder mapping	Scenario building	Historical analysis	AHP	Benefits modelling	Brainstorming			The majority of problems I assess are complex, wide ranging and multi-dimensional. [...] [see above]
Implications of Policy Analysis (1)	Government Department Business Unit, SCS1 (2)	3 years	8	Expert judgement / stakeholder judgement	Project management / Gantt charts	Stakeholder mapping	Scenario building	AHP	Benefits modelling	Brainstorming	Stochastic computer modelling			
Strategy development (3)	Departmental Agency, divisional senior management team (3)	ca 5 days	8	VSM	Strategy diamond	Context mapping	PESTLE	SWOT	Scenario development	Pig [Gareth Morgan]	Power vs interest			Range of methods to understand the system in focus, the external environment, freedoms and constraints, opportunities to shape potential strategic choices, and scenarios to understand the resilience of the future organisation against potential future challenges.
Procurement (9)	SCS1 sometimes ministers (2)	Variable	9	Simulation modelling	Brainstorming (Osborn)	Cost-Benefit Analysis / Net Present Value / Financial Modelling	Delphi Technique (RAND)	Expert Workshops	MCDA / DA / Decision Tree	Project Management / Project Networks / Gantt Charts / Critical Path Analysis	Scenario Building/ Planning/ Analysis	SWOT Analysis		Questions are quite nebulous and require the generation of a portfolio of evidence which cover various factors from costs and numbers down to stakeholder influence analysis.
Capability development (1)	SCS1 and SCS2 (2)	Variable	9	Simulation modelling	Brainstorming (Osborn)	Cost-Benefit Analysis / Net Present Value / Financial Modelling	Delphi Technique (RAND)	Expert Workshops	MCDA / DA / Decision Tree	Project Management / Project Networks / Gantt Charts / Critical Path Analysis	Scenario Building/ Planning/ Analysis	SWOT Analysis		
Strategic operations (5)	Government Department Business Unit, SCS1 (2)	3 years	10	Expert judgement / stakeholder judgement	Project management / Gantt charts	Scenario building	Brainstorming	Stochastic computer modelling	Statistical analysis	MCDA	Historical analysis	Response surface modelling	Data mining / analytics	The majority of problems I assess are complex, wide ranging and multi-dimensional. [...] [see above]

Table 70: Project examples with brainstorming, SWOT, PESTLE

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**						**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	
Improving ways of working (2)	Head of Portfolio Office (Grade 6/7) at Government Department Business Unit (3)	1 week (others had started earlier) for 1-day workshop	2	Brainstorming	SWOT				
Setting strategic direction (Technology) (3)	Working with Domain User in Government Department Business Unit, ultimately for SCS4 (2)	1 month preparation for a 2-day workshop	3	Expert workshop	RACI analysis [Responsible, Accountable, Consulted, Informed]	Brainstorming			We often go through several steps, such as generating ideas and then analysing or rating them in some way, before trying to come up with agreed ways forward. Different tools and methods have strengths in each of these steps.
Setting strategic direction (3)	Departmental Agency Division Head (3)	1 week (others had started earlier) for 1-day workshop	3	Brainstorming	Stakeholder elicitation	Facilitated discussion and voting on options			
Domain strategic goals (3)	Government Department Business Unit Leadership (2)	1 year	4	Vision and Strategic Analysis	PEST	[Domain-specific method]	CBA		Complex and Uncertain Operational Environments; Integrated and Multidisciplinary Human-System Environments
Concept and delivery investigation (a specific equipment) (9)	Government Department Business Unit / Departmental Agency (6)	Over several months	4	Simple tabulation	SME 'So What?'	SWOT	Q Method		One method would not get us to all the outputs and outcomes we needed, or would not get us to the final outputs/outcomes. We needed to complete several steps to reach the end result.
Reorganisation of Departmental Agency (7)	Corporate centre Departmental Agency (2)	Seconded into transformation team for 12 months	4	VSM	Rich pictures	Brainstorming	Activity modelling		The methods can be complimentary and help you look at a problem through a different lenses to discover different aspects or cover different parts of the problem space e.g.as consultants we are seeking to understand the problem, structure it so that we can reflect it back to our customer in some sort of order and then identify a way forward. Thus we use different tools in different parts of that process but often iterate. ... Most of my problems are multi-stakeholder so part of the approach is about getting the stakeholder community to a degree of shared problems understanding so we build rich pictures but so when I facilitate a group I will use SSM, VSM, CSH, metaphor, iceberg.... as thinking tools to inquire of the group
Engineering decision making (11)	Chief Engineer (2)	<1month	4	SWOT	Critical Path	Stakeholder Analysis	Cost-Benefit Analysis		Tasks are by nature complex and require multiple methods to develop understanding of alternative factors, alternative viewpoints and due to complex nature often require breaking elements down into area where single methods can then be used. But to provide an answer requires the combination of techniques to provide a balanced thorough response.
Futures (10)	Government Department, SCS1 (2)	2 months	4	Pathways	Brainstorming	Morphological analysis	Workshop		Projects often have multiple phases or layers, where different techniques allow you to build up, filter and present evidence before analysing it.

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**						**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	
Improved Evidence-Based Policy Making (2)	Government Department Chief Scientist (2)	3 years	4	Gaming - within a training context	SWOT	Visualisation	Pre-mortem		To enable the most effective approach to the problem at hand, taking into account the data available and the stakeholder views.
Strategic Planning (1)	Government Department (SCSI) (2)	4 months	5	Brainstorm	Data Mining	Historical Analysis	Statistical Analysis	Project Mgt	Brainstorm with other team members for longer-term studies to consider options and methods and potential case studies etc. Data mining, HA and Stats used to identify-locate data and process/validate. PM to maintain personal oversight of budget allocated spend.
Strategic Planning (1)	Government Department Business Unit (SCSI) (2)	3 months	5	Brainstorm	Data Mining	Historical Analysis	Statistical Analysis	Project Mgt	
Departmental Agency workforce planning (1)	Departmental Agency (6)	1 day	5	Brainstorming	Assumption testing	SME 'So What?'	Focus Groups	SWOT	One method would not get us to all the outputs and outcomes we needed, or would not get us to the final outputs/outcomes. We needed to complete several steps to reach the end result.
Reorganisation of team in central government department (7)	Government Department Business Unit (SEO) (4)	I was embedded part time with team for 6 months	5	VSM	Gareth Morgan's metaphors	Iceberg model	Ladder of abstraction	Brainstorming	The methods can be complimentary and help you look at a problem through a different lenses [...] [see above]
The potential of a process to provide benefit in a government department (2)	Head of Function, Government Department Head Office (2)	4 months	5	Workshop	Thematic analysis of perspectives	SWOT	Stakeholder perspectives/ profiling	Stakeholder engagement	One method does not guarantee the most useful and fully thought through answer/options. Using multiple methods adds extra layers of detail and perspectives that supports the customer in making a more robust decision or forward plan. Some methods act as risk mitigations e.g. stakeholder engagement and profiling are to try and understand who might be impacted by my proposals so that I can encourage engagement or adjust plans
National capability analysis (1)	Government Department Business Unit, Senior m'gmt (2)	18 months	5	Expert Workshops	Brainstorming	Morphological Analysis	Cost-benefit analysis	Mathematical Programming	Three main reasons: 1. Many of the above cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope. Consequently many studies involved phases in which PSM [broadly defined] were employed followed by more focused analysis. 2. The above cases are typically very broad with several areas of interest for stakeholders ranging from e.g. "optimal" solutions, relative strengths and weaknesses, overall costs, current risks etc. 3. Some of the above cases used a range of methods as an understanding of the problem area emerged, in order to pull out more fidelity in specific areas
Project planning (13)	Government Department, SCSI downwards (2)	few hours	5	Brainstorm	Cognitive mapping	Swimlane analysis	Spreadsheet	Gantt chart	Exploration of the necessary steps needed to deliver against a high level requirement, constraints, freedoms, options, interfaces, delivery options, development of delivery plan

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**								**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
National Capability Development (1)	Government Department (Hd SCSI / DepHd Grade 6/7) (2)	3-4 Months	6	Gaming	PESTLE	Historical Analysis	Expert Workshop	Project Management	SWOT			No one method would meet the range of project requirements
Policy/ strategy development (3)	Government Department (Hd SCSI / DepHd Grade 6/7) (2)	1-12 Months	6	Gaming	PESTLE	Historical Analysis	Expert Workshop	Project management	SWOT			
Policy insights (12)	Government Department (6)	2 days	6	Brainstorming	PESTLE	Assumption Testing	Cone of Plausibility	SME 'So What?'	Wind Tunnelling			One method would not get us to all the outputs and outcomes we needed, or would not get us to the final outputs/outcomes. We needed to complete several steps to reach the end result.
Policy Analysis (12)	Minister (1)	6 months	6	SWOT	Brainstorm	Stakeholder [Analysis]	Policy Analysis	Systems Analysis	Risk Analysis			To enable the most effective approach to the problem at hand, taking into account the data available and the stakeholder views.
Training Facilities (location, staffing impact) (5)	SCSI+, Government Department and Business Units (2)	6 months	6	PESTLE	SWOT	MCDA	Financial Modelling	Project Management	Mathematical Programming			Complexity of the problem and at multiple levels (where should the facility be located, what is the impact on currently-shared staffing).
Option Assessment (4)	Government Department Business Unit, Middle m'gmt (3)	8 months	6	Statistical Analysis	Discrete Event Simulation	Brainstorming	Expert Workshops	Cost-Benefit Analysis	SWOT			Three main reasons: [...] [see above]
Cost-benefit analysis (4)	(8)	A little over a year	7	Discrete event simulation	Causal mapping	Scenario analysis	Brainstorming	PESTLE	Morphological box	Linear programming		This was a complex analysis project and numerous methods were used in different parts of the analysis. Linear programming was used to inform and populate one of the simulation models. The outputs of two simulation models were used as inputs to the causal mapping and benefits analysis. The qualitative analysis methods were used to scope the non-quantifiable issues (and in some cases led to the identification of aspects that could be quantified and used in the "hard" analysis).

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**									**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Organisational change (7)	Government Department Capabilities, programme level (3)	6 months to first draft, 2 years to IOC [initial operating capability]	8	VSM	Facilitation	Context mapping	Interviewing	Brainstorming	Collaboration	Visualisation	Problem solving	I don't know of any problem that doesn't require a mix of methods if you include softer OR skills/approaches. Although many problems 'major' on a certain method, they will always need additional skills (as above). I work in the soft OR area so major on facilitation and consultancy [s]kills, drawing in OR method as a means of structuring or visualising a problem. [...] perhaps add an alternative view that is more 'general' i.e., whatever my problem, I tend to use a mix of these approaches.... (more difficult in 'softer' problem solving areas).
National Capability Development (1)	Government Department Business Unit, SCS1 (2)	6 months	8	Expert judgement / stakeholder judgement	Project management / Gantt charts	Stakeholder mapping	Scenario building	Historical analysis	AHP	Benefits modelling	Brainstorming	The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. I often (initially) do not have the depth of knowledge or expertise required to answer the problem or properly formulate a methodology. As such, I will use expert or [stakeholder] judgement to properly understand the issues. Often historical analysis or data mining is necessary to gather data. Context is required (not least to ensure policy compliance and [quality assurance]) thus requiring usage of scenarios.
Implications of Policy Analysis (1)	Government Department Business Unit, SCS1 (2)	3 years	8	Expert judgement / stakeholder judgement	Project management / Gantt charts	Stakeholder mapping	Scenario building	AHP	Benefits modelling	Brainstorming	Stochastic computer modelling	

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**										**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Strategy development (3)	Departmental Agency, divisional senior management team (3)	ca 5 days	8	VSM	Strategy diamond	Context mapping	PESTLE	SWOT	Scenario development	Pig [Gareth Morgan]	Power vs interest			Range of methods to understand the system in focus, the external environment, freedoms and constraints, opportunities to shape potential strategic choices, and scenarios to understand the resilience of the future organisation against potential future challenges.
Procurement planning (9)	SCS1 (2)	6 mths	9	Cost-Benefit Analysis	Stakeholder analysis	Statistical Analysis	Statistical Forecasting	PESTLE	Critical Path Analysis	Delphi	Benefits Modelling	Expert Workshop		Tasks are by nature complex and require multiple methods to develop understanding [...] [see above]
Procurement (9)	SCS1 sometimes ministers (2)	Variable	9	Simulation modelling	Brainstorming (Osborn)	Cost-Benefit Analysis / Net Present Value / Financial Modelling	Delphi Technique (RAND)	Expert Workshops	MCDA / DA / Decision Tree	Project Management / Project Networks / Gantt Charts / Critical Path Analysis	Scenario Building/ Planning/ Analysis	SWOT Analysis		Questions are quite nebulous and require the generation of a portfolio of evidence which cover various factors from costs and numbers down to stakeholder influence analysis.
Capability development (1)	SCS1 and SCS2 (2)	Variable	9	Simulation modelling	Brainstorming (Osborn)	Cost-Benefit Analysis / Net Present Value / Financial Modelling	Delphi Technique (RAND)	Expert Workshops	MCDA / DA / Decision Tree	Project Management / Project Networks / Gantt Charts / Critical Path Analysis	Scenario Building/ Planning/ Analysis	SWOT Analysis		
Strategic decision (departmental policy) making (3)	SCS1-SCS3 (2)	1 year	10	Cost-Benefit Analysis	Stakeholder analysis	Statistical Analysis	Statistical Forecasting	PESTLE	Critical Path Analysis	Delphi	Benefits Modelling	Historical Analysis	MCDA	Tasks are by nature complex and require multiple methods to develop understanding [...] [see above]
Strategic operations (5)	Government Department Business Unit, SCS1 (2)	3 years	10	Expert judgement / stakeholder judgement	Project management / Gantt charts	Scenario building	Brainstorming	Stochastic computer modelling	Statistical analysis	MCDA	Historical analysis	Response surface modelling	Data mining / analytics	The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, [...] [see above]

Table 71: Other project examples with Management/Strategy methods

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**							**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	
IT Procurement Planning (9)	Government department business unit (experienced official) (3)	12 mths	2	Logical Activity Modelling	Business Activity Modelling					The presenting problem needed methods a) linking strategic outcomes to business processes and b) linking business processes and information structures.
Prioritisation (4)	N/A (8)	3 Months	2	Benefits Modelling	Balance Score Card					One method cannot provide the answer to all aspects of a complex question
Business Planning (13)	Director (SCS2) (2)	12 months	3	HPM [Hierarchical Process Modelling]	VSM	Maturity Models				To tailor the method to the problem
Domain Capability Audit (6)	Government Department Business Unit, Middle m'gmt (3)	6 months	3	Expert Workshops	Graph Theory/ Network Analysis	Balanced Scorecard				Three main reasons: 1. Many of the above cases where initially ill-defined and required activity with stakeholders in order to understand key requirements and scope. Consequently many studies involved phases in which PSM [broadly defined] were employed followed by more focused analysis. 2. The above cases are typically very broad with several areas of interest for stakeholders ranging from e.g. "optimal" solutions, relative strengths and weaknesses, overall costs, current risks etc. 3. Some of the above cases used a range of methods as an understanding of the problem area emerged, in order to pull out more fidelity in specific areas
Requirements setting (8)	Working level Departmental Agency (5)	6 hours	4	Elements of cognitive mapping	Feasibility & Impact Grids	Elements of Delphi (eliciting information individually first)	Bespoke framework (to capture information in desired format)			Cognitive mapping to develop goals and constituent activities, Delphi style elicitation of ideas to generate ideas from individuals, bespoke framework - to capture information in the desired format, feasibility impact grids to assess options.
Damage Estimation (11)	Government Department Business Unit (6)	Requests answered in weeks - built on years of experience	4	Engineering simulations	Hi-Fidelity simulations	Trials (operations)	Lab based experiments			Engineering models cannot model the complexity of all the interactions. The hi-fidelity models take too long to run. All models have to be validated against trails, operations and experiments.
Review of the process used within government department to ensure humans are appropriately protected if they are taking part in research sponsored by department (2)	SCS2 (2)	3 months	5	NPV / Financial Modelling	Process Mapping	Data Visualisation	Project Management	Stakeholder Analysis		Tools in and of themselves rarely in my experience 'work', and definitely not in isolation. It is important to use an approach that will work in the circumstances and achieves buy-in from customers/end users. This I would class as a soft systems approach.

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**							**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	
Review of governance and operating models used with Departmental Agency to enable transformation and realisation of costs savings (7)	Departmental Agency Executive level (2)	6 months	5	COSO [Committee of sponsoring organisations of the Treadway commission]	Benefits Mapping	Cost Benefit	Prince II concepts	Managing Successful Programmes		Tools in and of themselves rarely in my experience 'work', and definitely not in isolation. It is important to use an approach that will work in the circumstances and achieves buy-in from customers/end users. This I would class as a soft systems approach.
Get more out of departmental professional analysts (2)	Government Department Heads of Analysis (SCSI) (2)	Team of 3 for 18 months	5	Stakeholder engagement	Cognitive map	Technical benchmarking	Community of practice	Seminars and website info		One method would not have been sufficient to meet the customer requirement
Strategic Workforce planning (1)	SCS3 Government Department stakeholders (2)	6 months	5	Visualisation (graphs and geographic)	Spreadsheet modelling	SME workshops	Manual and automated text analysis	Benchmarking		Using Excel + Tableau to develop understanding of workforce. Use workshops for 2-way knowledge transfer, excel modelling to conduct what-ifs, text analysis to identify functions undertaken by personnel, benchmarking to help compare and contrast across multiple organisations within [government department].
Major change to departmental structure and management (7)	Minister (1)	4 months	6	Data analytics	Psychological analysis	Market analysis	Systems analysis	Rich pictures	Data visualisation	To enable the most effective approach to the problem at hand, taking into account the data available and the stakeholder views.
System health (6)	Government Department, SCS3 downwards (2)	3 months	6	VSM	Italian flag	Structured interviews	Structured workshops	Stakeholder mapping	RACI [Responsible, Accountable, Consulted, Informed]	Capture of understanding of the system through iterative stakeholder mapping and 1-1 engagement through interview; system representation through VSM and RACI; health scoring through structured stakeholder workshops, Italian flag scoring, elicitation and capture of rationale for scoring.

Table 72: Project examples with Stakeholder Analysis

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**							**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	
Strategic - understanding the problem space (3)	Research councils - Research integrators (7)	2 weeks	3	Stakeholder analysis mapping	Network analysis	CATWOE / concept mapping				A single method was not sufficient to fully explore the rich problem space.
Developing a roadmap (10)	Officer (5)	Team of 1 for a few months	3	Stakeholder analysis	Strategic roadmapping workshop	Interviews with stakeholders				One method would not have been sufficient to meet the customer requirement
Engineering decision making (11)	Chief Engineer (2)	<1month	4	SWOT	Critical Path	Stakeholder Analysis	Cost-Benefit Analysis			Tasks are by nature complex and require multiple methods to develop understanding of alternative factors, alternative viewpoints and due to complex nature often require breaking elements down into area where single methods can then be used. But to provide an answer requires the combination of techniques to provide a balanced thorough response.
Review of the process used within government department to ensure humans are appropriately protected if they are taking part in research sponsored by department (2)	SCS2 (2)	3 months	5	NPV /Financial Modelling	Process Mapping	Data Visualisation	Project Management	Stakeholder Analysis		Tools in and of themselves rarely in my experience 'work', and definitely not in isolation. It is important to use an approach that will work in the circumstances and achieves buy-in from customers/end users. This I would class as a soft systems approach.
Organisational best practice (2)	Civil servant, Programme Leader (3)	Intermittently over 9 months	5	Structured interviews	Numerical analysis	Stakeholder analysis	Data visualisation	Presentation of findings		To access diversity of viewpoints, keep audience interested/engaged, challenge problem from different perspectives, make outputs more relevant to customers.
Identifying and prioritising investment options (4)	SCS2, Government Department Head Office (2)	Team of 4 for 6 months/ ongoing	5	Stakeholder analysis	Semi-Structured interviews	Qualitative data in spreadsheet	Team judgement	Facilitated workshop with customers	Potentially more	One method would not have been sufficient to meet the customer requirement
The potential of a process to provide benefit in a government department (2)	Head of Function, Government Department Head Office (2)	4 months	5	Workshop	Thematic analysis of perspectives	SWOT	Stakeholder perspectives/ profiling	Stakeholder engagement		One method does not guarantee the most useful and fully thought through answer/options. Using multiple methods adds extra layers of detail and perspectives that supports the customer in making a more robust decision or forward plan. Some methods act as risk mitigations e.g. stakeholder engagement and profiling are to try and understand who might be impacted by my proposals so that I can encourage engagement or adjust plans
Policy Analysis (12)	Minister (1)	6 months	6	SWOT	Brainstorm	Stakeholder [Analysis]	Policy Analysis	Systems Analysis	Risk Analysis	To enable the most effective approach to the problem at hand, taking into account the data available and the stakeholder views.
Requirements Setting study (8)	SCS2 and SCS3 (2)	8 months + 6 month follow on	6	SME interviews	Financial modelling/ prediction	Stakeholder analysis	Rich Picture	Visualisation (sun ray diagram)	Financial modelling/ prediction (outsourced)	Complexity - it was not possible to address the issues with a single method because there was a lot of connectivity between issues, uncertainty in terms of need. For senior stakeholders there was also a need to draw in a variety of different visualisations to engage with them - this means that many different methods are needed to generate the data.
System health (6)	Government Department, SCS3 downwards (2)	3 months	6	VSM	Italian flag	Structured interviews	Structured workshops	Stakeholder mapping	RACI [Responsible, Accountable, Consulted, Informed]	Capture of understanding of the system through iterative stakeholder mapping and 1-1 engagement through interview; system representation through VSM and RACI; health scoring through structured stakeholder workshops, Italian flag scoring, elicitation and capture of rationale for scoring.

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**										**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
National Capability Development (1)	Government Department Business Unit Head Office, typically SCS1 and above (2)	ranges from months to 2 years	7	SSM	Stakeholder analysis	HA / Literature search	Data analysis (data from training)	Simulation modelling	Gaming	Metagaming				It is not possible to generate credible evidence in support of [national capability] Development decisions (i.e., [across all aspects of a departmental capability]) unless a multi-disciplinary approach is adopted.
National Capability Development (1)	Government Department Business Unit, SCS1 (2)	6 months	8	Expert judgement / stakeholder judgement	Project management / Gantt charts	Stakeholder mapping	Scenario building	Historical analysis	AHP	Benefits modelling	Brainstorming			The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. I often (initially) do not have the depth of knowledge or expertise required to answer the problem or properly formulate a methodology. As such, I will use expert or [stakeholder] judgement to properly understand the issues. Often historical analysis or data mining is necessary to gather data. Context is required (not least to ensure policy compliance and [quality assurance]) thus requiring usage of scenarios.
Implications of Policy Analysis (1)	Government Department Business Unit, SCS1 (2)	3 years	8	Expert judgement / stakeholder judgement	Project management / Gantt charts	Stakeholder mapping	Scenario building	AHP	Benefits modelling	Brainstorming	Stochastic computer modelling			
Strategy development (3)	Departmental Agency, divisional senior management team (3)	ca 5 days	8	VSM	Strategy diamond	Context mapping	PESTLE	SWOT	Scenario development	Pig [Gareth Morgan]	Power vs interest			Range of methods to understand the system in focus, the external environment, freedoms and constraints, opportunities to shape potential strategic choices, and scenarios to understand the resilience of the future organisation against potential future challenges.
Procurement planning (9)	SCS1 (2)	6 mths	9	Cost-Benefit Analysis	Stakeholder analysis	Statistical Analysis	Statistical Forecasting	PESTLE	Critical Path Analysis	Delphi	Benefits Modelling	Expert Workshop		Tasks are by nature complex and require multiple methods to develop understanding of alternative factors, alternative viewpoints and due to complex nature often require breaking elements down into area where single methods can then be used. But to provide an answer requires the combination of techniques to provide a balanced thorough response.
Strategic decision (departmental policy) making (3)	SCS1-SCS3 (2)	1 year	10	Cost-Benefit Analysis	Stakeholder analysis	Statistical Analysis	Statistical Forecasting	PESTLE	Critical Path Analysis	Delphi	Benefits Modelling	Historical Analysis	MCDA	

Table 73: Project examples with Historical Analysis

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**									**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Operational Planning (5)	Government Department (SCSI) (2)	1 week	2	Data Mining	Historical Analysis							Data mining, HA and Stats used to identify-locate data and process/validate. PM to maintain personal oversight of budget allocated spend.
Operational Planning (5)	Government Department Business Unit (SCSI) (2)	1 month	4	Data Mining	Historical Analysis	Statistical Analysis	Project Mgt					
Strategic use of national capability (1)	Government Department Business Unit Leadership (2)	Months	4	Deterministic modelling	Monte Carlo modelling	Historical Analysis	SME subjective/ objective assessment					To cover different aspects of the problem space
Strategic Planning (1)	Government Department (SCSI) (2)	4 months	5	Brainstorm	Data Mining	Historical Analysis	Statistical Analysis	Project Mgt				Brainstorm with other team members for longer-term studies to consider options and methods and potential case studies etc. Data mining, HA and Stats used to identify-locate data and process/validate. PM to maintain personal oversight of budget allocated spend.
Strategic Planning (1)	Government Department Business Unit (SCSI) (2)	3 months	5	Brainstorm	Data Mining	Historical Analysis	Statistical Analysis	Project Mgt				
Setting requirements for future national capability (8)	Government Department Head Office (6)	Ongoing project	5	Scenario planning	Historical analysis	Simulation modelling	Gaming	Expert workshops				To balance the hypothetical qualitative discussions with quantitative analysis, hopefully leading to more balanced insights.
Equipment Procurement (9)	Government Department Procurement (6)	months	5	Discrete event simulation	Q-method	Expert Workshops	Statistical Analysis	Historical Analysis				To ensure multiple perspectives on a problem are derived and therefore to increase the evidence base. In addition some of the methods are used to narrow down options for other methods, e.g. some expert workshops are used to define the scope of a simulation activity or a gaming event.
Domain assessments (6)	Government Department (Grade 6) (3)	3 months	5	Simulation modelling	Gaming (computer-based)	Expert Workshops	Historical Analysis	Scenario Building and Planning				All projects I am asked to lead/support are looking at systems level questions so it is important we consider many factors before delivering insights and analysis output to our customers. Single method studies are never suitable for these types of question hence we use a variety of techniques to ensure we can answer the customer's questions. We have a process we usually follow for general capability study questions which will include gaming, simulation, [expert] judgement, scenario building and statistical analysis but the process is flexible and can be amended as studies require.
National Capability Development (1)	Government Department (Hd SCSI / DepHd Grade 6/7) (2)	3-4 Months	6	Gaming	PESTLE	Historical Analysis	Expert Workshop	Project Management	SWOT			No one method would meet the range of project requirements
Policy/ strategy development (3)	Government Department (Hd SCSI / DepHd Grade 6/7) (2)	1-12 Months	6	Gaming	PESTLE	Historical Analysis	Expert Workshop	Project management	SWOT			

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**									**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Operational Planning (5)	CSA [Chief Scientific Adviser] (2)	months	6	ABM	Discrete Event Simulation	Expert Workshops	Statistical Analysis	Historical Analysis	Gaming			To ensure multiple perspectives on a problem are derived and therefore to increase the evidence base. In addition some of the methods are used to narrow down options for other methods, e.g. some expert workshops are used to define the scope of a simulation activity or a gaming event.
Capability people requirements (8)	Government Department Business Units, officers (5)	3 months	6	Deterministic modelling	Expert judgement / stakeholder judgement	Project management / Gantt charts	Scenario building	Historical analysis	Cost benefit analysis			The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, it is extremely unlikely that any one single methodology will provide an adequate response. I often (initially) do not have the depth of knowledge or expertise required to answer the problem or properly formulate a methodology. As such, I will use expert or [stakeholder] judgement to properly understand the issues. Often historical analysis or data mining is necessary to gather data. Context is required (not least to ensure policy compliance and [quality assurance]) thus requiring usage of scenarios.
National Capability Development (1)	Government Department Business Unit Head Office, typically SCS1 and above (2)	ranges from months to 2 years	7	SSM	Stakeholder analysis	HA / Literature search	Data analysis (data from training)	Simulation modelling	Gaming	Metagaming		It is not possible to generate credible evidence in support of [national capability] Development decisions (i.e., [across all aspects of a departmental capability]) unless a multi-disciplinary approach is adopted.
Assessing factors which impact on national capability (6)	Departmental Agency Programme manager (Grade 6/7) and national capability stakeholders (Grades 6/7) (3)	4 months	7	Simulation modelling	Gaming (computer-based)	Expert Workshops	Statistical Analysis for hypothesis testing	Statistical Forecasting	Scenario Building and Planning	Historical Analysis		All projects I am asked to lead/support are looking at systems level questions so it is important we consider many factors before delivering insights and analysis output to our customers. [...] We have a process we usually follow for general capability study questions [...] [see above]
National Capability Development (1)	Government Department Business Unit, SCS1 (2)	6 months	8	Expert judgement / stakeholder judgement	Project management / Gantt charts	Stakeholder mapping	Scenario building	Historical analysis	AHP	Benefits modelling	Brainstorming	The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, [...] [see above]

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**											**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Strategic decision (departmental policy) making (3)	SCS1-SCS3 (2)	1 year	10	Cost-Benefit Analysis	Stakeholder analysis	Statistical Analysis	Statistical Forecasting	PESTLE	Critical Path Analysis	Delphi	Benefits Modelling	Historical Analysis	MCDA	Tasks are by nature complex and require multiple methods to develop understanding of alternative factors, alternative viewpoints and due to complex nature often require breaking elements down into area where single methods can then be used. But to provide an answer requires the combination of techniques to provide a balanced thorough response.
Strategic operations (5)	Government Department Business Unit, SCS1 (2)	3 years	10	Expert judgement / stakeholder judgement	Project management / Gantt charts	Scenario building	Brainstorming	Stochastic computer modelling	Statistical analysis	MCDA	Historical analysis	Response surface modelling	Data mining / analytics	The majority of problems I assess are complex, wide ranging and multi-dimensional. As such, [...] [see above]

Table 74: Other project examples (not in other tables), including with other Qualitative/Soft OR methods

Subject matter (Figure 15 category)	**Customer** (Figure 16 category)	**Time available**	**Methods**						**Why did you use more than one method...?**
			Σ	**1**	**2**	**3**	**4**	**5**	
Operational planning (5)	Government Department Business Unit Leadership (2)	3 yrs	3	[Domain-specific method]	[Domain-specific method]	[Domain-specific method]			Complex and Uncertain Operational Environments; Integrated and Multidisciplinary Human-System Environments
Collecting delegate feedback (2)	Internal Government Department (6)	3 months	3	Questionnaire	Electronic voting	Thematic Analysis			To gain further insight into delegate opinions. The e-voting allowed them to choose single options and provided quantifiable data. The questionnaire allowed them to explain their choices. The thematic analysis allowed me to draw out common themes from across a broad sample of delegates, based on those qualitative responses to questionnaires.
Future policy awareness (10)	Experienced official, Departmental Agency (3)	2 days prep, 1 day delivery	3	Facilitated workshop	Expert workshop	Output summary			To access diversity of viewpoints, keep audience interested/engaged, challenge problem from different perspectives, make outputs more relevant to customers.
Designing a process pilot (2)	Head of Function, Government Department Head Office (2)	4 months	3	Stakeholder engagement	Problem structuring with "6 questions"	Visualisation			One method does not guarantee the most useful and fully thought through answer/options. Using multiple methods adds extra layers of detail and perspectives that supports the customer in making a more robust decision or forward plan. Some methods act as risk mitigations e.g. stakeholder engagement and profiling are to try and understand who might be impacted by my proposals so that I can encourage engagement or adjust plans, and visualisations are often part of attempts to manage expectations/clarify problems and show how my proposal presents a solution to that problem.
Ensuring research programme aligned to and achieves strategic objectives in Personnel area (2)	Assistant Head Government Department Function (3)	2 months	4	Structured interviews	Data visualisation	Thematic analysis - wants and needs	Mapping (needs to objectives)		
Identifying and prioritising capability collaboration options (2)	SCS3/2 International Capability Steering Board via officers (2)	Team of 4 for a year/ ongoing	4	Literature search	Stakeholder engagement	Bespoke qualitative analysis method to compare capabilities (piloted first)	Facilitated workshop with key subject matter experts		One method would not have been sufficient to meet the customer requirement
Departmental Agency User Needs - programme mapping (2)	Departmental Agency (6)	7-8 specific days	5	Simple tabulation	Mind-mapping	Assumption testing	SME 'So What?'	Focus Groups	One method would not get us to all the outputs and outcomes we needed, or would not get us to the final outputs/outcomes. We needed to complete several steps to reach the end result.

Appendix U Survey: Project success results and analysis

In this appendix, I report survey results on project success. For further details of the survey, see section 4.6 and chapter 5 above.

1. Practitioners' project success ratings

Figure 54 below shows practitioners' ratings of average project success for their single and multimethod projects. For single method projects, the median rating was five out of ten, for multimethod projects it was 8 out of 10.

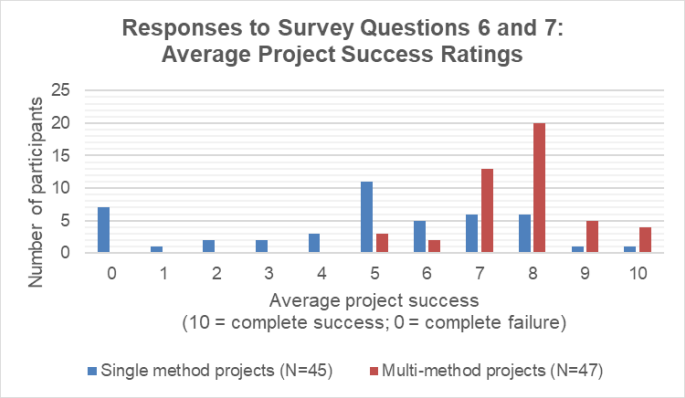
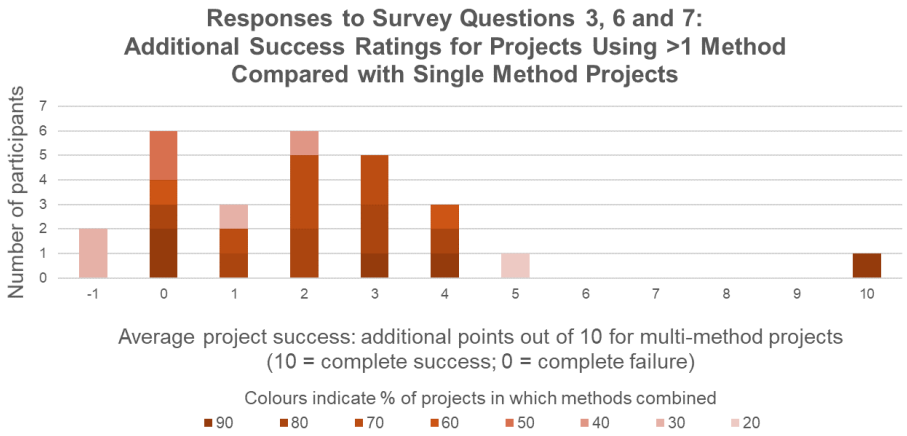


Figure 54: Success ratings for single and multimethod projects

70% (19) of 27 practitioners who reported using both single and multimethod approaches in their work rated the average success of their multimethod projects higher than their single method projects, while 30% (8/27) rated it the same or slightly worse. Figure 55 shows the additional points out of ten that practitioners gave for average project success when they use more than one method, as compared with when they use one OR method (without other methods).



Adapted from Christie (2017a, p. 19; 2017b, p. 12)

Figure 55: Additional success ratings for multimethod projects (N=27)

2. Practitioners' explanations of their project success ratings

In this section, I review how practitioners explained differences in their project success ratings, and other views of project success from across survey responses. Results are summarized in Table 75 below.

Amongst practitioners who *rated the success of their multimethod projects higher that their single-method projects*, the dominant theme from their explanations was that single method projects provide only a partial response or limited output, being from one perspective (e.g., only qualitative judgement, or only quantitative output) and less thorough in the aspects of 'the problem' and context covered or understood. With multimethod projects, practitioners could: achieve better, broader understanding of the 'problem/question' or 'whole system' from different perspectives, covering a range of requirements; 'model particular areas in more detail'; and, triangulate findings, hence the greater success of their multimethod projects, on average. At the same time, amongst these practitioners, one noted that project success is 'Always dependent on a balance of the circumstances, question being addressed, and the time available', while one had found it was important (for success) to use multiple methods in 'a planned and coordinated fashion' with a 'clear understanding of overall requirements'.

In terms of other explanations of higher project success for multimethod projects, three participants noted that combining methods 'adds value', or that 'different methods [...] are each more useful for different parts of the problem', or 'strands of enquiry', given 'Cost and resourcing constraints'. Another three practitioners implicated the suitability of choice of a single or multimethod approach, given the project or questions tackled, with multiple methods seen as required for certain projects, including for 'strategic level' questions 'for robustness', and for 'complex (if not chaotic)' questions requiring 'a multi-disciplinary approach [...] to represent [domain] capability sufficiently' (q8). Other explanations included higher expectations and quality control of single method projects, where 'often the problem is perceived to be simple - even if it is not' (one participant), and 'maybe' coincidence (one participant).

Three of six practitioners who *rated the success of their multimethod projects the same* as their single method projects provided views on what leads to success in their projects. Their reasons were 'matching methodology to a problem' (one participant), producing work that is not 'then ignored' (one participant), and use of 'well trodden' techniques and 'generating a common understanding of the problem with the customer [...] with ongoing customer collaboration' (one participant). That last participant also commented, 'I find that good knowledge management, collaboration and customer collaboration are equally as important to the solution of problems'. The other three of the six participants who *rated the success of their multi-method projects the same* as their single method projects instead provided reasons for choosing single or multi-method approaches, or no response to question 8.

Two participants *rated the average success of their single method projects slightly higher* because they were easier to deliver. For one, a single method was 'normally simpler [...] (and perhaps the problem being tackled simpler too)'. The other explained, 'We are able to deliver useful information / advice in time - but it is limited by unknowns within the scenario and what is experimentally possible'. Both participants reported combining methods in 30% of their projects.

Seven (of 19) practitioners who reported in question 3 that they *always combine methods* (see section 5.2.3 above) then commented on project success in question 8. The first theme, based on responses from four participants, was difficulty in defining, measuring or assessing project success, including understanding customer feedback scores reflecting their perceptions (one participant), and because

practitioner outputs may be different from the original ask (one participant), or not what the customer wishes to hear (two participants), and/or ignored (one participant). The second theme reflects three participants' comments on the value of seeing the 'big picture', the likelihood of 'tackling the real issue', and the client value from 'greater understanding' from using multiple methods. Three of the seven participants noted there were other or multiple factors to consider in project success, in addition to 'combining techniques', including 'complicating factors that contribute to whether a project is *deemed* a success or failure e.g. customer expectations, duration, etc.' (one participant, *emphasis added*), and not 'framing [the question or] the output incorrectly' (one participant).

Another participant, whose comments in question 8 suggest they used multiple methods in at least some projects, suggested that:

> [...] I suppose that more complex and involved projects might be slightly more likely to require multiple techniques and also being more complex slightly more prone to failure, but I really don't think that it is meaningful to look at technique to explain project success. (BTW: My personal observation is that complex simulations are almost always a poor solution as they tend to demand huge amounts of data). (q8) [...] *Generally success depends on whether there is enough time and resource to address the problem and whether the process is managed well, not which techniques are used*. (q10, *emphasis added*)

In summary, survey respondents together implicated a wide range of interrelated issues in explaining their assessments of levels of project success. These included the choice of methods and overall methodological approach, including its suitability given the project/questions/problem, benefits (including of multiple compared with single method approaches, and the other way around), and practitioners' (collective) experience of the methods. Issues included aspects of managing the process of a project, including choice and framing of questions to tackle, planning and co-ordination of methods, collaboration with clients and customers, achieving common understanding with project stakeholders, and presenting findings or framing output, as well as time available, project duration, and quality control processes. Assessments of project success were dependent upon customer expectations and perceptions, including whether projects delivered what clients wanted to hear, and whether outputs were acted upon, or ignored. There was acknowledgement that questions changed during projects, and that rather than answers and solutions, practitioners may provide a broader understanding of issues, leading to 'tackling the real issue'.

Table 75: Thematic summary of practitioners' explanations of their project success ratings and views of their project success

How frequently do you combine methods? (10-0) (Question 3)	Ppts	**Average multimethod project success** compared with single method projects	Ppts	**Explanations of differences in project success ratings** (Question 8)	Ppts	**Views of project success** (Question 8 and 10)	Ppts	Total ppts
10 (always combine)	19	Higher	11	**Seeing the bigger picture / real issue with multimethod projects,** • There is greater likelihood of seeing 'the big picture' (1), or leading to 'tackling the real issue' (1), or • The customer 'always gets value from the greater understanding they gain even if it does not lead to a solution' (1)	2	**I have difficulty defining, measuring or assessing success (4)** • Outputs may differ from original customer ask (1) or what customer wants to hear (2) or be ignored (1) • Difficulty understanding 'scores from customer feedback [...] tempered by perceptions of success' (1) **There are other/multiple factors to consider (3)** • 'other complicating factors that contribute to whether a project is deemed a success or failure e.g. customer expectations, duration, etc.' (1) • 'success of a project [...] will be multifactorial, not down to combining techniques' (1) • 'Typically [...] analysis gets it 'wrong' [...] as a result of framing the output incorrectly, or [...] choosing the wrong question in the first place to answer" (1)	3	**7**
		The same	2		0		1	
		Lower	0		0		0	
		Missing	6		1		1	
9-2 (sometimes combine)	30	Higher	19	**Single method projects provide partial responses** from one perspective (e.g., only qualitative judgement, or only quantitative) **whereas multimethod approaches allow practitioners to achieve better, broader understanding of the 'problem/question' or 'whole system' from different perspectives**, covering a range of requirements (3), 'model particular areas in more detail' (1), and triangulate findings (1)	9	**There are (also) other contributors to project success (3)** • 'Always dependent on a balance of the circumstances, question being addressed, and the time available.' (1) • Using multiple methods in 'a planned and coordinated fashion' with a 'clear understanding of overall requirements' (1) • Suitability of choice of single or multimethod approach, given project/questions (1)	3	**17**
				Combining methods 'adds value' (1) / **'different methods [...] are each more useful for different parts of the problem rather than the whole problem'** (1) / **'there is not "one size of analysis that fits all"** because of 'multiple strands of inquiry' and 'Cost and resourcing constraints' (1)	3			
				One method is 'not suitable' for 'strategic level' questions that cover more than one simple area (for robustness), whilst 'multi-million pound+' decisions 'require looking backwards, consideration of today and forecasting forward' (1) **nor for 'complex (if not chaotic) questions - [...]** need [...] a multi-disciplinary approach [...] to represent [domain] capability sufficiently' (1)	2			
				There are higher expectations and 'much more stringent' quality control of single method projects, where 'often the problem is perceived to be simple - even if it is not'	1			
				'It may be coincidental'	1			
		The same	6	**Single method projects are easier to deliver (2)** • A single method is 'normally simpler [...] (and perhaps the problem being tackled simpler too)' (1) • 'We are able to deliver useful information / advice in time - but it is limited by unknowns within the scenario and what is experimentally possible' (1)	2/2	**Other factors 'drive' success (3)** • 'matching methodology to a problem' (1) • Use of 'well-trodden' techniques and 'generating a common understanding of the problem with the customer [...] with ongoing customer collaboration' (q8); 'good knowledge management, collaboration and customer collaboration are equally as important to the solution of problems.' (q10) (1) • Producing work that is not 'then ignored' – '(Can a project be successful if it ultimately achieves little or nothing?)' (1)	3/6	**5**
		Lower	2					
		Missing	3	n/a	n/a	-	-	-
0 (never combine)	1	Missing	1	n/a	n/a	-	-	-
Missing / Excluded	4	Missing	4	n/a	n/a	'[...] Generally success depends on whether there is enough time and resource to address the problem and whether the process is managed well, not which techniques are used.' (q10)	1	**1**
Total	**54**	**Total**	**54**	**Total**	**21**	**Total**	**12**	**30 /54**

Appendix V Multiple case study results and analysis

Table 76: Selected practitioners' questionnaire responses, by case

Case	1. Analysis for a business case for future investment in a national capability	2. Review of an approach to an organizational process to advise on its applicability to the enhancement of a national capability	3. Review of a national capability to inform its future strategy	4. Review of options for the future organizational model and governance of an organization comprising a number of national capabilities	5. Review and prioritization of options for the future technological configuration of a national capability
Number of practitioners interviewed	2	1	1	2	1
Number of practitioners also participating in survey (chapter 5)	1	1	0	2	1
How frequently do you combine methods (0-10)? (survey question 3)	10/10	10/10	n/a	10/10; 5/10	8/10

Table 77: Overview of practitioner activities at intervention outset, by case

Case Subject matter	How intervention came about	Activities at outset of intervention	Purpose or function of activities (Why?)	Other reasons for / explanations of activities	Illustrative data	What practitioners did next
I. Analysis for a business case for future investment in a national capability	Practitioners' colleagues had provided OR analysis for previous business cases relating to the capability. This intervention was in the practitioners' organization's pipeline of work. Practitioners were assigned to deliver the intervention (provide OR analysis).	Background reading, talking to colleagues, meetings with stakeholders, capability site visits, discussions with assurers	To understand capability, problem space, stakeholders and their different views and requirements, methodological approaches To prepare for engaging with, and to engage, build trust, and form relationships with stakeholders To establish ways of working	To ask 'what do I need to be thinking about here in supporting this decision' For 'identifying the questions we need to answer, to satisfy those who are judging' (for development of methodological approach and study plan) / To avoid later delays 'some of the key stakeholders, [...] could derail' 'I needed access to [capability stakeholders'] data, to be able to do the [...] work effectively' To be seen as independent and impartial in case work Because of cultural differences and tensions between stakeholders with different views / 'this was complex politically and practically' Lack of awareness and experience of systems thinking methods used by practitioners in more recent projects (including pig diagrams, root definitions, CATWOE, stakeholder influence analysis/diagrams, power versus interest, stakeholder engagement plan, consideration of boundaries, context mapping) / 'the questions I was asking were exactly same as the ones that I would normally ask now' Discussions with assurers 'on advice of my [senior analyst]' [and in line with best practice in guidance]	'I didn't use formal toolsets! I asked questions. I asked 'why' a lot.' 'I came to this with no background in formal OR' 'I'd never worked with [assurance] before' Stakeholders had 'differing views and perspectives about what the work needs to accomplish'. 'There were so many so much politics going on here.' 'I don't think that I'd anticipated the political mess that was going on there? [QUIETLY] And how many different players had to be juggled?'	Choose methodology – MCDA; initiate work on MCDA criteria (capability user requirements/ benefits) and potential options (organizational models for the future capability); and, work on and document in a study plan (proposed methodological approach, tools, evidence sources, option costing methodology of government cost consultants who would do the costings, and intervention risks). Practitioners took consultancy approach (rather than delivering 'a cut and dried, straight OR piece') and challenged project clients with questions

Case Subject matter	How intervention came about	Activities at outset of intervention	Purpose or function of activities (Why?)	Other reasons for / explanations of activities	Illustrative data	What practitioners did next
2. Review of an approach to an organizational process to advise on its applicability to the enhancement of a national capability	As part of a wider initiative to enhance a national capability through a number of projects, the client tasked practitioners with talking with a named third-party commercial organization identified by the client. Around six months later, when leaders heard no action had been taken, other practitioners were asked to talk with the third party.	Two weeks of planning prior to meeting with third party	To understand that organization's approach to a particular organizational process. 'to be investigated 'as a possible way of doing [a particular organizational process] differently' To investigate and understand the applicability of the approach and how it differed from current practice [in government], and its value benefits and challenges [for government].	Practitioners tasked by project client with talking with named third party commercial organization, which project client had identified as of interest to them during pre-work in the context of a wider initiative to enhance a national capability though a number of projects in line with a new strategy.	'[…] [we practitioners] were tasked to go and talk to a [third party] company that our customer, [project client], had identified as somebody interesting to talk to when trying to work out what they were going to do in in the [capability domain] space. So, [a strategic review] had said […] we need to do more [in this domain]. We think we should do these things. There'd been some pre-work done by [client] looking at what that might look like to help inform [the organization developing the capability] so they already knew they wanted to do things like try and have [some new and/or enhanced, named 'industry' ways of working in this domain, including what another, larger initiative project on related capability processes was to develop and deliver] […]. And they wanted [the third company's approach] as a possible way of doing [a particular organizational process] differently' '[…] it was very much a what is good practice or what does this way of working look like and what might it do. […] it's part of an exercise where we went like this [OPENS ARMS WIDELY]. What does everybody else do, now what can we do.' '[…] they knew they wanted to talk to the [third party] company but they didn't know what they wanted to do with them or how to progress it […]'	Meeting with third party Discussions with colleagues for 'baseline' understanding of current government processes vis-à-vis third-party company processes Later, conducted a workshop with the third party and government stakeholders with relevant experience and knowledge.

Case Subject matter	How intervention came about	Activities at outset of intervention	Purpose or function of activities (Why?)	Other reasons for / explanations of activities	Illustrative data	What practitioners did next
3. Review of a national capability to inform its future strategy	Capability leaders, concerned about future funding for the capability, approached practitioners and asked them to draft a project plan. The main practitioner came to the intervention with some familiarity with the capability.	Writing and then refining project plan (description of project, need for it, and ideas of what practitioners could look at, given different stakeholder views) Drafting scoping document (description of what different stakeholders wanted from project – subject matter, issues, deadlines, questions, outputs, project team, and types of stakeholders to engage in 'structured conversations')	Writing project plan to obtain funding for intervention from client (achieved) Refining project plan as scoping document drafted Scoping document to understand and document views and stakeholder requirements / To check understanding of views To get stakeholder agreement / consensus (achieved after a number of weeks while the intervention was ongoing)	[standard documents within practitioners' organization?]	'[…] just some ideas of the types of things we could look at […] and more what we needed to look at to understand the problem space […] So there was [a number of] different viewpoints came in and so mine was very much trying to get down you need to think about certain aspects rather than particularly thinking about how I was going to do it or what I was going to do or anything like that.' 'I basically just wrote the, what it was, why we wanted to do it and all the rest of it.' '[…] trying to get a handle on what people wanted because you had [a number of] different [project] customers. […] we tried to put a [scoping] document together to match what we thought they were asking for.' '[…] we were getting so many different viewpoints, and so hence why we prob[ably] got numerous versions of it because we were trying to, you'd do it once and then, it would go round and, by the time you've got [a number of] people look at it, they've all got a different opinion of what's right and what's wrong, so, that was more just a process of iteration until everyone was kind of happy, or moderately happy, across the board. So it was more a, trying to get consensus than particularly a lot of thought going in from our side, […] are we interpreting what you are saying right, are you all agreed? […] it probably wasn't as us-led as much as it should be.' 'And as time went on you kept realising that they hadn't really decided even the one, none of them individually had decided exactly what they wanted so each time we asked them it moved slightly moved slightly so what we [were] originally asked wasn't what, we ended up with.'	Drafted scoping document, facilitated a series of information-gathering workshops with capability employees, worked on a paper of high-level assumptions about strategic needs, and later followed up workshops with stakeholder interviews, and obtaining information on capability income and costs. The strategic needs were derived from a review of extant strategy and policy documents (provided a means of 'measuring' (colour-coding according to meet, partially meet, or don't meet) the extent to capability activities – and, later, options – mitigated strategic risks, by mapping them to strategic needs

Case Subject matter	How intervention came about	Activities at outset of intervention	Purpose or function of activities (Why?)	Other reasons for / explanations of activities	Illustrative data	What practitioners did next
4. Review of options for the future organizational model and governance of an organization comprising a number of national capabilities	A review of the organization would be required. Practitioners were directed to do some preparatory work for the organization itself.	Background research looking at governmental guidance on options for organizational models, and their strengths and weaknesses Talking to people and looking at constitutional documents to understand organizational models and governance of other organizations Compiling comparative spreadsheet of findings (possible options)	To understand options that might be looked at in the review 'exploring what's the art of the possible here'	To prepare for the review 'we knew the review was going to happen. What we didn't know was quite when it was going to start. Because that was up to [the project team] when they wanted to start it' 'Looking at different models and looking at their different strengths and weaknesses. So fairly straightforward policy analysis type stuff, looking for other examples of other [organizations] that had changed [model], why they had changed [model], and when that had happened. What were the key drivers'	'a lot of this was around building a consensus internally. And then being prepared to start building that consensus externally as well as to what do our customers, and what do [the organization]'s senior stakeholders think. What do they want to happen with [the future organization]?' '[the organization] could have done absolutely nothing, and [the project team] would still have started the [project] anyway.'	Worked with organization executives to understand the organization's preferred option (their view of 'the best fit for the future of the organization') and why. This included 'benefits analysis' of the relative importance of aspects of the organizational model ('different characteristics of the organization') using simple ranking exercises with executives, to inform how they might negotiate the future [organizational model], if required. '[…] some other bits and pieces like stakeholder analysis', where practitioners, 'did the usual, four-box stakeholder [power-interest] analysis grid, and then we put that to the […] executive team and tried to get them to commit to owning those relationships […] [and] got an agreed stakeholder plan' From this analysis they 'developed things like a comm[unication]s plan' for staff of [the organization] and other stakeholders, including customers. In the meantime, the project leader was drafting a scoping document for the review.

Case Subject matter	How intervention came about	Activities at outset of intervention	Purpose or function of activities (Why?)	Other reasons for / explanations of activities	Illustrative data	What practitioners did next
5. Review and prioritization of options for the future technological configuration of a national capability	OR analysis for aspects of a periodic strategic review was in the pipeline of work of the practitioners' organization. An earlier intervention looked at many of the same issues (as this intervention) but was not considered a success. This intervention started several months after it was announced publicly, when it was assigned to the main practitioner. A scoping document for a wider, overarching project, led by the client, had been published some weeks before.	Discussions with clients and customer engagement committee, literature searches, meetings with colleagues, project team discussions and meetings	To progress project, given 'keen' client and tight timescale / To allow practitioners to 'deliver on time and cover as much as possible' '[...] trying to understand what the question is' / '[...] starting to think about, what would drive what the question really might be' To generate 'a view of what we should do' / To think about 'how to do it' / To explore methodological approach, while trying to avoid using a model that doesn't fit or the wrong model for the eventual question '[...] trying to work out what would the shape of all this was' [with customer engagement committee] / To agree and document the 'difficult' scope of the project, approach of practitioners and timetable / To decide what in and out of scope – where 'to draw the line' To try to align understanding with colleagues 'who have different perspectives on this [capability]' / To ensure 'we're not missing something really key'	To respond to pressure to get on with the project, given its announcement / To drive project for client As 'always', 'first step' is to understand what customer is trying to achieve / 'the route that most projects go on' / 'Analyst [...] thinks about, what that question might look like and what the solution space might look like' 'Complex, unbound' subject matter, 'challenging stakeholder base' [To engage (range of) customers] [Because colleagues in same organization may do overlapping work] [To learn from previous, similar studies undertaken by colleagues] '[...] one of the issues we had in [this intervention phase], is we had, pretty much zip I think the planning time was one afternoon?' [Less directed by client than subsequent intervention phases]	'So it was very, unbound initially. A very complex community. A lot of politics involved, politics small p. So you had [stakeholder groups] in particular domains, [...] always jock[ey]ing for position. So a lot of politics, lots of vested interests involved. Complex, [...] a lot of complexity in terms of [the domain, e.g. in linking capability elements to capability requirements/benefits] [...] Unbound, and difficult to scope and, challenging stakeholder base.' '[...] we had a few conversations [...] two or three meetings [with colleagues], about, how we could do this' / 'I don't recall using any formal [problem structuring] methods or anything like [...] we did sit around a whiteboard and we scribbled and scribbled and did whatever' '[...] you get into the, how much of it is sort of formal methods if you like that you could actually define and how much of it is actually a wet towel over your head thinking stuff and there's a lot of that ha ha. A lot of that goes on and a lot of informal, I suspect there was quite a lot of brainstorming and sitting in a room and certainly in the early stages because I was sitting with [main practitioner] and we had quite a lot of whiteboarding and, those sorts of, problem structuring type activities. By the time we got to [the later phase that is the focus of this research] I suspect we were fairly much into that and it was more, directed. But that's kind of the, route that most projects go on.'	Adapted and ran an existing multi-integer linear programme (MILP) and conducted expert workshops. For the MILP, practitioners used modelling from technical colleagues of representative equipment combinations, and a costing tool used by technical colleagues in a related project with functionality taken from an earlier OR intervention. The modelling was also informed by outside consultants' work on equipment available or under development by industry (products, performance and costs), cost-saving opportunities, and operational issues. A policy- and scenario-based review of capability requirements and assumptions, drawing on at least one previous study.

Source: Rich case descriptions (see section 4.10.5 above and Appendix L)

Table 78: Case mechanisms – illustrative data for case 1 (Figure 32)

Aspect of context	**Context** (structural analysis)	**Mechanisms of method choice** *(note)*	**Enabling / constraining conditions**	**Illustrative data** *(note)*	
				Agency	**Social structural conditioning**
Structure	Relations between intervention roles – practitioners and clients, and associated responsibilities and power	Practitioners' aim to deliver analysis in support of clients' business case	Clients' expectations of practitioners' work	'Everything's driven from what are you trying to achieve, in this piece [intervention] rather than taking a, methodology, approach basis to it. Let's start with the questions we need to answer, to satisfy those who are judging, [...]' (practitioner) '[QUIETLY] I think we challenged [clients] massively. We could have, in terms of doing the right job for [the client organization], I'd rate it very highly. Doing what the customer wanted, no. I was the thorn in their sides. But I kept [the client] out of hot water, [...] because they were ultimately responsible for making sure that a robust business case was being put through.' (practitioner)	'[...] it started off with, there's a business need, to, make sure that, the business case for, whatever the future of [the capability] is, has appropriate, [OR] support to it.' (practitioner) 'It's quite a formal process, owned by the [assurers]' (client) 'But, as I say, so it's back to understanding the context in which this [OR] happened. This was kind of forced upon us rather than something that we chose to do.' (client)
Structure	Relations between business case approval roles – practitioners and assurers; assurers and approvers – and associated responsibilities and power	Practitioners' aim to provide sufficient evidence, acceptable to assurers, who would advise business case approvers (decision makers)	Assurers' expectation of robust evidence	To provide 'at least sufficient evidence' for business case (practitioner) 'So we had to have something which [assurance], [...] would accept as being, sufficient basis to inform a decision by the seniors' (practitioner) 'The, fundamental disagreements we had in this area, were, about how much we actually had to do, to prove our case, back to, was this level of activity which was very large, appropriate, and what success metrics looked like in terms of value-for-money.' (client)	'Everything governed by the [policy documents]. Formal processes to go through. Formal boards whose requirements needed to be met all the way through. [...] Here you've got a whole load of hoops that need to be satisfied.' (practitioner) 'So, my role in most of that was, brokering the discussions between the people who were responsible for generating the evidence, [...] writing the business case [...] and the [assurance] teams who were requiring a particular level a particular standard a particular approach to the solution.' (client)
Structure	Relations between employment roles – practitioners and government employer – and associated responsibilities and power	Practitioners' aim to be seen as trustworthy, fair, independent practitioners (taking into account a broad range of stakeholder opinions, while seeking agreement as to recommendations)	Practitioners' employer's expectations of practitioners' work	'[...] [the MCDA paper] sets out a whole bunch of top-level scoring but also a massive sensitivity analysis. Looking at different perspectives. So it's not just about hard numbers, it's about how palatable options are to different communities, and what factors, where the key issues are between different communities. So therefore recommendations about how one can build a more viable system in the future, where your bridges need to be built, where you need to be searching for your common viewpoints. Hard numbers kind of didn't do it. Hard numbers were there, but it was really the richness that sat behind that?' (practitioner) 'So I think what we sought to choose was to extract comments [on workshop participants' rationales when voting on weights and scores] which, reflected the majority position. But I think it provides, useful additional colour, beyond, a fairly sterile, it's a six or a seven. And particularly can be used to illustrate or draw out some of the reasons which led to, people voting as they have. I think it also flags up some of the issues that, going forward, the [...] [parties] needed to think about, so for example perhaps some of the concerns or risks that people might have had so, our vote is a seven but, this point, so, if you do choose this option, then, that point represents something that, the [parties need] to have a think about. So it could be about, how a benefit could be better realised, or perhaps how, something's not working very well and needs to be addressed, [...]' (practitioner)	'There was such resistance, within the [existing capability] delivery community that there was any other way apart from [the existing capability]. And that nobody else could possibly do this, apart from [the existing capability]. There was no other delivery mechanism, apart from the one that there was now. I needed some mechanism to be able to challenge that, from a fact-based position. Through being able to paint some pictures about different ways of doing things. And what some of the pros and cons might be of that.' (practitioner) If, we'd have just done a straight [combination of MCDA and costings] on this, it wouldn't have given analysis that was really particularly helpful. Because actually it wouldn't have challenged any of the mess that was there. And that was the big thing that needed doing. [QUIETLY] Which was about challenging to make sure that the requirement set was the right one. Really pushing down on, [QUIETLY] what is the need for this thing?' (practitioner) 'the [main practitioner], was someone who was brought in, very much because, [they were], quite independent of that [capability] activity ongoing on.' (client)
Agency	Practitioners' dispositions	Practitioners' tendency to use available methods used in the past (not novel methods)	Limited resources (time and money) for OR projects and trying new methods Risk aversion (amongst practitioners and assurers)	'But, each question, there's a means to it? You focus on what it is that I need to achieve, and then, what are the appropriate toolsets to do that, that are already available? And if those toolsets don't fully satisfy the needs, then you look at other means of doing it. So what can you do to bring different things together. Can you integrate, can you develop a new, method. But I'll only develop a new method if, a totally new method if there isn't something there that which adequately delivers it safely.' (practitioner)	'We do things that we're comfortable with, and the techniques we're seeing, are stuff that's been used. [...] I think there are lots of techniques. The difficulty is, using them in the context that we want to use them [...] The difficulty we face is, if we are going to use a new technique, we really have to be sure it's going to work [...] and [intervention clients] have enough problem understanding benefits modelling. [...] part of my [assurer] role is to talk through the methodologies, and approaches and say, OK, you can do it this way, no-one has done it before, I think it's do-able, but you're taking a risk. And, generally, this is a risk, I think you categorize the [organization] as a risk averse organisation.' (assurer) 'we have got into a situation where we, are not applying novel techniques' (assurer)

Aspect of context	**Context** (structural analysis)	**Mechanisms of method choice** *(note)*	**Enabling / constraining conditions**	**Illustrative data** *(note)*	
				Agency	**Social structural conditioning**
Culture	Rules in policy documents for business case approvals	Rules requiring robust evidence from quantitative methods where possible, and measurement of cost-effectiveness of options Rules requiring the provision of additional commentary on risks and risk mitigations	Business case within scope of rules Unsuitability and resistance of stakeholders to 'more objective' cost-effectiveness methods	'we did think long and hard about whether or not we could get to, more objective methods but, very very difficult to see an objective method for this.' (intervention stakeholder) 'So of the three sort of worlds that we've got here, there's the world of hard numerical analysis with physics-based modelling. I didn't see any possibility. A much more econ- cost-benefit analysis, possibilities there but we, weren't able to, land that. Which left you with this thing in the middle, which was, MCDA, carefully applied, [...].' (practitioner assurer) 'I don't think there was a great deal of consideration of, a wider variety of methods, partly I think because of the subject matter [business case support].' (practitioner)	'Practitioner: [...] there's a fairly hard rule set, applied to [this type of analysis], so there's [the relevant policy document], [...] But still that gives an awful lot of room. Interviewer: Yes, they are guidelines. Practitioner: Yeah.' 'As a business case, there was an expectation from [assurers] that, we needed to provide robust evidence here, ... We were ... looking at a cost-effectiveness measurement.' (practitioner)
Culture	Discourses and documents regarding past projects, and the appropriateness of certain methods and not others	Practitioner cognitive resource (knowledge) and confidence that using MCDA was feasible and would result in acceptable answer	Lack of knowledge of apparent alternatives	'to an extent it drew on previous experience. General analytical knowledge of how one goes about that kind of problem' (practitioner) 'all the advice I was getting was this is probably looking like an MCDA piece. And so my, face was like, 'What does that mean then?' What can it do? What can't it do?' (practitioner)	'I looked at, past approaches [to the capability] which have been very much founded upon MCDA. But with I think a more limited view of the problem space. I talked to [my assurer] up at the front about what [they] saw success as looking like, and then we, played around, I had a lot of discussions with [...] my [senior practitioner colleague] at the time, about what kind of approaches might satisfy because I came to this with no background in formal [OR], at all, so I batted around with [them] about what success might look like and what kind of methods might work. I also talked to [another colleague] quite a lot, who had led one of the previous [business cases] [...] all the advice I was getting was this is probably looking like an MCDA piece.' (practitioner) 'the two factors were probably (1) the general feeling that this was an appropriate technique for this type of activity and (2) it wasn't immediately apparent what other options there might have been. And sometimes you, that's where you get to with analysis.' (practitioner)
Relations	Lack of agreement amongst capability stakeholders as to the purpose and value of the capability, and plenty of politics playing	Practitioners' aim to capture different capability stakeholder views on viable options, while seeking stakeholder acceptance of recommendations	Stakeholders' expectations of practitioners' work	'We didn't seek consensus. It was more just trying to, make sure that the final vote represented what people were happy with, taking forward.' (practitioner)	'There were so much politics going on here. There was so little agreement about actually what the purpose of [the capability] was.' (practitioner)

Note: Mechanisms of method choice include effects of practitioners' reflexive deliberation and values (and other aspects of agency, including norms [after Fleetwood, 2021]), as well as their circumstances, and social structural conditioning (Bhaskar, 2016, p. 66).

Table 79: How decision options were constructed, shortlisted, and their effectiveness assessed, by case

Case	What options represented	Option construction		Option shortlisting		Option effectiveness				How option costings were used by practitioners (combined with effectiveness analysis, or used separately)	Risk analysis (quantitative and/or qualitative)
		How constructed	**Data sources for construction**	**How shortlisted**	**Number of options** (following shortlisting, indicative)	**Effectiveness criteria**	**Data sources for criteria**	**How effectiveness assessed**	**Who assessed effectiveness**		
1	**Organizational models for future capability**	Using framework of (1) capability roles and (2) organizations that could take each role	Previous interventions (including a version of the framework), brainstorming with clients	With stakeholders, ruleset, and workshop	≤5	**Hierarchy of benefits (user requirements)** (qualitative and quantitative criteria)	Previous interventions, workshops, stakeholder consultation	**MCDA: benefits criteria weighted; options scored against benefits** (quantitative)	Stakeholders in workshops (and interviews)	**Combined** in cost-effectiveness calculations	Quantitative and qualitative
2	**Ways of applying third party approach to organizational processes**	Possible actions in relation to adopting third party approach to organizational processes (e.g., adopt, run pilot, do not adopt)	Constructed by practitioners following workshop with third party and government stakeholders in which current government processes were compared to those of the third party	*No shortlisting; constructed by practitioners at end*	≤5	**Advantages and disadvantages** (qualitative)	Talking with and workshop with third party and government stakeholders	**Narrative description**	Practitioners, using data from third party and government stakeholders (including workshop)	**Used separately** alongside description of options	Qualitative
3	**Activities to include in future capability**	Different bundles of capability activities	Constructed by practitioners following stakeholder workshops and interviews in which information was sought on capability activities and their importance	*No shortlisting; constructed by practitioners towards end*	≤5	**Strategic needs met** (qualitative)	Policy documents	**Description and categorization according to extent strategic needs met** (colour coding)	Practitioners, using data from stakeholders	**Used separately** alongside other analysis of options	Qualitative
4	**Future organizational models**	Organizational models taken from government guidance and comparative organizations	Document and literature review	Stakeholder consultation	≤5	**Success criteria** (qualitative)	Stakeholder consultation	**Description and categorization of risks against success criteria** (colour coding)	Practitioners, using data from documentation and literature review, and stakeholder consultation, including workshops	**Used separately** alongside risk categorizations and recommendations	Qualitative
5	**Future technological configurations**	Spreadsheet modelling (combinatorial), using high-level approaches to mitigating capability gaps generated by practitioners	Previous intervention phases (including data on future capability requirements and gaps), technical colleagues, outsourcing	Workshops with stakeholder committees	Hundreds of thousands	**Benefits, including equipment performance** (quantitative)	Previous intervention phases, technical colleagues, outsourcing, stakeholder workshops	**Spreadsheet modelling** (quantitative)	Practitioners, with input from stakeholders on risks and caveats	**Combined** in cost-benefit / effectiveness calculations	Quantitative and qualitative

Table 80: Assessment of methodological designs against propositions for PSM use in Yearworth and White (2014)

Propositions for PSM use in Yearworth & White (2014, Table I; 'YW')		Cross-case summary	
		Behaviour reflected in case data?	**Summary of analysis, based on case data**
P1	**Improvement activity**	Yes	Practitioners designed their interventions to make progress with strategic issues for stakeholders, undertaking purposeful activities.
P2	**Systemic approach**	No	With the possible exception of the systems analysis in case 4, practitioners did not represent stakeholder views in systemic models, nor take an explicit approach to, for example, boundary critique.
P3	**Adaptation / Creativity**	Yes	Practitioners thought through how they would adapt and combine methods for particular situations.
P4	**Methodological lessons**	Yes	Practitioners in this context were evaluated for their work on the interventions, requiring them to reflect on methodological (and other) lessons.
P5	**Worldviews**	No	Practitioners 'acknowledged [...] and worked with' different world views (YW, P5) through facilitated workshops and interviews. However, for practical reasons, their 'problematisation' (p. 939) tended to reflect a subset of stakeholder views, generally privileging questions constructed by/with clients. (For summary of analysis of case data on this point, see Table 81, Appendix U.)
P6	**Messiness**	Yes (not case 4)	Practitioners addressed strategic issues that can be interpreted as wicked, messes, or in the swamp. In all cases, there were multiple perspectives and conflicting interests across stakeholders. In case 4, practitioners did not view their work as addressing a wicked problem.
P7	**Interactive / Iterative / Therapeutic**	Yes	Practitioners employed participative methods, with practitioners acting as facilitators and not as subject matter experts
P8	**Subjectivity**	Yes	Practitioners acknowledged differences in subjective views and interests of stakeholders. Disagreement between stakeholders influenced method choice.
P9	**Limits**	Not assessed	Not assessed due to lack of data

Note: Shaded boxes indicate dimensions that are not considered to distinguish PSM use from OR modelling or interventions generally in this context.

Table 81: Assessment of practitioners' 'process of problematisation' as in PSM proposition 5 (P5) in Yearworth and White (2014)

Case	**Analysis, based on case data** leading to conclusion in Table 80 that, for practical reasons, practitioners' 'problematisation' (problem framing) tended to reflect a subset of stakeholder views, generally privileging questions constructed by/with clients *(note)*
1	Practitioners' clients sought analysis for a business case to support a continuing need for a capability. In the initiation phase, practitioners discussed with stakeholders their different views and requirements of the intervention. Then, for all the reasons in Figure 32 (chapter 6)above, including risk aversion amongst practitioners and assurers, practitioners adopted a version of the methodology used in a previous intervention that had supported a business case for the existing capability. MCDA provided a previously tested means of structuring a choice between decision options using quantitative and qualitative evidence and judgement, in workshops and interviews, from multiple stakeholders who were known to have conflicting views as to the purpose and value of the capability. Practitioners adapted the options framework from the previous project, dividing one capability role into two, and increasing the number and variety of possible incumbents across the roles. Clients were involved in brainstorming capability roles. For the benefits hierarchy, practitioners 'looked at' the one from the previous project, which needed updating (practitioner, case 1). They re-thought assumptions about the capability, its activities, how the capability would serve changing government needs, and how capability activities would be assured and governed, putting things [draft benefits criteria] up as strawmen, and then testing that out with, first of all [clients], and then taking that out to a wider stakeholder group within [government] [...] and testing and refining about what the most important things were, what was missing, what the boundaries might be [including in workshops] (practitioner, case 1)

Case	**Analysis, based on case data** leading to conclusion in Table 80 that, for practical reasons, practitioners' 'problematisation' (problem framing) tended to reflect a subset of stakeholder views, generally privileging questions constructed by/with clients *(note)*
2	Practitioners were specifically tasked with speaking with a company in order to answer specific questions, which they did. They later used a structured workshop to generate a consensus view across government stakeholders of how the third party's approach compared with processes in government, before making recommendations as to next steps.
3	Practitioners' scoping document brought together diverse client asks, and was described by practitioners as, [...] more a, trying to get consensus than particularly a lot of thought going in from our side. Are we interpreting what you are saying right, are you all agreed? It probably wasn't as us-led as much as it should be. Then, through their intervention, in engaging with stakeholders, including in workshops and structured interviews, practitioners sought a shared view of capability activities and justifications for their inclusion (or not) in different options for the future capability (i.e., bundles of capability activities) through triangulation.
4	Practitioners saw their role as answering 'a very well-defined question', as set out in a 'very well explicitly set out [scoping document]', and as making recommendations regarding a limited number of options already set out in government guidance (practitioner, case 4). Practitioners therefore saw 'probably limited opportunity to use those broader, softer methodologies', commenting that this was 'not an uncommon thing [...] in this kind of policy problem, where you've got a fairly well-scoped-out end point, and there are certain [government] guidelines which you are operating within' (practitioner, case 4). Rather, they used stakeholder consultation, including structured interviews and workshops, to gather and triangulate evidence to support their options analysis.
5	As an early step in their analysis in this intervention phase, practitioners used technical colleagues' conceptual modelling of equipment types, and findings on future capability requirements from earlier intervention phases, in generating **high-level approaches to mitigating key capability gaps** expected to result when equipment went out of service in future. They matched equipment types to subsets of future requirements they could deliver. This was to define – for comparison and costing – a broad range of ways in which future capability gaps could be mitigated, i.e., different combinations of different types of equipment replacing outgoing equipment. The high-level approaches were reviewed by a stakeholder committee for inclusion in practitioners' scoping document. The high-level approaches facilitated the building of feasible options for the technological configuration of each of the different types of equipment (including the new type of equipment) in line with organizational policies. A **spreadsheet model** was developed in Excel to generate, assess and cost options for mitigating future capability gaps, building on data and calculations from the LP from the earlier intervention phase, and using input data and spreadsheets from earlier intervention phases, technical colleagues, and outside consultants. The spreadsheet model scaled combinations of equipment to requirements (for the capability as a whole) across different scenarios, in line with the high-level approaches. This included consideration of fixed and variable configurations of equipment, different staffing assumptions, equipment performance data, and associated cost implications. Practitioners' spreadsheet modelling was designed to provide a transparent, auditable approach, and evidence as to why options were not recommended, as well as evidence of recommended options. The modelling allowed for a broad and changing scope in terms of the (number of) options under consideration. Practitioners aimed to agree scope, gather data, and agree assumptions of their OR analysis with stakeholders at each step of the process.

Note: 'The process of problematisation' (Yearworth & White, 2014, Table 1, P5, p. 939) refers to problem framing (White et al., 2016), or 'asking what the problem is that needs to be addressed and who the relevant actors are' (Freeman & Yearworth, 2017, after White, 2009, after Callon, 1986).

Table 82: Assessment of methodological designs against characteristics of PSMs in C. M. Smith and Shaw (2019)

Characteristics of PSMs in C. M. Smith and Shaw (2019, Figures 5-9; 'SS')			Cross-case summary	
			Characteristic reflected in data?	**Summary of analysis, based on case data**
Pillar 1: System characteristics	**Q1**	**Identify system to model**	Yes (cases 1, 4, 5)	Practitioners established what was in scope for their analysis, and used this in identifying their methods. Practitioners undertook modelling in cases 1, 4 and 5.
	Q2	**Models subjective interpretations**	Yes	Practitioners acknowledged differences in subjective views and interests of stakeholders. Disagreement between stakeholders influenced method choice. Stakeholder judgement was used where objective, quantitative data was not available.
	Q3	**Holistic understanding**	No (not reflected in modelling)	While practitioners included qualitative findings in their reports (e.g., on risks, as captured in the final column of Table 79, Appendix U), they privileged quantitative or material aspects for decision makers. They did not tend to model personal and social aspects (Mingers, 2014; Mingers & Brocklesby, 1997; *Note 2 below*)
Pillar 2: Knowledge and involvement of stakeholders	**Q4**	**Build qualitative models**	No	With the possible exception of the systems analysis in case 4, practitioners did not represent stakeholder views in qualitative, diagrammatic models. Practitioners tended to generate and challenge evidence in seeking objective, quantitative representation (where possible).
	Q5	**Facilitates participants' involvement in model building**	No	The extent to which participants were involved in model building as opposed to data generation and testing was limited, notwithstanding that the scope and types of modelling actually undertaken (especially in cases 1 and 5) were influenced by stakeholders' (especially clients') expectations
	Q6	**Participant learning through participation in model building process**	No	Where models were built, arguably, stakeholder learning was more 'through analysis of the model rather than through participation in the model building process' (SS, p. 408)
	Q7	**Buy-in to politically feasible outcomes**	Yes (within constraints of cost-effectiveness analysis)	Practitioners sought stakeholder acceptance or buy-in in relation to findings, i.e., 'politically feasible and implementable' recommendations (SS, p. 408, after Checkland, 1981) within necessary constraints of providing recommendations based on their cost-effectiveness analysis.
Pillar 3: The values of model building	**Q8**	**Credibility through preserving participant contributions**	No	Workshop and interview outputs (stakeholder judgement in the form of data gathered, categorized, weighted, ranked, scored, and/or voted on) tended to be used in practitioners' analyses of the effectiveness and costs of options, i.e., for objective assessment of material decision aspects in order to develop practitioners' modelling and/or make recommendations. Practitioners sought consensus views, or at least acceptance. In practitioners' modelling in cases 1 and 5, the structure of the models provided constraints on which and how stakeholders' views were represented. In case 5, practitioners moved from an optimization approach in an earlier intervention phase to a more participative approach in which ranges of alternative solutions were proposed.
	Q9	**Generic model building approach (transferable)**	Yes	The methodological designs could be used in other situations with other clients.
	Q10	**Shows procedural rationality**	Yes (cases 1 and 5)	In cases 1 and 5 there was particular emphasis on achieving transparency in the modelling process throughout the intervention, not least because of conflict between stakeholders' views, and to facilitate stakeholder buy-in.
	Q11	**Builds audit trail of decision making from and using accurate representation of stakeholder views of situation**	No	In cases 1 and 5, practitioners' modelling provided an audit trail in that contributions of stakeholders could be traced through the analysis to model outputs, albeit that the structure of the models provided constraints on which and how stakeholders' views were represented. Stakeholder judgement was only used as a model input where objective, quantitative data was not available.
Pillar 4: Structured analysis	**Q12**	**Different stages of analysis**	Yes	Practitioners used different methods for different activities across different intervention stages, allowing them to structure issues in different ways through their interventions. Methods were often used iteratively.
	Q13	**Phases of divergent and convergent thinking**	Yes	In workshops and interviews, practitioners tended to provide opportunities for participants to express, then compare and reconcile individuals' views.

Note 1: Shaded boxes indicate dimensions that are not considered to distinguish PSM use from OR modelling or interventions generally.
Note 2: Material aspects are 'actual and possible states of affairs', personal aspects are 'experiences and beliefs' and social aspects are 'normatively regulated social relations and interactions' (Mingers, 2014, pp. 184-185, after Mingers & Brocklesby, 1997)

Table 83: Assessment of methodological designs against PSM characteristics in Franco and Rouwette (2022)

Characteristics of PSMs in Franco & Rouwette (2022, Table 23.2; 'FR')		Cross-case summary		
		Characteristic reflected in data?		Summary of analysis, based on case data
		Case 1	Case 5	
Tools	**Model-based, where models are:**	Yes	Yes	In cases 1 and 5, analysis was based on OR modelling (MCDA and combinatorial spreadsheet modelling, respectively)
	- **amenable to formal analysis of relationships**	Yes	Yes	
	- **requisite**	Yes	No	Practitioners in case 1 developed a small set of discrete options for their MCDA modelling. Practitioners' modelling in case 5 was combinatorial, exploring a very large 'solution space'.
	- **expressed in visual/diagrammatic form, and with reduced quantitative data requirements**	No	No	In cases 1 and 5, modelling was primarily quantitative
	- **transparent and accessible**	Yes	Yes	In cases 1 and 5, there was particular emphasis on achieving transparency in the modelling processes and to involve stakeholders in workshops
	Open technology to support model building	Yes	Yes	In all cases, workshops and interviews involved participation using simple workshop tools (generating, categorizing, weighting, ranking, scoring, and/or voting on data)
Process	**Group-based Participative**	No	No	Interventions were participative, but, generally, stakeholders were not brought together and facilitated 'to jointly construct the problem situation, make sense of it, arrive at a shared problem definition, and develop a portfolio of options relevant to the problem so defined' as envisaged by FR (p. 743, after Rosenhead & Mingers, 2001b; see also *note 2* below). For practical reasons, the number of different problem frames considered in workshops and interviews was limited. Case practitioners' problem framing tended to reflect a subset of stakeholder views, and generally privileged questions constructed by/with clients (see Table 81, Appendix U).
	Facilitated Interactive	Yes	Yes	In cases 1 and 5, there was interaction between stakeholders in workshops, and between stakeholder discussions and the model-supported analysis which shaped each other.
	Iterative	No	No	In case 1, practitioners worked through an MCDA analysis with little iteration. In case 5, practitioners described their work as sequential.
	Phased Non-Linear	No	No	In cases 1 and 5, all stages of the modelling process (cost-effectiveness analysis) were required for clients to conclude.

Note 1: Shaded boxes indicate dimensions that are not considered to distinguish PSM use from OR interventions generally.
Note 2: FR state that, 'when a stakeholder group engages in problem structuring [supported by PSMs], multiple problem frames will be exchanged and shared among those involved. Typically, the creation of an agreed problem frame will be needed to ensure stakeholder groups can make progress' (p. 741) and that, 'The aim of PSMs is to aid groups of stakeholders in coming to agreement on the nature of a problem situation they face so that progress can be made. ... unless the problem situation is resolved by an exercise of power, stakeholder will need to find an effective way to develop appropriate response to the problem and commitment to the way forward' (p. 743).

REFERENCES

Abdel-Malek, L., Wolf, C., Johnson, F., & Spencer III, T. (1999). OR practice: Survey results and reflections of practising INFORMS members. *Journal of the Operational Research Society*, *50*(10), 994–1003. https://doi.org/10.1057/palgrave.jors.2600805

Abuabara, L., & Paucar-Caceres, A. (2021). Surveying applications of strategic options development and analysis (SODA) from 1989 to 2018. *European Journal of Operational Research*, *292*(3), 1051–1065. https://doi.org/10.1016/j.ejor.2020.11.032

Ackermann, F. (2012). Problem structuring methods 'in the dock': Arguing the case for soft OR. *European Journal of Operational Research*, *219*(3), 652–658. https://doi.org/10.1016/j.ejor.2011.11.014 Ackermann, F. (2024). Managing grand challenges: Extending the scope of problem structuring methods and behavioural operational research. *European Journal of Operational Research*, *319*(2), 373–383. https://doi.org/10.1016/j.ejor.2024.01.024

Ackermann, F., & Eden, C. (2011a). Negotiation in strategy making teams: Group support systems and the process of cognitive change. *Group Decision and Negotiation*, *20*, 293–314. https://doi.org/10.1007/s10726-008-9133-y

Ackermann, F., & Eden, C. (2011b). Strategic management of stakeholders: Theory and practice. *Long Range Planning*, *44*(3), 179–196. https://doi.org/10.1016/j.lrp.2010.08.001

Ackermann, F., & Eden, C. (2020). Strategic options development and analysis. In M. Reynolds & S. Holwell (Eds.), *Systems approaches to making change: A practical guide* (2nd ed., pp. 139–199). Springer. https://doi.org/10.1007/978-1-4471-7472-1_4

Ackermann, F., Franco, L. A., Rouwette, E. A. J. A., & White, L. (2014). Special issue on problem structuring research and practice. *EURO Journal on Decision Processes*, *2*(3–4), 165–172. https://doi.org/10.1007/s40070-014-0037-6

Ackermann, F., & Howick, S. (2022). Experiences of mixed method OR practitioners: Moving beyond a technical focus to insights relating to modelling teams. *Journal of the Operational Research Society*, *73*(9), 1905–1918. https://doi.org/10.1080/01605682.2021.1970486

Ackoff, R. L. (1956). The development of operations research as a science. *Operations Research*, *4*(3), 265–295. https://doi.org/10.1287/opre.4.3.265

Ackoff, R. L. (1979). The future of operational research is past. *Journal of the Operational Research Society*, *30*(2), 93–104. https://doi.org/10.1057/jors.1979.22

Ackroyd, S., & Karlsson, J. C. (2014). Critical realism, research techniques, and research designs. In P. K. Edwards, J. O'Mahoney, & S. Vincent (Eds.), *Studying organizations using critical realism: A practical guide* (pp. 21–45). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199665525.003.0002

Agrell, P. S., & Holmberg, S. (1998). Operational research in Swedish military long-term and complex development projects. *Systems Research and Behavioral Science*, *15*(1), 61–65. https://doi.org/10.1002/(SICI)1099-1743(199801/02)15:1<61::AID-SRES170>3.3.CO;2-I

Al-Amoudi, I., & Willmott, H. (2011). Where constructionism and critical realism converge: Interrogating the domain of epistemological relativism. *Organization Studies*, *32*(1), 27–46. https://doi.org/10.1177/0170840610394293

Alderson, P. (2021). *Critical realism for health and illness research: A practical introduction*. Policy Press. https://doi.org/10.2307/j.ctv1fcf8g0

Alvesson, M., & Ka, D. (2007). Constructing mystery: Empirical matters in theory development. *Academy of Management Review*, *32*(4), 1265–1281. https://doi.org/10.5465/amr.2007.26586822

Andersen, D. F., Bryson, J. M., Richardson, G. P., Ackermann, F., Eden, C., & Finn, C. B. (2006). Integrating modes of systems thinking into strategic planning education and practice: The thinking persons' institute approach. *Journal of Public Affairs Education*, *12*(3), 265–293. https://doi.org/10.1080/15236803.2006.12001436

Andersen, D. F., Vennix, J. A. M., Richardson, G. P., & Rouwette, E. A. J. A. (2007). Group model building: Problem structuring, policy simulation and decision support. *Journal of the Operational Research Society*, *58*(5), 691–694. https://doi.org/10.1057/palgrave.jors.2602339

Andersen, P. H., & Kragh, H. (2011). Beyond the inductive myth: New approaches to the role of existing theory in case research. In R. Piekkari & C. Welch (Eds.), *Rethinking the case study in international business and management research* (pp. 146–170). Edward Elgar. https://doi.org/10.4337/9780857933461.00017

Anseel, F., Lievens, F., Schollaert, E., & Choragwicka, B. (2010). Response rates in organizational science, 1995–2008: A meta-analytic review and guidelines for survey researchers. *Journal of Business and Psychology 25*, 335–349. https://doi.org/10.1007/s10869-010-9157-6

Archer, M. S. (1995). *Realist social theory: The morphogenetic approach*. Cambridge University Press. https://doi.org/10.1017/CBO9780511557675

Archer, M. S. (1996). *Culture and agency: The place of culture in social theory* (Rev. ed.). Cambridge University Press. https://doi.org/10.1017/CBO9780511557668

Archer, M. S. (2000). For structure: its reality, properties and powers: A reply to Anthony King. *Sociological Review*, *48*(3), 464–472. https://doi.org/10.1111/1467-954X.00226

Archer, M. S. (2010). Routine, reflexivity, and realism. *Sociological Theory*, *28*(3), 272–303. https://doi.org/10.1111/j.1467-9558.2010.01375.x

Archer, M. S. (2024). Can complexity add anything to critical realism and the morphogenetic approach? *Journal for the Theory of Social Behaviour*, *54*(4), 422–433. https://doi.org/10.1111/jtsb.12419

Ash, S. (2022). *Explaining morality*. Routledge. https://doi.org/10.4324/9781003080442

Aubert, A. H., Bauer, R., & Lienert, J. (2018). A review of water-related serious games to specify use in environmental multi-criteria decision analysis. *Environmental Modelling and Software*, *105*, 64–78. https://doi.org/10.1016/j.envsoft.2018.03.023

Balaban, M., Hester, P., & Diallo, S. (2016). Towards a theory of multi-method M&S approach: Part III. In *Proceedings of the 2015 Winter Simulation Conference (WSC)* (pp. 1633–1644). IEEE. https://doi.org/10.1109/WSC.2015.7408283

Bammer, G. (2018). Strengthening community operational research through exchange of tools and strategic alliances. *European Journal of Operational Research*, *268*(3), 1168–1177. https://doi.org/10.1016/j.ejor.2017.09.041

Bana e Costa, C. A., Lourenço, J. C., Oliveira, M. D., & Bana e Costa, J. C. (2014). A socio-technical approach for group decision support in public strategic planning: The Pernambuco PPA case. *Group Decision and Negotiation*, *23*, 5–29. https://doi.org/10.1007/s10726-012-9326-2

Bastow, S., Dunleavy, P., & Tinkler, J. (2014). Government and public policy making. In S. Bastow, P. Dunleavy, & J. Tinkler (Eds.), *The impact of the social sciences: How academics and their research make a difference* (pp. 141–172). Sage. https://doi.org/10.4135/9781473921511

Bell, S. (2012). DPSIR = A problem structuring method? An exploration from the 'imagine' approach. *European Journal of Operational Research*, *222*(2), 350–360. https://doi.org/10.1016/j.ejor.2012.04.029

Belton, V., Ackermann, F., & Shepherd, I. (1997). Integrated support from problem structuring through to alternative evaluation using COPE and V·I·S·A. *Journal of Multi-Criteria Decision Analysis*, *6*(3), 115–130. https://doi.org/10.1002/(SICI)1099-1360(199705)6:3%3C115::AID-MCDA140%3E3.0.CO;2-I

Belton, V., & Stewart, T. (2002). *Multiple criteria decision analysis: An integrated approach*. Springer. https://doi.org/10.1007/978-1-4615-1495-4

Belton, V., & Stewart, T. J. (2010). Problem structuring and multiple criteria decision analysis. In M. Ehrgott, J. R. Figueira, & S. Grego (Eds.), *Trends in multiple criteria decision analysis* (pp. 209–241). Springer. https://doi.org/10.1007/978-1-4419-5904-1_8

Bennett, P. G. (1985). On linking approaches to decision-aiding: Issues and prospects. *Journal of the Operational Research Society*, *36*(8), 659–669. https://doi.org/10.1057/jors.1985.123

Bennett, P. G., Ackermann, F., Eden, C., & Williams, T. (1997). Analysing litigation and negotiation: Using a combined methodology. In J. Mingers & A. Gill (Eds.), *Multimethodology: The theory and practice of combining management science methodologies* (pp. 59–88). Wiley. http://eprints.soton.ac.uk/id/eprint/36855

Berends, H., & Deken, F. (2021). Composing qualitative process research. *Strategic Organization*, *19*(1), 134–146. https://doi.org/10.1177/1476127018824838

Bernroider, E. W. N., & Schmöllerl, P. (2013). A technological, organisational, and environmental analysis of decision making methodologies and satisfaction in the context of IT induced business transformations. *European Journal of Operational Research*, *224*(1), 141–153. https://doi.org/10.1016/j.ejor.2012.07.025

Bhaskar, R. (1997). On the ontological status of ideas. *Journal for the Theory of Social Behaviour*, *27*(2-3), 139–147. https://doi.org/10.1111/1468-5914.00031

Bhaskar, R. (1998). *The possibility of naturalism: A philosophical critique of the contemporary human sciences* (3rd ed.). Routledge. https://doi.org/10.4324/9781315756332

Bhaskar, R. (2008). *A realist theory of science* (3rd ed.). Verso. https://doi.org/10.4324/9780203090732

Bhaskar, R. (2010). Contexts of interdisciplinarity: Interdisciplinarity and climate change. In R. Bhaskar, C. Frank, K. G. Høyer, P. Næss, & J. Parker (Eds.), *Interdisciplinarity and climate change: Transforming knowledge and practice for our global future* (pp. 1–24). Routledge. https://doi.org/10.4324/9780203855317

Bhaskar, R. (2014). Foreword. In P. K. Edwards, J. O'Mahoney, & S. Vincent (Eds.), *Studying organizations using critical realism: A practical guide* (pp. v–xvi). Oxford University Press. https://doi.org/https://doi.org/10.1093/acprof:oso/9780199665525.002.0004

Bhaskar, R. (2016). *Enlightened common sense: The philosophy of critical realism*. Routledge. https://doi.org/10.4324/9781315542942

Bhaskar, R., Danermark, B., & Price, L. (2018). *Interdisciplinarity and wellbeing: A critical realist general theory of interdisciplinarity*. Routledge. https://doi.org/10.4324/9781315177298

Biró, P., Van De Klundert, J., Manlove, D., Pettersson, W., Andersson, T., Burnapp, L., Chromy, P., Delgado, P., Dworczak, P., Haase, B., Hemke, A., Johnson, R., Klimentova, X., Kuypers, D., Nanni Costa, A., Smeulders, B., Spieksma, F., Valentín, M. O., & Viana, A. (2019). Modelling and optimisation in European kidney exchange programmes. *European Journal of Operational Research*, *291*(2), 447–456. https://doi.org/10.1016/j.ejor.2019.09.006

Bourn, J. (2004). *Ministry of Defence: The management of defence research and technology, Report by the Comptroller and Auditor General* (HC Publication No. 360 2003-2004). National Audit Office. https://webarchive.nationalarchives.gov.uk/ukgwa/20170207052351/https://www.nao.org.uk/wp-content/uploads/2004/03/0304360.pdf

Bourne, L., & Walker, D. H. T. (2005). Visualising and mapping stakeholder influence. *Management Decision*, *43*(5), 649–660. https://doi.org/10.1108/00251740510597680

Bowers, T. D. (2011). Towards a framework for multiparadigm multimethodologies. *Systems Research and Behavioral Science*, *28*(5), 537–552. https://doi.org/10.1002/sres.1120

Boyd, A., Brown, M., & Midgley, G. (2004). Systemic intervention for community OR: Developing services with young people (under 16) living on the streets. In: G. Midgley & A. Ochoa-Arias (Eds.), *Community operational research: OR and systems thinking for community development*. Springer. https://doi.org/10.1007/978-1-4419-8911-6_10

Brailsford, S. C., Eldabi, T., Kunc, M., Mustafee, N., & Osorio, A. F. (2019). Hybrid simulation modelling in operational research: A state-of-the-art review. *European Journal of Operational Research*, *278*(3), 721–737. https://doi.org/10.1016/j.ejor.2018.10.025

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1017/CBO9781107415324.004

Braun, V., & Clarke, V. (2021). To saturate or not to saturate? Questioning data saturation as a useful concept for thematic analysis and sample-size rationales. *Qualitative Research in Sport, Exercise and Health*, *13*(2), 201–216. https://doi.org/10.1080/2159676X.2019.1704846

Brocklesby, J. (1993). Methodological complementarism or separate paradigm development—Examining the options for enhanced operational research. *Australian Journal of Management*, *18*(2), 133–157. https://doi.org/10.1177/031289629301800201

Brocklesby, J. (2009). Ethics beyond the model: How social dynamics can interfere with ethical practice in operational research/management science. *Omega*, *37*(6), 1073–1082. https://doi.org/10.1016/j.omega.2008.12.004

Brocklesby, J. (2016). The what, the why and the how of behavioural operational research – An invitation to potential sceptics. *European Journal of Operational Research*, *249*(3), 796–805. https://doi.org/10.1016/j.ejor.2015.09.034

Brocklesby, J. (2023). Mixing methods in systems practice. *Journal of Systems Thinking*. https://doi.org/10.54120/jost.0000021

Brocklesby, J., & Beall, E. (2018). Processes of engagement and methodology design in community operational research - Insights from the indigenous peoples sector. *European Journal of Operational Research*, *268*(3), 996–1005. https://doi.org/10.1016/j.ejor.2017.07.053

Brown, J., Cooper, C., & Pidd, M. (2006). A taxing problem: The complementary use of hard and soft OR in the public sector. *European Journal of Operational Research*, *172*(2), 666–679. https://doi.org/10.1016/j.ejor.2004.10.016

Bryant, J., Darwin, J., & Booth, C. (2011). Strategy making with the whole organisation: OR and the art of the possible. *The Journal of the Operational Research Society*, *62*(5), 840–854. https://doi.org/10.2307/20868920

Bryman, A. (2008). Why do researchers integrate/combine/mesh/blend/mix/merge/fuse quantitative and qualitative research. In M. M. Bergman (Ed.), *Advances in mixed methods research* (pp. 86–100). Sage. https://doi.org/10.4135/9780857024329

Bryson, J. M. (2015). Strategic planning for public and nonprofit organizations. In J. D. Wright (Ed.), *International encyclopedia of the social & behavioral sciences* (2nd ed., pp. 515–521). Elsevier. https://doi.org/10.1016/B978-0-08-097086-8.74043-8

Brönnimann, A. (2020). A causal mechanism approach to explain business process adoption and rejection phenomena. In D. Fahland, C. Ghidini, J. Becker, & M. Dumas (Eds.), *Business Process Management Forum. BPM 2020. Lecture notes in business information processing*, *392,* 297–312. Springer. https://doi.org/10.1007/978-3-030-58638-6_18

Brönnimann, A. (2022). How to phrase critical realist interview questions in applied social science research. *Journal of Critical Realism*, *21*(1), 1–24. https://doi.org/10.1080/14767430.2021.1966719

Brönnimann, A. (2023). *Explaining organisational business process adoption mechanisms - A critical realist perspective on social reflexivity and process affordances* [Doctoral dissertation, Edith Cowan University]. Research Online. https://ro.ecu.edu.au/theses/2628

Burger, K. (2020). Understanding participant engagement in problem structuring interventions with self-determination theory. *Journal of the Operational Research Society*, *72*(10), 2365–2379. https://doi.org/10.1080/01605682.2020.1790307

Burger, K. (2024, 30 June–July 3). *AI-Enhanced spaces for problem structuring: Better understanding, stakeholder engagement, and decision support?* [Conference presentation abstract]. 33rd European Conference on Operational Research and Management Science (EURO 2024), Copenhagen, Denmark. http://www.euro-online.org/conf/euro33/treat_abstract?paperid=1195

Burrell, G., & Morgan, G. (1979). *Sociological paradigms and organisational analysis - Elements of the sociology of corporate life*. Heinemann. https://doi.org/10.1177/003803858001400219

Bygstad, B., & Bergquist, M. (2018). Horizontal affordances for patient centred care in hospitals. In *Proceedings of the 51st Hawaii International Conference on System Sciences (HICSS-51)* (pp. 3170–3179). http://urn.kb.se/resolve?urn=urn:nbn:se:hh:diva-35291

Bygstad, B., Munkvold, B. E., & Volkoff, O. (2016). Identifying generative mechanisms through affordances: A framework for critical realist data analysis. *Journal of Information Technology*, *31*(1), 83–96. https://doi.org/10.1057/jit.2015.13

Cabrera, D. (2023). Editorial: The four waves: Then and now. *Journal of Systems Thinking*. https://doi.org/10.54120/jost.234567

Cabrera, D., & Colosi, L. (2008). Distinctions, systems, relationships, and perspectives (DSRP): A theory of thinking and of things. *Evaluation and Program Planning*, *31*(3), 311–317. https://doi.org/10.1016/j.evalprogplan.2008.04.001

Cabrera, D., Colosi, L., & Lobdell, C. (2008). Systems thinking. *Evaluation and Program Planning*, *31*(3), 299–310. https://doi.org/10.1016/j.evalprogplan.2007.12.001

Cairns, G., Goodwin, P., & Wright, G. (2015). A decision-analysis-based framework for analyzing stakeholder behaviour in scenario planning. *European Journal of Operational Research*, *249*(3), 1050–1062. https://doi.org/10.1016/j.ejor.2015.07.033

Callon, M. (1980). Struggles and negotiations to define what is problematic and what is not: The socio-logic of translation. In K. Knorr, R. Krohn & R. Whitley (Eds.), *The social process of scientific investigation. Sociology of the sciences a yearbook* (Vol. IV, pp. 197-219). Springer. https://doi.org/10.1007/978-94-009-9109-5_8

Cameron, R., & Golenko, X. (Eds.). (2023). *Handbook of mixed methods research in business and management*. Edward Elgar. https://doi.org/10.4337/9781800887954

Camillus, J. C. (2008). Strategy as a wicked problem. *Harvard Business Review*, *86*(5), 98–101.

Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin*, *56*(2), 81–105. https://doi.org/10.1037/h0046016

Castellini, M. A., & Paucar-Caceres, A. (2019). A conceptual framework for integrating methodologies in management: Partial results of a systemic intervention in a textile SME in Argentina. *Systems Research and Behavioral Science*, *36*(1), 20–35. https://doi.org/10.1002/sres.2552

Chalmers, A. F. (2013). *What is this thing called science?* (4th ed.) McGraw Hill https://www.mheducation.co.uk/what-is-this-thing-called-science-9780335262786-emea-group

Checkland, P. (1981). *Systems thinking, systems practice*. Wiley.

Checkland, P. (1985). From optimizing to learning: A development of systems thinking for the 1990s. *Journal of the Operational Research Society*, *36*(9), 757–767. https://doi.org/10.1057/jors.1985.141

Checkland, P. (1999). *Systems thinking, systems practice: Includes a 30-year retrospective*. Wiley. https://www.wiley.com/en-us/Systems+Thinking%2C+Systems+Practice%3A+Includes+a+30-Year+Retrospective-p-9780471986065

Checkland, P., & Holwell, S. (1998). Action research: Its nature and validity. *Systemic Practice and Action Research*, *11*(1), 9–21. https://doi.org/https://doi.org/10.1023/A:1022908820784

Checkland, P., & Holwell, S. (2004). 'Classical' OR and 'soft' OR – an asymmetric complementarity. In M. Pidd (Ed.), *Systems modelling: Theory and practice* (pp. 45–60). Wiley. https://www.wiley.com/en-us/Systems+Modelling%3A+Theory+and+Practice-p-9780470867310

Checkland, P., & Poulter, J. (2020). Soft systems methodology. In M. Reynolds & S. Holwell (Eds.), *Systems approaches to making change: A practical guide* (2nd ed., pp. 201–253). Springer. https://doi.org/10.1007/978-1-4471-7472-1_5

Checkland, P., & Scholes, J. (1990). *Soft systems methodology in action*. Wiley.

Checkland, P., & Scholes, J. (1999). *Soft systems methodology in action: Includes a 30-year retrospective*. Wiley. https://www.wiley.com/en-us/Soft+Systems+Methodology+in+Action-p-9780471986058

Checkland, P., & Winter, M. (2006). Process and content: Two ways of using SSM. *Journal of the Operational Research Society*, *57*(12), 1435–1441. https://doi.org/10.1057/palgrave.jors.2602118

Christie, J. S. (2017a, July 17–21). *Choosing and combining problem structuring methods in practice* [Conference presentation]. 21st Triennial Conference of the International Federation of Operational Research Societies (IFORS 2017), Québec City, Canada. https://kar.kent.ac.uk/90277

Christie, J. S. (2017b, October 2–3). *Supporting strategic decision-making in the UK government: Realizing benefits from the use of multi-methodology* [Conference presentation]. 11th NATO

Operations Research and Analysis (OR&A) Conference, London, UK. https://kar.kent.ac.uk/97264

Christie, J. S. (2021). *Intervening in wicked problems: Mixed methods practice in operational research* [Unpublished manuscript]. Kent Business School, University of Kent. https://kar.kent.ac.uk/id/eprint/90281

Christie, J. S. (2023). Mixed methods practice in operational research: Designs for wicked problems. In R. Cameron & X. Golenko (Eds.), *Handbook of mixed methods research in business and management* (pp. 163–178). Edward Elgar. https://doi.org/10.4337/9781800887954.00019

Christie, J. S., Mingers, J., & Kotiadis, K. (2022, September 13–15). *Using problem structuring methods with quantitative OR: Six methodological designs* [Conference presentation]. 64th Annual Conference of the Operational Research Society (OR64), Warwick, UK. https://theorsociety.eventsair.com/or64-annual-conference/programme

Churchman, C. W., Ackoff, R. L., & Arnoff, E. L. (1957). *Introduction to Operations Research*. Wiley.

Cinelli, M., Kadziński, M., Gonzalez, M., & Słowiński, R. (2020). How to support the application of multiple criteria decision analysis? Let us start with a comprehensive taxonomy. *Omega*, *96*, 102261. https://doi.org/10.1016/j.omega.2020.102261

Cinelli, M., Kadziński, M., & Słowiński, R. (2021, September). MCDA methods selection software (MCDA-MSS 2021): A radar for decision analysts. *IFORS News*, *16*(3), 24–25. ifors.org/newsletter/ifors-news-sept2021.pdf

Clark, D. N., & Scott, J. L. (1995). Strategic level MS/OR tool usage in the United Kingdom: An empirical survey. *Journal of the Operational Research Society*, *46*(9), 1041–1051. https://doi.org/10.1057/jors.1995.148

Clark, D. N., & Scott, J. L. (1996). Response to 'OR/MS and Strategic Management'. *Journal of the Operational Research Society*, *47*(3), 474–476. https://doi.org/10.1057/jors.1996.52

Cloutier, C., & Langley, A. (2020). What makes a process theoretical contribution? *Organization Theory*, *1*(1), 1–32. https://doi.org/10.1177/2631787720902473

Cloutier, C., & Ravasi, D. (2021). Using tables to enhance trustworthiness in qualitative research. *Strategic Organization*, *19*(1), 113–133. https://doi.org/10.1177/1476127020979329

Clutterbuck, J. (2001). Is a complementary strategy the way forward? In J. Holt & G. Pickburn (Eds.), *Proceedings of OA Techniques for the Future* (Publication No. DERA/CDA/SEA/AIR/CR000141, pp. 47–49). DERA/Operational Research Society Defence Study Group.

Clyne, R., Savur, S., Pope, T., Coggins, M., Bishop, M., Barr, B., Durrant, T., Dalton, G., Amos, N., Worlidge, J., Shepley, P., Nye, P., & Thomas, A. (2023). *Whitehall Monitor 2023*. Institute for Government. https://www.instituteforgovernment.org.uk/sites/default/files/2023-01/whitehall-monitor-2023.pdf

Çoban, B., Scaparra, M. P., & O'Hanley, J. R. (2021). Use of OR in earthquake operations management: A review of the literature and roadmap for future research. *International Journal of Disaster Risk Reduction*, *65*, 102539. https://doi.org/10.1016/j.ijdrr.2021.102539

Coffey, A. (2013). Analysing documents. In U. Flick (Ed.), *The SAGE handbook of qualitative data analysis* (pp. 367–379). Sage. https://doi.org/10.4135/9781446282243

Collander-Brown, S. (2016, February 10–11). *How do we plan for the future requirements for defence?* [Workshop presentation]. Decision Making Under Risk & Uncertainty Workshop, The Grantham Institute. London, UK. https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/dtp/events/previous/FINAL_SESSION_III_POP_UP.pdf

Collier, A. (1994). *Critical realism: An introduction to Roy Bhaskar's philosophy*. Verso. https://www.versobooks.com/products/1444-critical-realism

Colorni, A., & Tsoukiàs, A. (2024). What is a decision problem? *European Journal of Operational Research*, *314*(1), 255–267. https://doi.org/10.1016/j.ejor.2023.10.025

Connell, N. A. D. (2001). Evaluating soft OR: Some reflections on an apparently 'unsuccessful' implementation using a soft systems methodology (SSM) based approach. *The Journal of the Operational Research Society*, *52*(2), 150–160. https://doi.org/10.2307/254142

Cooper, K., Brailsford, S. C., & Davies, R. (2007). Choice of modelling technique for evaluating health care interventions. *Journal of the Operational Research Society*, *58*(2), 168–176. https://doi.org/10.1057/palgrave.jors.2602230

Corbett, C. J., Overmeer, W. J. A. M., & Van Wassenhove, L. N. (1995). Strands of practice in OR (the practitioner's dilemma). *European Journal of Operational Research*, *87*(3), 484–499. https://doi.org/10.1016/0377-2217(95)00224-3

Corbett, C. J., & Van Wassenhove, L. N. (1993). The natural drift: What happened to operations research? *Operations Research*, *41*(4), 625–640. https://doi.org/10.1287/opre.41.4.625

Crabtree, B. F., & Miller, W. F. (1992). A template approach to text analysis: Developing and using codebooks. In B. F. Crabtree & W. L. Miller (Eds.), *Doing qualitative research* (1st ed., pp. 93–110). Sage.

Creamer, E. G. (2020). Visualizing dynamic fully integrated mixed method designs. *International Journal of Multiple Research Approaches*, *12*(1), 65–77. https://doi.org/10.29034/ijmra.v12n1a1

Creswell, J. W., & Plano Clark, V. L. (2011). The nature of mixed methods research. In J. Cresswell & V. Clark (Eds.), *Designing and conducting mixed methods research* (1st ed., pp. 1–7). Sage.

Cropper, S. A. (1990a). The complexity of decision support practice. In C. Eden & J. Radford (Eds.), *Tackling strategic problems: The role of group decision support* (pp. 29–40). Sage. https://strathprints.strath.ac.uk/43598/

Cropper, S. A. (1990b). Variety, formality, and style: Choosing amongst decision-support methods. In C. Eden & J. Radford (Eds.), *Tackling strategic problems: The role of group decision support* (pp. 92–98). Sage. https://strathprints.strath.ac.uk/43598/

Crowe, S., Brown, K., Tregay, J., Wray, J., Knowles, R., Ridout, D. A., Bull, C., & Utley, M. (2017). Combining qualitative and quantitative operational research methods to inform quality improvement in pathways that span multiple settings. *BMJ Quality & Safety*, *26*(8), 641–652. https://doi.org/10 .1136/bmjqs-2016-005636

Currie, C. S. M., Fowler, J. W., Kotiadis, K., Monks, T., Onggo, B. S., Robertson, D. A., & Tako, A. A. (2020). How simulation modelling can help reduce the impact of COVID-19. *Journal of Simulation*, *14*(2), 83–97. https://doi.org/10.1080/17477778.2020.1751570

Curtis, N. J., Dortmans, P. J., & Ciuk, J. (2006). 'Doing the right problem' versus 'doing the problem right': Problem structuring within a land force environment. *Journal of the Operational Research Society*, *57*(11), 1300–1312. https://doi.org/10.1057/palgrave.jors.2602123 Dahler-Larsen, P. (2023). The practical utility of mixed methods: An empirical study. *Journal of Mixed Methods Research*, *17*(2), 187–208. https://doi.org/10.1177/15586898211057359

Danermark, B., Ekström, M., Jakobsen, L., & Karlsson, J. C. (2002). *Explaining society: Critical realism in the social sciences* (1st ed.). Routledge. https://doi.org/10.4324/9780203996249

Danermark, B., Ekström, M., & Karlsson, J. C. (2019). *Explaining society: Critical realism in the social sciences* (2nd ed.). Routledge. https://doi.org/10.4324/9781351017831

Davies, J., Mabin, V. J., & Balderstone, S. J. (2005). The theory of constraints: A methodology apart?—A comparison with selected OR/MS methodologies. *Omega*, *33*(6), 506–524. https://doi.org/10.1016/j.omega.2004.07.015

De Gooyert, V. (2020). Stakeholder behavior in operational research: Connecting the why, who, and how of stakeholder involvement. In L. White, M. H. Kunc, K. Burger, & J. Malpass (Eds.), *Behavioral operational research: A capabilities approach* (pp. 219–235). Springer. https://doi.org/10.1007/978-3-030-25405-6_12

De Gooyert, V., Rouwette, E. A. J. A., Van Kranenburg, H., & Freeman, E. (2017). Reviewing the role of stakeholders in operational research: A stakeholder theory perspective. *European Journal of Operational Research*, *262*(2), 402–410. https://doi.org/10.1016/j.ejor.2017.03.079

De Gooyert, V., Rouwette, E. A. J. A., Van Kranenburg, H., Freeman, E., & Van Breen, H. (2022). Cognitive change and consensus forming in facilitated modelling: A comparison of experienced and observed outcomes. *European Journal of Operational Research*, *299*(2), 589–599. https://doi.org/10.1016/j.ejor.2021.09.007

De Souza, D. E. (2013). Elaborating the context-mechanism-outcome configuration (CMOc) in realist evaluation: A critical realist perspective. *Evaluation*, *19*(2), 141–154. https://doi.org/10.1177/1356389013485194

De Souza, D. E. (2016). Critical realism and realist review: Analyzing complexity in educational restructuring and the limits of generalizing program theories across borders. *American Journal of Evaluation*, *37*(2), 216–237. https://doi.org/10.1177/1098214015605175

De Souza, D. E. (2022). A critical realist approach to systems thinking in evaluation. *Evaluation*, *28*(1), 72–90. https://doi.org/10.1177/13563890211064639

The Defence Science and Technology Laboratory. (2015a). *Annual report and accounts 2014/15* (HC 93). Ministry of Defence. https://assets.publishing.service.gov.uk/media/5a756bc640f0b6360e473fb2/20150622-Dstl_ARAC_2014-15_FINAL_v1_1-O_WEB-OPTIMISED.pdf

The Defence Science and Technology Laboratory. (2015b). *Strategy and Capability*. Ministry of Defence. https://assets.publishing.service.gov.uk/media/5a808286e5274a2e8ab508ea/StrandCap.pdf

The Defence Science and Technology Laboratory. (2023a, March 13). *Analysis for science and technology research in defence (ASTRID) framework*. Ministry of Defence. Retrieved February 27, 2024, from https://www.gov.uk/government/publications/dstl-science-and-technology-procurement-frameworks/analysis-for-science-and-technology-research-in-defence-astrid-framework

The Defence Science and Technology Laboratory. (2023b). *Annual report and accounts 2022/23* (HC 1676). Ministry of Defence. https://assets.publishing.service.gov.uk/media/64b8f3c506f78d000d742560/20230710_Dstl_Annual_Report_and_Accounts_2023_Digital_Only_FINAL.pdf

The Defence Science and Technology Laboratory. (2023c, November 29). *Cyber and Information Systems*. Ministry of Defence. Retrieved February 27, 2024, from https://www.gov.uk/government/publications/dstls-divisions/cyber-and-information-systems

The Defence Science and Technology Laboratory. (2023d, November 29). *Exploration Division*. Ministry of Defence. Retrieved February 27, 2024, from https://www.gov.uk/government/publications/dstls-divisions/exploration-division

The Department for Communities and Local Government. (2009). Multi-criteria decision analysis. In *Multi-Criteria analysis: A manual* (pp. 46–72). https://www.gov.uk/government/publications/multi-criteria-analysis-manual-for-making-government-policy

Derakhshan, R., Turner, R., & Mancini, M. (2019). Project governance and stakeholders: A literature review. *International Journal of Project Management*, *37*(1), 98–116. https://doi.org/10.1016/j.ijproman.2018.10.007

DeTombe, D. J. (2001). Compram, a method for handling complex societal problems. *European Journal of Operational Research*, *128*(2), 266–281. https://doi.org/10.1016/S0377-2217(00)00070-9

Duijnhoven, H., & Neef, M. (2015). Disentangling wicked problems: A reflexive approach towards resilience governance. In A. J. Masys (Ed.), *Applications of systems thinking and soft operations research in managing complexity* (pp. 91–106). Springer. https://doi.org/10.1007/978-3-319-21106-0_5

Dutruel, F., Eliana, Z. A. D., Hui, Y., & Petra, C. (2024). *Bridging the gap: The use of simulation in communication with stakeholders during policy analysis* [Unpublished manuscript]. Faculty of Technology, Policy and Management, Delft University of Technology. https://simulation.tudelft.nl/SEN9110/results/12_paper.pdf

Dyson, R. G. (2000). Strategy, performance and operational research. *Journal of the Operational Research Society*, *51*(1), 5–11. https://doi.org/10.1057/palgrave.jors.2600916

Dyson, R. G. (2022, September 13–15). *Soft OR/PSMs through six decades* [Conference presentation]. 64th Annual Conference of the Operational Research Society (OR64), Warwick, UK. https://theorsociety.eventsair.com/or64-annual-conference/programme

Dyson, R. G., O'Brien, F. A., & Shah, D. B. (2021). Soft OR and practice: The contribution of the founders of OR. *Operations Research*, *69*(3), 727–738. https://doi.org/10.1287/opre.2020.2051

Easton, G. (2010). Critical realism in case study research. *Industrial Marketing Management*, *39*(1), 118–128. https://doi.org/10.1016/j.indmarman.2008.06.004

Eastwood, J. G., De Souza, D. E., & Mukumbang, F. C. (2021). Realist research, design and evaluation for integrated care initiatives. In V. Amelung, V. Stein, E. Suter, N. Goodwin, E. Nolte, & R. Balicer (Eds.), *Handbook Integrated Care* (pp. 629–656). Springer. https://doi.org/10.1007/978-3-030-69262-9_37

Eden, C. (1982). Management science process—Problem construction and the influence of O.R. *INFORMS Journal on Applied Analytics*, *12*(2), 50–60. https://doi.org/10.1287/inte.12.2.50

Eden, C. (1989). SODA and cognitive mapping in practice. In J. Rosenhead (Ed.), *Rational analysis for a problematic world: Problem structuring methods for complexity, uncertainty and conflict* (1st ed., pp. 43–70). Wiley.

Eden, C. (1990). The unfolding nature of group decision support. In C. Eden & J. Radford (Eds.), *Tackling strategic problems: The role of group decision support* (pp. 48–52). Sage. https://strathprints.strath.ac.uk/43598/

Eden, C. (1996). The stakeholder/collaborator strategy workshop. In. C. Huxham (Ed.), *Creating collaborative advantage* (pp. 44–56). Sage. https://doi.org/10.4135/9781446221600.n3

Eden, C., & Ackermann, F. (1996). "Horses for courses": A stakeholder approach to the evaluation of GDSSs. In M. F. Shakun (Ed.), *Negotiation Processes: Modeling Frameworks and Information Technology* (pp. 201–219). Springer. https://doi.org/10.1007/978-94-009-1824-5_12

Eden, C., & Ackermann, F. (1998). *Making strategy: The journey of strategic management*. Sage. https://doi.org/10.4135/9781446217153

Eden, C., & Ackermann, F. (2004). Use of 'soft OR' models by clients: What do they want from them? In M. Pidd (Ed.), *Systems modelling: Theory and practice* (pp. 146–163). Wiley. https://www.wiley.com/en-us/Systems+Modelling%3A+Theory+and+Practice-p-9780470867310

Eden, C., & Ackermann, F. (2006). Where next for problem structuring methods. *The Journal of the Operational Research Society*, *57*(7), 766–768. http://www.jstor.org/stable/4102262

Eden, C., & Ackermann, F. (2021). Modelling stakeholder dynamics for supporting group decision and negotiation: Theory to practice. *Group Decision and Negotiation*, *30*, 1001–1025. https://doi.org/10.1007/s10726-021-09745-y

Eden, C., Ackermann, F., Bryson, J. M., Richardson, G. P., Andersen, D. F., & Finn, C. B. (2009). Integrating modes of policy analysis and strategic management practice: Requisite elements and dilemmas. *Journal of the Operational Research Society*, *60*, 2–13. https://doi.org/10.1057/palgrave.jors.2602575

Eden, C., & Huxham, C. (1996). Action research for the study of organizations. In S. Clegg, C. Hardy, & W. Nord (Eds.), *Handbook of organization studies* (pp. 526–542). Sage. https://strathprints.strath.ac.uk/43687/

Eden, C., Jones, S., & Sims, D. (1983). *Messing about in problems: An informal structured approach to their identification and management*. Pergamon. https://pureportal.strath.ac.uk/en/publications/messing-about-in-problems-an-informal-structured-approach-to-thei

Eden, C., & Radford, J. (Eds.). (1990). *Tackling strategic problems: The role of group decision support*. Sage. https://strathprints.strath.ac.uk/43598/

Edwards, P. K., O'Mahoney, J., & Vincent, S. (2014). *Studying organizations using critical realism: A practical guide*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199665525.001.0001

Egessa, M. M., & Liyala, S. (2021). Holistically placing the ICT artefact in capability approach. In *Proceedings of the 1st Virtual Conference on Implications of Information and Digital Technologies for Development* (pp. 910–923). https://doi.org/10.48550/arXiv.2108.09780

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *Management Review*, *14*(4), 532–550. https://doi.org/10.5465/AMR.1989.4308385

Eisenhardt, K. M. (2021). What is the Eisenhardt method, really? *Strategic Organization*, *19*(1), 147–160. https://doi.org/10.1177/1476127020982866

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–32. https://doi.org/10.5465/amj.2007.24160888

Elder-Vass, D. (2010). *The causal power of social structures: Emergence, structure and agency*. Cambridge University Press. https://doi.org/10.1017/CBO9780511761720

Elder-Vass, D. (2015a). Developing social theory using critical realism. *Journal of Critical Realism*, *14*(1), 80–92. https://doi.org/10.1179/1476743014Z.00000000047

Elder-Vass, D. (2015b). Disassembling actor-network theory. *Philosophy of the Social Sciences*, *45*(1), 100–121. https://doi.org/10.1177/0048393114525858

Elder-Vass, D. (2022). Critical realism: A philosophy for science. In G. Delanty & S. P. Turner (Eds.), *Routledge international handbook of contemporary social and political theory* (2nd ed., pp. 241–249). Routledge. https://doi.org/10.4324/9780203875575

Elder-Vass, D., Fryer, T., Groff, R. P., Navarrete, C., & Nellhaus, T. (2023). Does critical realism need the concept of three domains of reality? A roundtable. *Journal of Critical* Realism, *22*(2), 222–239. https://doi.org/10.1080/14767430.2023.2180965

Espinosa, A., & Walker, J. (2013). Complexity management in practice: A viable system model intervention in an Irish eco-community. *European Journal of Operational Research*, *225*(1), 118–129. https://doi.org/10.1016/j.ejor.2012.09.015

Esposito Amideo, A., Scaparra, M. P., & Kotiadis, K. (2019). Optimising shelter location and evacuation routing operations: The critical issues. *European Journal of Operational Research*, *279*(2), 279-295. https://doi.org/10.1016/j.ejor.2018.12.009

Essén, A., & Värlander, S. W. (2019). How technology-afforded practices at the micro-level can generate change at the field level: Theorizing the recursive mechanism actualized in Swedish rheumatology 2000-2014. *MIS Quarterly*, *43*(4), 1155–1176. https://doi.org/10.25300/MISQ/2019/12164

Evers, J. C. (2011). From the past into the future. How technological developments change our ways of data collection, transcription and analysis. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *12*(1), Article 38. https://doi.org/10.17169/fqs-12.1.1636

Faulkner, P., & Runde, J. (2013). Technological objects, social positions and the transformational model of social activity. *MIS Quarterly*, *37*(3), 803–818. https://doi.org/10.25300/MISQ/2013/37.3.06

Faulkner, P., & Runde, J. (2019). Theorizing the digital object. *MIS Quarterly*, *43*(4), 1279–1302. https://doi.org/10.25300/MISQ/2019/13136

Ferreira, J. S. (2013). Multimethodology in metaheuristics. *Journal of the Operational Research Society*, *64*(6), 873–883. https://doi.org/10.1057/jors.2012.88

Ferretti, V. (2016). From stakeholders analysis to cognitive mapping and multi-attribute value theory: An integrated approach for policy support. *European Journal of Operational Research*, *253*(2), 524–541. https://doi.org/10.1016/j.ejor.2016.02.054

Ferretti, V. (2019). Why is it worth it to expand your set of objectives? Impacts from behavioral decision analysis in action. In D. C. Morais, A. Carreras, A. T. De Almeida, & R. Vetschera (Eds.), *GDN 2019* (Vol. 351, pp. 92–105). Springer. https://doi.org/10.1007/978-3-030-21711-2_8

Ferretti, V. (2020). Layering, expanding, and visualizing: Lessons learned from three "process boosts" in action. In R. Viale (Ed.), *Routledge handbook of bounded rationality* (pp. 610–625). Routledge. https://doi.org/10.4324/9781315658353

Ferretti, V., Pluchinotta, I., & Tsoukiàs, A. (2019). Studying the generation of alternatives in public policy making processes. *European Journal of Operational Research*, *273*(1), 353–363. https://doi.org/10.1016/j.ejor.2018.07.054

Fetters, M. D. (2020). *The mixed methods research workbook: Activities for designing, implementing, and publishing projects*. Sage. https://doi.org/10.4135/9781071909713

Fetters, M. D., & Freshwater, D. (2015). The 1+ 1= 3 integration challenge. *Journal of Mixed Methods Research*, *9*(2), 115–117. https://doi.org/10.1177/1558689815581222

Fildes, R., & Ranyard, J. C. (1997). Success and survival of operational research groups—A review. *The Journal of the Operational Research Society*, *48*(4), 336–360. https://doi.org/10.1057/palgrave.jors.2600389

Fildes, R., Ranyard, J. C., & Crymble, W. R. (1999). The management of OR groups: Results of a survey. *Journal of the Operational Research Society*, *50*(6), 563–580. https://doi.org/10.1057/palgrave.jors.2600756

Finlay, P. N. (1998). On evaluating the performance of GSS: Furthering the debate. *European Journal of Operational Research*, *107*(1), 193–201. https://doi.org/10.1016/S0377-2217(97)00177-X

Fleetwood, S. (2005). Ontology in organization and management: A critical realist perspective. *Organization*, *12*(2), 197–222. https://doi.org/10.1177/1350508405051188

Fleetwood, S. (2008). Institutions and social structures. *Journal for the Theory of Social Behaviour*, *38*(3), 241–265. https://doi.org/10.1111/j.1468-5914.2008.00370.x

Fleetwood, S. (2009). The ontology of things, properties and powers. *Journal of Critical Realism*, *8*(3), 343–366. https://doi.org/10.1558/jocr.v8i3.343

Fleetwood, S. (2021). Re-visiting rules and norms. *Review of Social Economy*, *79*(4), 607–635. https://doi.org/10.1080/00346764.2019.1623909

Fletcher, A. J. (2017). Applying critical realism in qualitative research: Methodology meets method. *International Journal of Social Research Methodology*, *20*(2), 181–194. https://doi.org/10.1080/13645579.2016.1144401

Flood, R. L. (1989a). Six scenarios for the future of systems "problem solving". *Systems Practice*, *2*(1), 75–99. https://doi.org/10.1007/BF01061618

Flood, R. L. (1989b). Archaeology of (systems) inquiry. *Systems Practice*, *2*(1), 117–124. https://doi.org/10.1007/BF01061620

Flood, R. L. (1995a). *Solving problem solving: A potent force for effective management*. Wiley. https://www.wiley.com/en-us/Solving+Problem+Solving%3A+A+Potent+Force+for+Effective+Management-p-9780471955900

Flood, R. L. (1995b). Total systems intervention (TSI): A reconstitution. *Journal of the Operational Research Society*, *46*(2), 174–191. https://doi.org/10.1057/jors.1995.23

Flood, R. L. (2001). Local systemic intervention. *European Journal of Operational Research*, *128*(2), 245–257. https://doi.org/10.1016/S0377-2217(00)00068-0

Flood, R. L., & Jackson, M. C. (1991a). *Creative problem solving: Total systems intervention*. Wiley. https://www.wiley.com/en-us/Creative+Problem+Solving%3A+Total+Systems+Intervention-p-9780471930525

Flood, R. L., & Jackson, M. C. (1991b). *Critical systems thinking: Directed readings*. Wiley.

Flood, R. L., & Midgley, G. (2022). Festschrift for Mike Jackson: Call for papers for a special issue of Systems Research and Behavioral Science. *Systems Research and Behavioral Science*, *39*(5), 1005–1008. https://doi.org/10.1002/sres.2905

Flood, R. L., & Romm, N. R. A. (1995). Enhancing the process of methodology choice in total systems intervention (TSI) and improving chances of tackling coercion. *Systems Practice*, *8*(4), 377–408. https://doi.org/10.1007/BF02253393

Flood, R. L., & Romm, N. R. A. (1996). *Diversity management: Triple loop learning*. Wiley. https://www.wiley.com/en-us/Diversity+Management%3A+Triple+Loop+Learning-p-9780471964490

Flood, R. L., & Romm, N. R. A. (1997). From metatheory to multimethodology. In J. Mingers & A. Gill (Eds.), *Multimethodology: The theory and practice of combining management science methodologies* (pp. 291–322). Wiley. https://www.wiley.com/en-gb/Multimethodology%3A+Towards+Theory+and+Practice+and+Mixing+and+Matching+Methodologies-p-9780471974901

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, *12*(2), 219–245. https://doi.org/10.1177/1077800405284363

Forder, R. A. (2004). Operational research in the UK Ministry of Defence: An overview. *Journal of the Operational Research Society*, *55*(4), 319–332. https://doi.org/10.1057/palgrave.jors.2601657

Foster-Collins, H. (2020). Trustworthiness. *Sentio*, *1*, 15–23. https://sentiojournal.uk/wp-content/uploads/2020/02/SentioJournal_Issue1_article02_FosterCollins.pdf

Franco, L. A. (2013). Rethinking soft OR interventions: Models as boundary objects. *European Journal of Operational Research*, *231*(3), 720–733. https://doi.org/10.1016/j.ejor.2013.06.033

Franco, L. A. (2014). Zooming in on problem structuring interventions: An affordance perspective. In S. Howick (Ed.), *56th Annual Conference of the Operational Research Society (OR56) – Keynote papers* (pp. 78–90). The Operational Research Society. https://www.theorsociety.com/media/3348/keynote-paper-booklet-2-sh_22072014105003.pdf#page=81

Franco, L. A., & Greiffenhagen, C. (2018). Making OR practice visible: Using ethnomethodology to analyse facilitated modelling workshops. *European Journal of Operational Research*, *265*(2), 673–684. https://doi.org/10.1016/j.ejor.2017.08.016

Franco, L. A., & Greiffenhagen, C. (2020). Group decision support practice 'as it happens'. In D. M. Kilgour, & C. Eden (Eds.), *Handbook of group decision and negotiation* (pp. 1–22). Springer. https://doi.org/10.1007/978-3-030-12051-1_54-1

Franco, L. A., & Hämäläinen, R. P. (2016a). Behavioural operational research: Returning to the roots of the OR profession. *European Journal of Operational Research*, *249*(3), 791–795. https://doi.org/10.1016/j.ejor.2015.10.034

Franco, L. A., & Hämäläinen, R. P. (2016b). Engaging with behavioral operational research: On methods, actors and praxis. In M. H. Kunc, J. Malpass, & L. White (Eds.), *Behavioral operational research* (pp. 3–25). Springer. https://doi.org/10.1057/978-1-137-53551-1_1

Franco, L. A., Hämäläinen, R. P., Rouwette, E. A. J. A., & Leppänen, I. (2021). Taking stock of behavioural OR: A review of behavioural studies with an intervention focus. *European Journal of Operational Research*, *293*, 401–418. https://doi.org/10.1016/j.ejor.2020.11.031

Franco, L. A., & Lord, E. (2011). Understanding multi-methodology: Evaluating the perceived impact of mixing methods for group budgetary decisions. *Omega*, *39*(3), 362–372. https://doi.org/10.1016/j.omega.2010.06.008

Franco, L. A., & Montibeller, G. (2010). Facilitated modelling in operational research. *European Journal of Operational Research*, *205*(3), 489–500. https://doi.org/10.1016/j.ejor.2009.09.030

Franco, L. A., O'Brien, F. A., & Bell, P. (2011). Supporting strategy: Contributions from OR. *Journal of the Operational Research Society*, *62*(5), 815–816. https://doi.org/10.1057/jors.2011.9

Franco, L. A., & Rouwette, E. A. J. A. (2022). Problem structuring methods: Taking stock and looking ahead. In S. Salhi & J. Boylan (Eds.), *The Palgrave handbook of operations research* (pp. 735–780). Palgrave Macmillan. https://doi.org/10.1007/978-3-030-96935-6_23

Frederiksen, D. J., & Kringelum, L. B. (2021). Five potentials of critical realism in management and organization studies. *Journal of Critical Realism*, *20*(1), 18–38. https://doi.org/10.1080/14767430.2020.1846153

Freeman, R. (1984). *Strategic management: A stakeholder approach.* Pitman.

French, S. (2013). Cynefin, statistics and decision analysis. *Journal of the Operational Research Society*, *64*(4), 547–561. https://doi.org/10.1057/jors.2012.23

French, S. (2022). From soft to hard elicitation. *Journal of the Operational Research Society*, *73*(6), 1181–1197. https://doi.org/10.1080/01605682.2021.1907244

Freshwater, D., & Cahill, J. (2023). The role of methodological paradigms for dialogic knowledge production: Using a conceptual map of discourse development to inform mixed methods research design. In C. N. Poth (Ed.), *The Sage handbook of mixed methods research design* (pp. 79–90). Sage. https://doi.org/10.4135/9781529614572.n10

Friend, J. K. (2006). Labels, methodologies and strategic decision support. *Journal of the Operational Research Society*, *57*(7), 772–775. https://doi.org/10.1057/palgrave.jors.2602089

Friend, J. K., & Hickling, A. (1987). *Planning under pressure: The strategic choice approach*. Pergamon.

Friend, J. K., & Hickling, A. (2005). *Planning under pressure: The strategic choice approach* (3rd ed.). Elsevier. https://doi.org/10.4324/9780080480053

Friend, J. K., Norris, M. E., & Stringer, J. (1988). The institute for operational research: An initiative to extend the scope of OR. *Journal of the Operational Research Society*, *39*(8), 705–713. https://doi.org/10.1057/jors.1988.125

Fromm, J., Mirbabaie, M., & Stieglitz, S. (2020). A systematic review of empirical affordance studies: Recommendations for affordance research in information systems. In *Proceedings of the 28th European Conference on Information Systems (ECIS2020) Research-in-Progress Papers*, *42*. Association for Information Systems Electronic Library (AISeL). https://aisel.aisnet.org/ecis2020_rip/42

Fryer, T. (2022). A critical realist approach to thematic analysis: Producing causal explanations. *Journal of Critical Realism*, *21*(4), 365–384. https://doi.org/10.1080/14767430.2022.2076776

Furnari, S., Crilly, D., Misangyi, V. F., Greckhamer, T., Fiss, P. C., & Aguilera, R. V. (2021). Capturing causal complexity: Heuristics for configurational theorizing. *Academy of Management Review*, *46*(4), 778–799. https://doi.org/10.5465/amr.2019.0298

Gehman, J., Glaser, V. L., Eisenhardt, K. M., Gioia, D., Langley, A., & Corley, K. G. (2018). Finding theory–method fit: A comparison of three qualitative approaches to theory building. *Journal of Management Inquiry*, *27*(3), 284–300. https://doi.org/10.1177/1056492617706029

Georgiou, I. (2012). Messing about in transformations: Structured systemic planning for systemic solutions to systemic problems. *European Journal of Operational Research*, *223*(2), 392–406. https://doi.org/10.1016/j.ejor.2012.06.010

Georgiou, I., & Heck, J. (2020). The emergence of problem structuring methods, 1950s–1989: An atlas of the journal literature. *Systems Research and Behavioral Science*, *38*(6), 756–796. https://doi.org/10.1002/sres.2737

Gerrits, L., & Verweij, S. (2013). Critical realism as a meta-framework for understanding the relationships between complexity and qualitative comparative analysis. *Journal of Critical Realism*, *12*(2), 166–182. https://doi.org/10.1179/rea.12.2.p663527490513071

Gibson, J. J. (1979). *The ecological approach to visual perception*. Lawrence Erlbaum.

Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory*. Aldine.

Gomes Júnior, A. de A., & Schramm, V. B. (2022). Problem structuring methods: A review of advances over the last decade. *Systemic Practice and Action Research*, *35*(1), 55–88. https://doi.org/10.1007/s11213-021-09560-1

Gorod, A., Hallo, L., Ireland, V., & Gunawan, I. (2019). *Evolving toolbox for complex project management*. Auerbach. https://doi.org/10.1201/9780429197079

The Government Operational Research Service. (n.d.-a). *GORS: Home*. Retrieved July 3, 2023, from http://www.operational-research.gov.uk/recruitment

The Government Operational Research Service. (n.d.-b). *How GORS works*. Retrieved June 22, 2023, from http://www.operational-research.gov.uk/recruitment/how_gors_works/

The Government Operational Research Service. (n.d.-c). *What is OR?* Retrieved June 22, 2023, from http://www.operational-research.gov.uk/recruitment/what_is_or

The Government Office for Science. (2022, May 24). *Systems thinking for civil servants*. Retrieved June 22, 2023, from https://www.gov.uk/government/publications/systems-thinking-for-civil-servants

The Grantham Institute. (2016). *Decision making under risk & uncertainty summary workshop report*. https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/events/ICL-2016---DM_Workshop-10-11-Feb_Summary_FINAL.pdf

Greene, J. C. (2015). Preserving distinctions within the multimethod and mixed methods research merger. In S. N. Hesse-Biber & R. B. Johnson (Eds.), *The Oxford handbook of multimethod and mixed methods research inquiry* (pp. 606–615). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199933624.013.37

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis*, *11*(3), 255–274. https://doi.org/10.3102/01623737011003255

Gregory, A. J., Atkins, J. P., Midgley, G., & Hodgson, A. M. (2019). Stakeholder identification and engagement in problem structuring interventions. *European Journal of Operational Research*, *283*(1), 321–340. https://doi.org/10.1016/j.ejor.2019.10.044

Gregory, A. J., & Ronan, M. (2015). Insights into the development of strategy from a complexity perspective. *Journal of the Operational Research Society*, *66*(4), 627–636. https://doi.org/10.1057/jors.2014.27

Gregory, W. J. (1996). Discordant pluralism: A new strategy for critical systems thinking. *Systems Practice*, *9*(6), 605–625. https://doi.org/10.1007/BF02169216

Grewatsch, S., Kennedy, S., & Bansal, P. (2023). Tackling wicked problems in strategic management with systems thinking. *Strategic Organization*, *21*(3), 721–732. https://doi.org/10.1177/14761270211038635

Gu, J., & Zhu, Z. (2000). Knowing wuli, sensing shili, caring for renli: Methodology of the WSR approach. *Systemic Practice and Action Research*, *13*(1), 11–20. https://doi.org/10.1023/A:1009567421256

Guitouni, A., & Martel, J.-M. (1998). Tentative guidelines to help choosing an appropriate MCDA method. *European Journal of Operational Research*, *109*(2), 501–521. https://doi.org/10.1016/S0377-2217(98)00073-3

Gummesson, E. (2017). *Case theory in business and management: reinventing case study research*. Sage. https://doi.org/10.4135/9781473920811

Hallsworth, M., Parker, S., & Rutter, J. (2011). *Policy making in the real world: Evidence and analysis*. Institute for Government. https://www.instituteforgovernment.org.uk/sites/default/files/publications/Policy making in the real world.pdf

Hämäläinen, R. P., & Lahtinen, T. J. (2016). Path dependence in operational research – How the modeling process can influence the results. *Operations Research Perspectives*, *3*, 14–20. https://doi.org/10.1016/j.orp.2016.03.001

Hämäläinen, R. P., Luoma, J., & Saarinen, E. (2013). On the importance of behavioral operational research: The case of understanding and communicating about dynamic systems. *European Journal of Operational Research*, *228*(3), 623–634. https://doi.org/10.1016/j.ejor.2013.02.001

Hanafizadeh, P., & Mehrabioun, M. (2018). Application of SSM in tackling problematical situations from academicians' viewpoints. *Systemic Practice and Action Research*, *31*(2), 179–220. https://doi.org/10.1007/s11213-017-9422-y

Handley, A. (2010). *Guidance on the use of subjective operational analysis methods in support of acquisition decisions* (Publication No. DSTL/CR43706). Defence Science and Technology Laboratory.

Harper, A., & Mustafee, N. (2023). Participatory design research for the development of real-time simulation models in healthcare. *Health Systems*, *12*(4), 375-386. https://doi.org/10.1080/20476965.2023.2175730

Harwood, S. A. (2019). Whither is problem structuring methods (PSMs)? *Journal of the Operational Research Society*, *70*(8), 1391–1392. https://doi.org/10.1080/01605682.2018.1502628

Harwood, S. A. (2020). Introducing the VIPLAN Methodology (with VSM) for handling messy situations – Nine lessons. *Systemic Practice and Action Research*, *34*, 635–668. https://doi.org/10.1007/s11213-020-09545-6

Hassan, N. R., & Mingers, J. (2018). Re-interpreting the Kuhnian paradigm in information systems. *Journal of the Association for Information Systems, 19*(7), 568–599. https://doi.org/10.17705/1jais.00502

Hathcoat, J. D., & Meixner, C. (2015). Pragmatism, factor analysis, and the conditional incompatibility thesis in mixed methods research. *Journal of Mixed Methods Research*, *11*(4), 433–449. https://doi.org/10.1177/1558689815622114 Hector, D., Christensen, C., & Petrie, J. (2009). A problem-structuring method for complex societal decisions: Its philosophical and

psychological dimensions. *European Journal of Operational Research*, *193*(3), 693–708. https://doi.org/10.1016/j.ejor.2007.06.058

Hedström, P., & Ylikoski, P. (2010). Causal mechanisms in the social sciences. Annual Review of Sociology, *36*, 49–67. https://doi.org/10.1146/annurev.soc.012809.102632 https://www.academia.edu/download/66793028/3b2ed83a772ad883445381491f5a07be3984.pdf

Henao, F., Benavides, J., Sandoval, H., Trejos, C., & O'Brien, F. A. (2017). Understanding the role of OR/MS in the strategic decisions of Colombian organisations - An exploratory study. *Pesquisa Operacional*, *37*(1), 1–28. https://doi.org/10.1590/0101-7438.2017.037.01.0001

Henao, F., & Franco, L. A. (2016). Unpacking multimethodology: Impacts of a community development intervention. *European Journal of Operational Research*, *253*(3), 681–696. https://doi.org/10.1016/j.ejor.2016.02.044

Henfridsson, O., & Bygstad, B. (2013). The generative mechanisms of digital infrastructure evolution. *MIS Quarterly*, *37*(3), 907–931.

Hermans, L. M., & Thissen, W. A. H. (2009). Actor analysis methods and their use for public policy analysts. *European Journal of Operational Research*, *196*(2), 808–818. https://doi.org/10.1016/j.ejor.2008.03.040

Herrera, H. J., McCardle-Keurentjes, M. H. F., & Videira, N. (2016). Evaluating facilitated modelling processes and outcomes: An experiment comparing a single and a multimethod approach in group model building. *Group Decision and Negotiation*, *25*(6), 1277–1318. https://doi.org/10.1007/s10726-016-9480-z

Hertwig, R., & Grüne-Yanoff, T. (2017). Nudging and boosting: Steering or empowering good decisions. *Perspectives on Psychological Science*, *12*(6), 973–986. https://doi.org/10.1177/1745691617702496

Hesse-Biber, S. N. (2010). *Mixed methods research: Merging theory with practice*. The Guildford Press.

Hester, P. (2015). Analyzing stakeholders using fuzzy cognitive mapping. *Procedia Computer Science*, *61*, 92–97. https://doi.org/10.1016/j.procs.2015.09.159

Heyer, R. (2004). *Understanding soft operations research: The methods, their application and its future in the defence setting* (Publication No. DSTO-GD-0411). Defence Science and Technology Organisation. http://www.dsto.defence.gov.au/corporate/reports/DSTO-GD-0411.pdf

Hillier, F., & Lieberman, G. (2020). *Introduction to operations research* (11th ed.). McGraw Hill. https://www.mheducation.com/highered/product/introduction-operations-research-hillier-lieberman/M9781259872990.html

Hindle, G. A. (2018, April 5). How to use PSMs for strategic thinking and exploring their role in policy making [Webinar presentation]. The Operational Research Society. https://www.youtube.com/watch?v=CnvTv4KA93E

Hindle, G. A., Kunc, M. H., Mortensen, M., Oztekin, A., & Vidgen, R. (2020). Business analytics: Defining the field and identifying a research agenda. *European Journal of Operational Research*, *281*(3), 483–490. https://doi.org/10.1016/j.ejor.2019.10.001

Hindle, G. A., Smith, C. M., Kunc, M. H., & Suresh, K. (2021). Strategy keynote: Exploring the link between strategy and OR. In *63rd Annual Conference of the Operational Research Society (OR63) – Keynote papers*. The Operational Research Society.

Hindle, G. A., & Vidgen, R. (2018). Developing a business analytics methodology: A case study in the foodbank sector. *European Journal of Operational Research*, *268*(3), 836–851. https://doi.org/10.1016/j.ejor.2017.06.031

Hinds, K., & Dickson, K. (2021). Realist synthesis: A critique and an alternative. *Journal of Critical Realism*, *20*(1), 1–17. https://doi.org/10.1080/14767430.2020.1860425

Hitchcock, J. H., & Onwuegbuzie, A. J. (2019). Using mathematical formulae as proof for integrating mixed methods research and multiple methods research approaches: A call for multi-mixed methods and meta-methods in a mixed research 2.0 era. *International Journal of Multiple Research Approaches*, *11*(3), 213–234. https://doi.org/https://doi.org/10.29034/ijmra.v11n3editorial2

Hitchcock, J. H., & Onwuegbuzie, A. J. (2022). The Routledge handbook for advancing integration in mixed methods research: An introduction. In J. H. Hitchcock & A. J. Onwuegbuzie (Eds.), *The Routledge handbook for advancing integration in mixed methods research* (pp. 3–27). Routledge. https://doi.org/10.4324/9780429432828-2

HM Treasury. (2003). *The green book: Appraisal and evaluation in central government* https://webarchive.nationalarchives.gov.uk/ukgwa/20080305121602/http://www.hm-treasury.gov.uk/media/3/F/green_book_260907.pdf

HM Treasury. (2015). *The aqua book: Guidance on producing quality analysis for government* https://assets.publishing.service.gov.uk/media/5a7f3bb8e5274a2e87db49be/aqua_book_final_web.pdf

HM Treasury. (2022). *The green book: Central government guidance on appraisal and evaluation* https://assets.publishing.service.gov.uk/media/623d99f5e90e075f14254676/Green_Book_2022.pdf

Hobbs, C., & Midgley, G. (2020). *Enhancing systemic capability in the civil service: Report of key findings*. University of Hull. https://doi.org/10.13140/RG.2.2.24529.61287

Hodgson, G. M. (2006). What are institutions? *Journal of Economic Issues*, *40*(1), 1–25. https://doi.org/10.1080/00213624.2006.11506879

Holzgrefe, J. P. L., & Hester, P. T. (2016). A framework to choose alternative analysis and selection methods. *International Journal of System of Systems Engineering*, *7*(4), 277–293. https://doi.org/10.1504/IJSSE.2016.080318

Hopes, J. (2021, April). Reinvigorating soft OR. *Inside OR*, *601*, 8–9. https://www.theorsociety.com/publications/magazines/inside-or/2021-april/

Hopes, J., Ranyard, J. C., & Murray, E. (2022, August). An edited response from the authors – John Hopes, John Ranyard and Emma Murray. *Inside OR*, *617*, 19. https://www.theorsociety.com/media/6951/2022-august-edition.pdf

Horlick-Jones, T., & Rosenhead, J. (2007). The uses of observation: Combining problem structuring methods and ethnography. *Journal of the Operational Research Society*, *58*(5), 588–601. https://doi.org/10.1057/palgrave.jors.2602271

The House of Commons Defence Committee. (2015a). *Decision-Making in defence policy: Eleventh report of session 2014–15* (Publication No. 682). http://www.publications.parliament.uk/pa/cm201415/cmselect/cmdfence/682/682.pdf

The House of Commons Defence Committee. (2015b). *Decision-Making in defence policy: Government response to the Committee's eleventh report of session 2014-15: Third special report of session 2015–16* (Publication No. HC 367). http://www.publications.parliament.uk/pa/cm201516/cmselect/cmdfence/367/367.pdf

Hoverstadt, P., & Loh, L. (2024). Back to basics: Developing systems methodologies from first (systems) principles. *Systems Research and Behavioral Science*, *41*(1), 207–215. https://doi.org/10.1002/sres.2949

Howick, S. (2023). Mixing methods: Reflections for simulation [Abstract]. In C. Currie, & L. Rhodes-Leader (Eds.), *Proceedings of the Operational Research Society Simulation Workshop 2023 (SW23)* (p. 10), The Operational Research Society. https://doi.org/10.36819/SW23.002

Howick, S., & Ackermann, F. (2011). Mixing OR methods in practice: Past, present and future directions. *European Journal of Operational Research*, *215*(3), 503–511. https://doi.org/10.1016/j.ejor.2011.03.013

Howick, S., Ackermann, F., Walls, L., Quigley, J., & Houghton, T. (2017). Learning from mixed OR method practice: The NINES case study. *Omega*, *69*, 70–81. https://doi.org/10.1016/j.omega.2016.08.003

Howick, S., Eden, C., Ackermann, F., & Williams, T. (2008). Building confidence in models for multiple audiences: The modelling cascade. *European Journal of Operational Research*, *186*(3), 1068–1083. https://doi.org/10.1016/j.ejor.2007.02.027

Institute for Apprenticeships and Technical Education. (2020a). *End-Point assessment plan for operational research specialist apprenticeship standard*.

https://www.instituteforapprenticeships.org/media/4389/st0884-operational-research-specialist_l7_ap01_17720_forpublication.pdf

Institute for Apprenticeships and Technical Education. (2020b). *End-Point assessment plan for systems thinking practitioner apprenticeship standard*. https://www.instituteforapprenticeships.org/media/qixdc2cm/st0787_l7_systems-thinking-practitioner_epa-plan_22062023.pdf

Institute for Apprenticeships and Technical Education. (2020c, August 24). *Operational research specialist*. Retrieved November 25, 2020, from https://www.instituteforapprenticeships.org/apprenticeship-standards/operational-research-specialist/

Institute for Apprenticeships and Technical Education. (2020d, May 13). *Systems thinking practitioner*. Retrieved November 17, 2020, from https://www.instituteforapprenticeships.org/apprenticeship-standards/systems-thinking-practitioner/

Institute for Government. (n.d.). *Grade structures of the civil service*. Retrieved February 27, 2024, from https://www.instituteforgovernment.org.uk/explainers/grade-structures-civil-service

Institute for Operations Research and the Management Sciences (n.d.). *What is O.R.?* Retrieved September 17, 2021, from https://www.informs.org/Explore/What-is-O.R.-Analytics/What-is-O.R.

International Journal of Multiple Research Approaches. (n.d.). *Home*. Retrieved May 20, 2022, https://ijmra.org/

Ishino, Y., & Kijima, K. (2005). Project management methodology for stimulating strategic communication in Japan. *Systems Research and Behavioral Science*, *22*(3), 209–221. https://doi.org/10.1002/sres.658

Jackson, M. C. (1987). Present positions and future prospects in management science. *Omega*, *15*(6), 455–466. https://doi.org/https://doi.org/10.1016/0305-0483(87)90003-X

Jackson, M. C. (1990). Beyond a system of systems methodologies. *Journal of the Operational Research Society*, *41*, 657–668. https://doi.org/10.1057/jors.1990.96

Jackson, M. C. (1997). Pluralism in systems thinking and practice. In J. Mingers & A. Gill (Eds.), *Multimethodology: The theory and practice of combining management science methodologies* (pp. 347–378). Wiley. https://www.wiley.com/en-gb/Multimethodology%3A+Towards+Theory+and+Practice+and+Mixing+and+Matching+Methodologies-p-9780471974901

Jackson, M. C. (1999). Towards coherent pluralism in management science. *Journal of the Operational Research Society*, *50*(1), 12–22. https://doi.org/10.1057/palgrave.jors.2600661

Jackson, M. C. (2000). *Systems approaches to management*. Springer. https://doi.org/10.1007/b100327

Jackson, M. C. (2001). Critical systems thinking and practice. *European Journal of Operational Research*, *128*(2), 233–244. https://doi.org/10.1016/S0377-2217(00)00067-9

Jackson, M. C. (2003a). *Systems thinking: Creative holism for managers*. Wiley.

Jackson, M. C. (2003b). The power of multi-methodology: Some thoughts for John Mingers. *Journal of the Operational Research Society*, *54*(12), 1300–1301. https://doi.org/10.1057/palgrave.jors.2601640

Jackson, M. C. (2006a). Beyond problem structuring methods: Reinventing the future of OR/MS. *Journal of the Operational Research Society*, *57*(7), 868–878. https://doi.org/10.1057/palgrave.jors.2602093

Jackson, M. C. (2007). Beyond the fads: Systems thinking for managers. *Systems Research*, *12*(1), 25–42. https://doi.org/10.1002/sres.3850120106

Jackson, M. C. (2019). *Critical systems thinking and the management of complexity*. Wiley.

Jackson, M. C. (2020). Critical systems practice 1: Explore—Starting a multimethodological intervention. *Systems Research and Behavioral Science*, *37*(5), 839–858. https://doi.org/10.1002/sres.2746

Jackson, M. C. (2021). Critical systems practice 2: Produce—Constructing a multimethodological intervention strategy. *Systems Research and Behavioral Science*, *38*(5), 594–609. https://doi.org/10.1002/sres.2809

Jackson, M. C. (2022a). Critical systems practice 3: Intervene —Flexibly executing a multimethodological intervention. *Systems Research and Behavioral Science*, *39*(6), 1014–1023. https://doi.org/10.1002/sres.2909

Jackson, M. C. (2022b). Critical systems practice 4: Check—Evaluating and reflecting on a multimethodological intervention. *Systems Research and Behavioral Science*, *40*(4), 617–632. https://doi.org/10.1002/sres.2912

Jackson, M. C. (2023, April 4). Pragmatism and critical systems thinking: Back to the future of systems thinking. *Integration and Implementation Insights: A Community Blog and Repository of Resources for Improving Research Impact on Complex Real-World Problems*. https://i2insights.org/2023/04/04/pragmatism-and-critical-systems-thinking/

Jackson, M. C., & Keys, P. (1984). Towards a system of systems methodologies. *Journal of the Operational Research Society*, *35*(6), 473–486. https://doi.org/10.2307/2581795

Jackson, M. C., Keys, P., & Cropper, S. A. (Eds.). (1989). *Operational research and the social sciences*. Plenum Press. https://doi.org/10.1007/978-1-4613-0789-1

Jahangirian, M., Borsci, S., Shah, S. G. S., & Taylor, S. J. (2015). Causal factors of low stakeholder engagement: A survey of expert opinions in the context of healthcare simulation projects. *Simulation*, *91*(6), 511–526. https://doi.org/10.1177/0037549715583150

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, *1*(2), 112–133. https://doi.org/10.1177/1558689806298224

Jones, G. C. (1993). *A critique of the practice and methodology of operational research* [Doctoral dissertation, Sheffield Hallam University]. ProQuest Dissertations & Theses Global. https://www.proquest.com/pqdtglobal/docview/1962385623/fulltextPDF/E865BC4B690B4ED6PQ

Jones, P. (2015, July 12–15). *Problem formulation and study design or doing the right analysis and doing the analysis right!* [Conference presentation]. 27th European Conference on Operational Research (*EURO 2015*), Glasgow, UK.

Jones, P., & Forder, R. A. (2013). Problem formulation and study design. In *55th Annual Conference of the Operational Research Society (OR55) – Keynote papers and extended abstracts*. The Operational Research Society. (Document No. DSTL/CP74527)

Jones, W., Kotiadis, K., & O'Hanley, J. R. (2022). Maximising stakeholder learning by looping again through the simulation life-cycle: A case study in public transport. *Journal of the Operational Research Society*, *73*(12), 2640-2659. https://doi.org/10.1080/01605682.2021.2007806

Jun, G. T., Morris, Z., Eldabi, T., Harper, P., Naseer, A., Patel, B., & Clarkson, J. P. (2011). Development of modelling method selection tool for health services management: From problem structuring methods to modelling and simulation methods. *BMC Health Services Research*, *11*, 108. https://doi.org/10.1186/1472-6963-11-108

Kahneman, D., Slovic, P., & Tversky, A. (Eds.). (1982). *Judgment under uncertainty: Heuristics and biases*. Cambridge University Press. https://doi.org/10.1017/cbo9780511809477

Kar, E., Fakhimi, M., Turner, C., & Eldabi, T. (2024). Hybrid simulation in healthcare: A systematic exploration of models, applications, and emerging trends. *Journal of Simulation*. Advance online publication. https://doi.org/10.1080/17477778.2024.2354250

Keeney, R. L., & Raiffa, H. (1976). *Decisions with multiple objectives: Preferences and value trade-offs*. Wiley.

Kempton, A. M. (2022). The digital is different: Emergence and relationality in critical realist research. *Information and Organization*, *32*(2), 100408. https://doi.org/10.1016/j.infoandorg.2022.100408

Ketokivi, M., & Choi, T. (2014). Renaissance of case research as a scientific method. *Journal of Operations Management*, *32*(5), 232–240. https://doi.org/10.1016/j.jom.2014.03.004

Keys, P. (1995). *Understanding the process of operational research: Collected readings*. Wiley.

Keys, P. (1997). Approaches to understanding the process of OR: Review, critique and extension. *Omega*, *25*(1), 1–13. https://doi.org/10.1016/S0305-0483(96)00049-7

Keys, P., & Midgley, G. (2002). Part special issue editorial: The process of OR. *Journal of the Operational Research Society*, *53*(2), 123–125. https://doi.org/10.1057/palgrave.jors.2601313

Kotiadis, K. (2007). Using soft systems methodology to determine the simulation study objectives. *Journal of simulation*, *1*(3), 215-222. https://doi.org/10.1057/palgrave.jos.4250025

Kotiadis, K., & Mingers, J. (2006). Combining PSMs with hard OR methods: The philosophical and practical challenges. *Journal of the Operational Research Society*, *57*(7), 856–867. https://doi.org/10.1057/palgrave.jors.2602147

Kotiadis, K., & Mingers, J. (2014). Combining problem structuring methods with simulation: The philosophical and practical challenges. In S. Brailsford, L. Churilov, & B. Dangerfield (Eds.), *Discrete-event simulation and system dynamics for management decision making* (pp. 52–75). Wiley. https://doi.org/10.1002/9781118762745.ch04

Kotiadis, K., & Tako, A. A. (2018). Facilitated post-model coding in discrete event simulation (DES): A case study in healthcare. *European Journal of Operational Research*, *266*(3), 1120–1133. https://doi.org/10.1016/j.ejor.2017.10.047

Kotiadis, K., & Tako, A. A. (2021). A tutorial on involving stakeholders in facilitated simulation studies. In M. Fakhimi, D. Robertson, & T. Bones (Eds.), *Proceedings of the Operational Research Society Simulation Workshop 2021 (SW21)* (pp. 42–56). The Operational Research Society. https://doi.org/10.36819/SW21.005

Kotiadis, K., Tako, A. A., & Vasilakis, C. (2014). A participative and facilitative conceptual modelling framework for discrete event simulation studies in healthcare. *Journal of the Operational Research Society*, *65*, 197–213. https://doi.org/10.1057/jors.2012.176

Kowalczyk, R. (2004). The effectiveness of high-dependency care. In M. Pidd (Ed.), *Systems modelling: Theory and practice* (pp. 61–75). Wiley. https://www.wiley.com/en-us/Systems+Modelling%3A+Theory+and+Practice-p-9780470867310

Kuhn, T. S. (2012). *The structure of scientific revolutions* (4th ed.). The University of Chicago Press. (Original work published 1962) https://press.uchicago.edu/ucp/books/book/chicago/S/bo13179781.html

Kunc, M. H., Malpass, J., & White, L. (Eds.). (2016). *Behavioral operational research: Theory, methodology and practice*. Palgrave Macmillan. https://doi.org/10.1057/978-1-137-53551-1

Kunc, M. H., Morecroft, J. D. W., & Brailsford, S. C. (2018). Special issue on advances in system dynamics modelling from the perspective of other simulation methods. *Journal of Simulation*, *12*(2), 87–89. https://doi.org/10.1080/17477778.2018.1469385

Kunc, M. H., & O'Brien, F. A. (2019). The role of business analytics in supporting strategy processes: Opportunities and limitations. *Journal of the Operational Research Society*, *70*(6), 974–985. https://doi.org/10.1080/01605682.2018.1475104

Lahtinen, T. J., Guillaume, J. H. A., & Hämäläinen, R. P. (2017). Why pay attention to paths in the practice of environmental modelling? *Environmental Modelling & Software*, *92*, 74–81. https://doi.org/10.1016/j.envsoft.2017.02.019

Lambert, N. J. (2004). Analysis and evaluation of the command and control concept of the NATO Immediate Reaction Task Force (Land). *Journal of the Operational Research Society*, *55*(4), 375–389. https://doi.org/10.1057/palgrave.jors.2601666

Lamé, G., Jouini, O., & Stal-Le Cardinal, J. (2019). Combining soft systems methodology, ethnographic observation, and discrete-event simulation: A case study in cancer care. *Journal of the Operational Research Society*, *71*(10), 1545–1562. https://doi.org/10.1080/01605682.2019.1610339

Lami, I. M., Abastante, F., Bottero, M., Masala, E., & Pensa, S. (2014). Integrating multicriteria evaluation and data visualization as a problem structuring approach to support territorial transformation projects. *EURO Journal on Decision Processes*, *2*(3–4), 281–312. https://doi.org/10.1007/s40070-014-0033-x

Lami, I. M., & White, L. (2022). Are PSMs relevant in a digital age? Towards an ethical dimension. In S. Salhi & J. Boylan (Eds.), *The Palgrave handbook of operations research* (pp. 781–801). Palgrave Macmillan. https://doi.org/10.1007/978-3-030-96935-6_24

Lanamäki, A., Thapa, D., & Stendal, K. (2016). When is an affordance? Outlining four stances. *IFIP Advances in Information and Communication Technology*, *489*, 125–139. https://doi.org/10.1007/978-3-319-49733-4_8

Langley, A. (1989). In search of rationality: The purposes behind the use of formal analysis in organizations. *Administrative Science Quarterly, 34*(4), 598–631. https://doi.org/10.2307/2393569

Langley, A. (1999). Strategies for theorizing from process data. *Academy of Management Review*, *24*(4), 691–710. https://doi.org/10.5465/AMR.1999.2553248

Langley, A., & Abdallah, C. (2016). Templates and turns in qualitative studies of strategy and management. In G. B. Dagnino & M. C. Cinici (Eds.), *Research methods for strategic management* (pp. 137–167). Routledge. https://doi.org/10.4324/9780203676615

Langley, A., Mintzberg, H., Pitcher, P., Posada, E., & Saint-Macary, J. (1995). Opening up decision making: The view from the black stool. *Organization Science*, *6*(3), 260–279. https://doi.org/10.1287/orsc.6.3.260

Lawson, T. (1997). *Economics and reality* (1st ed.). Routledge. https://doi.org/10.4324/9780203195390

Lawson, T. (2003). Theorizing ontology. *Feminist Economics*, *9*(1), 161–169. https://doi.org/10.1080/1354570032000063038

Lawson, T. (2022). *Social positioning theory*. *Cambridge Journal of Economics, 46*(1), 1–39. https://doi.org/10.1093/cje/beab040

Lawson, T. (2023a). The human person, the human social individual and community interactions. *Cambridge Journal of Economics*, *47*(3), 475–506. https://doi.org/10.1093/cje/bead016

Lawson, T. (2023b). Social positioning theory and quantum mechanics. *Journal for the Theory of Social Behaviour*, *53*(4), 583–619. https://doi.org/10.1111/jtsb.12390

Le Menestrel, M., & Van Wassenhove, L. N. (2004). Ethics outside, within, or beyond OR models? *European Journal of Operational Research*, *153*(2), 477–484. https://doi.org/10.1016/S0377-2217(03)00168-1

Ledington, P., & Donaldson, J. (1997). Soft OR and management practice: A study of the adoption and use of soft systems methodology. *Journal of the Operational Research Society*, *48*(3), 229–240. https://doi.org/10.1057/palgrave.jors.2600350

Leidner, D. E., Gonzalez, E., & Koch, H. (2018). An affordance perspective of enterprise social media and organizational socialization. *Journal of Strategic Information Systems*, *27*(2), 117–138. https://doi.org/10.1016/j.jsis.2018.03.003

Leleur, S. (2012). *Complex strategic choices: Applying systemic planning for strategic decision making*. Springer. https://doi.org/10.1007/978-1-4471-2491-7

Leleur, S. (2020). Systemic planning (SP): A generic framework for complex decision making. *Acta Europeana Systemica, 8*(1), 263–274. https://doi.org/10.14428/aes.v8i1.56443

Lempert, R. J. (2019). Robust decision making (RDM). In V. Marchau, W. Walker, P. Bloemen, & S. Popper. (Eds.), *Decision making under deep uncertainty: From theory to practice* (pp. 23-51). Springer. https://doi.org/10.1007/978-3-030-05252-2_2

Leong, C., Soon, D. W. X., Ong, C., & Howlett, M. (2023). Problems in applying Soft OR methods to climate actions: Lessons from two cases of governmental use. *npj Climate Action 2*, 1. https://doi.org/10.1038/s44168-023-00037-6

Li, Y., & Zhu, Z. (2014). Soft OR in China: A critical report. *European Journal of Operational Research*, *232*(3), 427–434. https://doi.org/10.1016/j.ejor.2013.04.035

Liberatore, M. J., & Luo, W. (2013). ASP, the art and science of practice: A comparison of technical and soft skill requirements for analytics and OR professionals. *INFORMS Journal on Applied Analytics*, *43*(2), 194–197. https://doi.org/10.1287/inte.1120.0647

Lienert, J., Schnetzer, F., & Ingold, K. (2013). Stakeholder analysis combined with social network analysis provides fine-grained insights into water infrastructure planning processes. *Journal of Environmental Management*, *125*, 134–148. https://doi.org/10.1016/j.jenvman.2013.03.052

Lienert, J., Scholten, L., Egger, C., & Maurer, M. (2015). Structured decision-making for sustainable water infrastructure planning and four future scenarios. *EURO Journal on Decision Processes*, *3*(1–2), 107–140. https://doi.org/10.1007/s40070-014-0030-0

Little, D. (2011). Causal mechanisms in the social realm. In P. M. Illari, F. Russo, & J. Williamson (Eds.), *Causality in the sciences* (pp. 583–605). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199574131.003.0013

Lorenz, T., & Jost, A. (2006). Towards an orientation framework in multi-paradigm modelling: Aligning purpose, object and methodology in system dynamics, agent-based modeling and discrete-event-simulation. In *Proceedings of the 24th International Conference of the System Dynamics Society* (pp. 2134–2151). System Dynamics Society. https://proceedings.systemdynamics.org/2006/proceed/papers/LOREN178.pdf

Lowe, D., Martingale, L., & Yearworth, M. (2016). Guiding interventions in a multi-organisational context: combining the viable system model and hierarchical process modelling for use as a problem structuring method. *Journal of the Operational Research Society*, *67*(12), 1–15. https://doi.org/10.1057/jors.2016.6

Lowe, D., & Yearworth, M. (2019). Response to viewpoint: Whither problem structuring methods (PSMs)? *Journal of the Operational Research Society*, *70*(8), 1393–1395. https://doi.org/10.1080/01605682.2018.1502629

Lund, C. (2014). Of what is this a case?: Analytical movements in qualitative social science research. *Human Organization*, *73*(3), 224–234. https://doi.org/10.17730/humo.73.3.e35q482014x03314

Luoma, J. (2016). Model-Based organizational decision making: A behavioral lens. *European Journal of Operational Research*, *249*(3), 816–826. https://doi.org/10.1016/j.ejor.2015.08.039

Maisuria, A., & Banfield, G. (2023). *Working with critical realism: Stories of methodological encounters*. Routledge. https://doi.org/10.4324/9781003193784

Marttunen, M., Lienert, J., & Belton, V. (2017). Structuring problems for multi-criteria decision analysis in practice: A literature review of method combinations. *European Journal of Operational Research*, *263*(1), 1–17. https://doi.org/10.1016/j.ejor.2017.04.041

Mathieson, G. L. (2004). Benefits analysis – a robust assessment approach. *Journal of the Operational Research Society*, *55*(4), 390–402. https://doi.org/10.1057/palgrave.jors.2601713

Maxwell, J. A. (2004). Using qualitative methods for causal explanation. *Field Methods*, *16*(3), 243–264. https://doi.org/10.1177/1525822X04266831

Maxwell, J. A. (2022a). Critical realism as a stance for designing qualitative research. In U. Flick (Ed.), *The SAGE handbook of qualitative research design* (pp. 142–155). Sage. https://doi.org/10.4135/9781529770278.n10

Maxwell, J. A. (2022b). Interactive approaches to qualitative research design. In U. Flick (Ed.), *The SAGE handbook of qualitative research design* (pp. 41–54). Sage. https://doi.org/10.4135/9781529770278.n4

Maxwell, J. A., & Loomis, D. M. (2003). Mixed methods design: An alternative approach. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (1st ed., pp. 241–272). Sage.

Mayer, I. S. (2009). The gaming of policy and the politics of gaming: A review. *Simulation & Gaming*, *40*(6), 825–862. https://doi.org/10.1177/1046878109346456

Mayer, I. S., & De Jong, M. (2004). Combining GDSS and gaming for decision support. *Group Decision and Negotiation*, *13*(3), 223–241. https://doi.org/10.1023/B:GRUP.0000031076.98581.fc

Meadows, M., & O'Brien, F. A. (2005). Editorial for OR Insight on 'OR and Strategy'. *OR Insight*, *18*(1), 2–3. https://doi.org/10.1057/ori.2005.1

Meadows, M., & O'Brien, F. A. (2020). The use of scenarios in developing strategy: An analysis of conversation and video data. *Technological Forecasting and Social Change*, *158*, 120147. https://doi.org/10.1016/j.techfore.2020.120147

Mertens, D. M. (2007). Transformative paradigm: mixed methods and social justice. *Journal of Mixed Methods Research*, *1*(3), 212–225. https://doi.org/10.1177/1558689807302811

Mertens, D. M. (2022, August 3–4). *Transformative mixed methods: Supporting equity and justice* [Conference presentation]. MMIRA Global Conference 2022, online.

Midgley, G. (1990). Creative methodology design. *Systemist*, *12*(3), 108–113.

Midgley, G. (1992a). Pluralism and the legitimation of systems science. *Systems Practice*, *5*(2), 147–172. https://doi.org/10.1007/BF01059938

Midgley, G. (1992b). The sacred and profane in critical systems thinking. *Systems Practice*, *5*(1), 5–16. https://doi.org/10.1007/BF01060044

Midgley, G. (1992c). *Unity and pluralism* [Doctoral dissertation, City University London]. City Research Online. http://openaccess.city.ac.uk/7893/

Midgley, G. (1997a). Developing the methodology of TSI: From the oblique use of methods to creative design. *Systems Practice*, *10*(3), 305–319. https://doi.org/10.1007/BF02557900

Midgley, G. (1997b). Mixing methods: Developing systemic intervention. In J. Mingers & A. Gill (Eds.), *Multimethodology: The theory and practice of combining management science methodologies* (pp. 249–290). Wiley. https://www.wiley.com/en-gb/Multimethodology%3A+Towards+Theory+and+Practice+and+Mixing+and+Matching+Methodologies-p-9780471974901

Midgley, G. (2000). *Systemic intervention: Philosophy, methodology, and practice*. Springer. https://doi.org/10.1007/978-1-4615-4201-8

Midgley, G. (2001). Rethinking the unity of science. *International Journal of General Systems*, *30*(3), 379–409. https://doi.org/10.1080/03081070108960713

Midgley, G. (Ed.). (2003). *Systems thinking: Volumes 1-4*. Sage. https://doi.org/10.4135/9781446263556

Midgley, G. (2004). Five sketches of postmodernism. *Journal of Organisational Transformation & Social Change*, *1*(1), 47–62. https://doi.org/10.1386/jots.1.1.47/0

Midgley, G. (2008). Response to paper "Systems thinking" by D. Cabrera et al.:: The unification of systems thinking: Is there gold at the end of the rainbow? *Evaluation and Program Planning*, *31*(3), 317–321. https://doi.org/10.1016/j.evalprogplan.2008.04.002

Midgley, G. (2011). Theoretical Pluralism in Systemic Action Research. *Systemic Practice and Action Research*, *24*(1), 1–15. https://doi.org/10.1007/s11213-010-9176-2

Midgley, G. (2015). Systemic intervention. In H. Bradbury (Ed.) *The SAGE handbook of action research* (pp. 157–166). Sage. https://doi.org/10.4135/9781473921290

Midgley, G. (2017, February 9). Critical back-casting. *Integration and Implementation Insights*. https://i2insights.org/2017/02/09/critical-back-casting/#more-5866

Midgley, G. (2018). Systemic intervention: Theory, methodology and practice. *In System analysis in economics – 2018: Proceedings of the V International research and practice conference–biennale* (pp. 13–21). Prometheus. https://doi.org/10.33278/sae-2018.eng.013-021

Midgley, G. (2023). The systemic intervention approach. *Journal of Systems Thinking*. https://doi.org/10.54120/jost.000050

Midgley, G., Cavana, R. Y., Brocklesby, J., Foote, J. L., Wood, D. R. R., & Ahuriri-Driscoll, A. (2013). Towards a new framework for evaluating systemic problem structuring methods. *European Journal of Operational Research*, *229*(1), 143–154. https://doi.org/10.1016/j.ejor.2013.01.047

Midgley, G., & Lilley, R. (2023, September 12–14). *Towards a new framework for methodological pluralism* [Conference presentation abstract]. 65th Annual Conference of the Operational Research Society (OR65), Bath, UK. https://www.theorsociety.com/media/7636/or65-abstract-book.pdf

Midgley, G., & Pinzón, L. A. (2011). Boundary critique and its implications for conflict prevention. *Journal of the Operational Research Society*, *62*(8), 1543–1554. https://doi.org/10.1057/jors.2010.76

Midgley, G., & Rajagopalan, R. (2021). Critical systems thinking, systemic intervention and beyond. In G. Metcalf, K. Kijima, & H. Deguchi (Eds.), *Handbook of systems science*. Springer. https://doi.org/10.1007/978-981-13-0370-8_7-1

Miles, R. K. (1992). Combining hard and soft systems practice: grafting and embedding revisited. *Systemist*, *14*(2), 62–66.

Miller, W. L., & Crabtree, B. F. (1992). Primary care research: A multimethod typology and qualitative road map. In B. F. Crabtree & W. L. Miller (Eds.), *Doing qualitative research* (1st ed., pp. 3–31). Sage.

Mingers, J. (1989). Problems of measurement. In M. C. Jackson, P. Keys, & S. A. Cropper (Eds.), *Operational research and the social sciences* (pp. 471–477). Plenum Press. https://doi.org/10.1007/978-1-4613-0789-1_70

Mingers, J. (1991). The content of MSc OR courses: Response. *Journal of the Operational Research Society, 42*(10), 926–927. https://doi.org/10.1057/jors.1991.180

Mingers, J. (1992). Recent developments in critical management science. *Journal of the Operational Research Society*, *43*(1), 1–10. https://doi.org/10.1057/jors.1992.1

Mingers, J. (1997a). Multi-Paradigm multimethodology. In J. Mingers & A. Gill (Eds.), *Multimethodology: The theory and practice of combining management science methodologies* (pp. 1–20). Wiley. https://www.wiley.com/en-gb/Multimethodology%3A+Towards+Theory+and+Practice+and+Mixing+and+Matching+Methodologies-p-9780471974901

Mingers, J. (1997b). Towards critical pluralism. In J. Mingers & A. Gill (Eds.), *Multimethodology: The theory and practice of combining management science methodologies* (pp. 407–441). Wiley. https://www.wiley.com/en-gb/Multimethodology%3A+Towards+Theory+and+Practice+and+Mixing+and+Matching+Methodologies-p-9780471974901

Mingers, J. (2000a). The contribution of critical realism as an underpinning philosophy for OR/MS and systems. *Journal of the Operational Research Society*, *51*(11), 1256–1270. https://doi.org/10.1057/palgrave.jors.2601033

Mingers, J. (2000b). Variety is the spice of life: Combining soft and hard OR/MS methods. *International Transactions in Operational Research*, *7*(6), 673–691. https://doi.org/10.1111/j.1475-3995.2000.tb00224.x

Mingers, J. (2000c). What is it to be critical?: Teaching a critical approach to management undergraduates. *Management Learning*, *31*(2), 219–237. https://doi.org/10.1177/1350507600312005

Mingers, J. (2001a). Combining IS research methods: Towards a pluralist methodology. *Information Systems Research*, *12*(3), 240–259. https://doi.org/10.1287/isre.12.3.240.9709

Mingers, J. (2001b). Future directions in soft OR - Multimethodology. In J. Holt & G. Pickburn (Eds.), *Proceedings of OA Techniques for the Future* (Publication No. DERA/CDA/SEA/AIR/CR000141, pp. 40–46). DERA/ Operational Research Society Defence Study Group.

Mingers, J. (2001c). Multimethodology – Mixing and matching methods. In J. Rosenhead & J. Mingers (Eds.), *Rational analysis for a problematic world revisited: Problem structuring methods for complexity, uncertainty and conflict* (2nd ed., pp. 289–310). Wiley. https://www.wiley.com/en-us/Rational+Analysis+for+a+Problematic+World+Revisited%3A+Problem+Structuring+Methods+for+Complexity%2C+Uncertainty+and+Conflict%2C+2nd+Edition-p-9780471495239

Mingers, J. (2003a). A classification of the philosophical assumptions of management science methods. *The Journal of the Operational Research Society*, *54*(6), 559–570. https://doi.org/10.1057/palgrave.jors.2601436

Mingers, J. (2003b). Replies to Jackson and Gregory. *Journal of the Operational Research Society*, *54*(12), 1303–1304. https://doi.org/10.1057/palgrave.jors.2601641

Mingers, J. (2004a). Critical realism and information systems: Brief responses to Monod and Klein. *Information and Organization*, *14*(2), 145–153. https://doi.org/10.1016/j.infoandorg.2004.02.003

Mingers, J. (2004b). Future directions in management science modeling. In S. Fleetwood & S. Ackroyd (Eds.), *Critical realist applications in organisation and management studies* (pp. 164–193). Routledge. https://doi.org/10.4324/9780203537077

Mingers, J. (2004c). Real-Izing information systems: Critical realism as an underpinning philosophy for information systems. *Information and Organization*, *14*(2), 87–103. https://doi.org/10.1016/j.infoandorg.2003.06.001

Mingers, J. (2004d). Re-Establishing the real: Critical realism and information systems. *Social Theory and Philosophy for Information Systems*, *372*(1), 372–406. https://www.academia.edu/download/35438568/Re-establishing_the_Real.pdf

Mingers, J. (2006a). A critique of statistical modelling in management science from a critical realist perspective: Its role within multimethodology. *The Journal of the Operational Research Society*, *57*(2), 202–219. https://doi.org/10.1057/palgrave.jors.2601980

Mingers, J. (2006b). *Realising systems thinking: Knowledge and action in management science*. Springer. https://doi.org/10.1007/0-387-29841-X

Mingers, J. (2006c). Response from the author: Intelligence and realism in OR. *The Journal of the Operational Research Society*, *57*(11), 1375–1379. https://doi.org/10.1057/palgrave.jors.2602238

Mingers, J. (2007). Operational research: The science of better? *Journal of the Operational Research Society*, *58*(5), 683–686. https://doi.org/10.1057/palgrave.jors.2602333

Mingers, J. (2008). Pluralism, realism, and truth: The keys to knowledge in information systems research. *International Journal of Information Technologies and Systems Approach*, *1*(1), 79–90. https://doi.org/10.4018/jitsa.2008010106

Mingers, J. (2009). Discourse ethics and critical realist ethics: An evaluation in the context of business. *Journal of Critical Realism*, *8*(2), 172–202. https://doi.org/10.1558/jocr.v8i2.172

Mingers, J. (2011). Soft OR comes of age—but not everywhere! *Omega*, *39*(6), 729–741. https://doi.org/10.1016/j.omega.2011.01.005

Mingers, J. (2014). *Systems thinking, critical realism and philosophy: A confluence of ideas*. Routledge. https://doi.org/10.4324/9781315774503

Mingers, J. (2015). Helping business schools engage with real problems: The contribution of critical realism and systems thinking. *European Journal of Operational Research*, *242*(1), 316–331. https://doi.org/10.1016/j.ejor.2014.10.058

Mingers, J. (2017). *Constructing problems and choosing methodologies for complex decision contexts* [Unpublished manuscript]. Kent Business School, University of Kent.

Mingers, J. (2018, July 8–11). *Constructing problems and choosing methodologies for complex decision contexts* [Conference presentation abstract]. 29th European Conference on Operational Research and Management Science (EURO 2018), Valencia, Spain.

Mingers, J., & Brocklesby, J. (1997). Multimethodology: Towards a framework for mixing methodologies. *Omega*, *25*(5), 489–509. https://doi.org/10.1016/S0305-0483(97)00018-2

Mingers, J., & Gill, A. (Eds.). (1997). *Multimethodology: The theory and practice of combining management science methodologies*. Wiley. https://www.wiley.com/en-gb/Multimethodology%3A+Towards+Theory+and+Practice+and+Mixing+and+Matching+Methodologies-p-9780471974901

Mingers, J., Mutch, A., & Willcocks, L. (2013). Critical realism in information systems research. *MIS Quarterly*, *37*(3), 795–802. https://doi.org/10.25300/misq/2013/37:3.3

Mingers, J., & Rosenhead, J. (2001). Diverse unity: Looking inward and outward. In J. Rosenhead & J. Mingers (Eds.), *Rational analysis for a problematic world revisited: Problem structuring methods for complexity, uncertainty and conflict* (2nd ed., pp. 337– 355). Wiley. https://www.wiley.com/en-us/Rational+Analysis+for+a+Problematic+World+Revisited%3A+Problem+Structuring+Methods+for+Complexity%2C+Uncertainty+and+Conflict%2C+2nd+Edition-p-9780471495239

Mingers, J., & Rosenhead, J. (2004). Problem structuring methods in action. *European Journal of Operational Research*, *152*(3), 530–554. https://doi.org/10.1016/S0377-2217(03)00056-0

Mingers, J., & Rosenhead, J. (2011). Introduction to the special issue: Teaching soft O.R., problem structuring methods, and multimethodology. *INFORMS Transactions on Education*, *12*(1), 1–3. https://doi.org/10.1287/ited.1110.0073

Mingers, J., & Standing, C. (2017). Why things happen – Developing the critical realist view of causal mechanisms. *Information and Organization*, *27*(3), 171–189. https://doi.org/10.1016/j.infoandorg.2017.07.001

Mingers, J., & Standing, C. (2020). A framework for validating information systems research based on a pluralist account of truth and correctness. *Journal of the Association for Information Systems*, *21*(1), 117–151. https://doi.org/10.17705/1jais.00594

Mingers, J., & Taylor, S. (1992). The use of soft systems methodology in practice. *Journal of the Operational Research Society*, *43*(4), 321–332. https://doi.org/10.1057/jors.1992.47

Mingers, J., & White, L. (2010). A review of the recent contribution of systems thinking to operational research and management science. *European Journal of Operational Research*, *207*(3), 1147–1161. https://doi.org/10.1016/j.ejor.2009.12.019

The Ministry of Defence. (2018). *Global strategic trends: The future starts today* (6th ed.). https://assets.publishing.service.gov.uk/media/62828be5e90e071f69f22596/GST_the_future_starts_today.pdf

The Ministry of Defence. (2020). *Science and technology strategy 2020*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/927708/20201019-MOD_ST_Strategy_2020_v1-23.pdf

Mitchell, I. (2021, March). Towards a technology of choice: The Public Policy Design (PPD) Special Interest Group (SIG) special virtual event. *Inside OR*, *600*, 26. https://www.theorsociety.com/media/5752/march-2021-inside-or.pdf

Mitchell, R. K., Agle, B. R., & Wood, D. J. (1997). Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts. *Academy of Management Review*, *22*(4), 853–886. https://doi.org/10.5465/amr.1997.9711022105

Modell, S. (2020). For structure: A critical realist critique of the use of actor-network theory in critical accounting research. *Accounting, Auditing and Accountability Journal*, *33*(3), 621–640. https://doi.org/10.1108/AAAJ-01-2019-3863

Mohr, L. B. (1982). *Explaining organizational behavior*. Jossey-Bass.

Molina-Azorín, J. F., Bergh, D. D., Corley, K. G., & Ketchen, D. J. (2017). Mixed methods in the organizational sciences: Taking stock and moving forward. *Organizational Research Methods*, *20*(2), 179–192. https://doi.org/10.1177/1094428116687026

Molina-Azorín, J. F., & Fetters, M. D. (2016). Mixed methods prevalence studies: Field-Specific studies on the state of the art of mixed methods research. *Journal of Mixed Methods Research*, *10*(2), 123-128. https://doi.org./10.1177/1558689816636707

Morgan, G. (1997). *Imaginization: New mindsets for seeing, organizing, and managing.* Sage.

Morgan, J. S. (2013). *Exploring frameworks for mixing discrete event simulation and system dynamics methods in theory and in practice* (Thesis Identifier: T13553) [Doctoral dissertation, University of Strathclyde]. STAX. https://doi.org/10.48730/h87j-2x52

Morgan, J. S., Howick, S., & Belton, V. (2011). Designs for the complementary use of system dynamics and discrete-event simulation. In S. Jain, R. R. Creasey, J. Himmelspach, K. P. White, & M. Fu (Eds.), *Proceedings of the 2011 Winter Simulation Conference (WSC)* (pp. 2715–2727). IEEE. https://doi.org/10.1109/WSC.2011.6147977

Morgan, J. S., Howick, S., & Belton, V. (2017). A toolkit of designs for mixing discrete event simulation and system dynamics. *European Journal of Operational Research*, *257*(3), 907–918. https://doi.org/10.1016/j.ejor.2016.08.016

Morrill, N. (2006). *Using PSMs in the public sector: The experience at Dstl* (Publication No. DSTL/CP21858) [Seminar presentation]. The Operational Research Society Problem Structuring Methods SIG Seminar, London, UK. https://www.theorsociety.com/Pages/ImagesAndDocuments/documents/SpecialInterest/ProblemStructuringMethods/Morrill2.pdf

Morrill, N. (2007). Are the benefits of PSMs being sold sufficiently? A practitioner's view. *Journal of the Operational Research Society*, *58*(5), 686–689. https://doi.org/10.1057/palgrave.jors.2602375

Morse, J. (1997). "Perfectly healthy, but dead": The myth of inter-rater reliability. *Qualitative Health Research*, *7*(4), 445–447. https://doi.org/10.1177/104973239700700401

Mortenson, M. J., Doherty, N. F., & Robinson, S. (2015). Operational research from Taylorism to terabytes: A research agenda for the analytics age. *European Journal of Operational Research*, *241*(3), 583-595. https://doi.org/10.1016/j.ejor.2014.08.029

Moumivand, A., Azar, A., & Eshlaghy, A. T. (2021). Combined soft system methodology and agent-based simulation for multi-methodological modelling. *Systems Research and Behavioral Science*, *39*(2), 200–217. https://doi.org/10.1002/sres.2802

Mukumbang, F. C., De Souza, D. E., & Eastwood, J. G. (2023). The contributions of scientific realism and critical realism to realist evaluation realist evaluation. *Journal of Critical Realism*, *22*(3), 504–524 https://doi.org/10.1080/14767430.2023.2217052

Munro, I., & Mingers, J. (2002). The use of multimethodology in practice—Results of a survey of practitioners. *Journal of the Operational Research Society*, *53*(4), 369–378. https://doi.org/10.1057/palgrave.jors.2601331

Munro, I., & Mingers, J. (2004). Response to Richard Ormerod. *Journal of the Operational Research Society*, *55*(1), 90–93. https://doi.org/10.1057/palgrave.jors.2601670

Murray, E. (2021, April). Modelling in uncertain times. *Inside OR*, *601*, 10. https://www.theorsociety.com/publications/magazines/inside-or/2021-april/

Mustafee, N., Harper, A., & Onggo, B. S. (2020). Hybrid modelling and simulation (M&S): Driving innovation in the theory and practice of M&S. In *Proceedings of the 2020 Winter Simulation Conference (WSC)* (pp. 3140–3151). IEEE. https://doi.org/10.1109/WSC48552.2020.9383892

Mustafee, N., & Katsaliaki, K. (2020). Classification of the existing knowledge base of OR/MS research and practice (1990–2019) using a proposed classification scheme. *Computers and Operations Research*, *118*, 104920. https://doi.org/10.1016/j.cor.2020.104920

Mustafee, N., & Powell, J. H. (2018). From hybrid simulation to hybrid systems modelling. In *Proceedings of the 2018 Winter Simulation Conference (WSC)* (pp. 1430–1439). IEEE. https://doi.org/10.1109/WSC.2018.8632528

Mutch, A. (2007). Reflexivity and the institutional entrepreneur: A historical exploration. *Organization Studies*, *28*(7), 1123–8406. https://doi.org/10.1177/0170840607078118

Mutch, A. (2017). Practices and morphogenesis. *Journal of Critical Realism*, *16*(5), 499–513. https://doi.org/10.1080/14767430.2017.1361289

Mutch, A. (2020). Margaret Archer and a morphogenetic take on strategy. *Critical Perspectives on Accounting*, *73*, 101985. https://doi.org/https://doi.org/10.1016/j.cpa.2016.06.007

Myers, M. D. (2013). *Qualitative research in business and management*. Sage.

Müller, M. O., Groesser, S. N., Ulli-Beer, S., (2012). How do we know who to include in collaborative research? Toward a method for the identification of experts. *European Journal of Operational Research*, *216*(2), 495–502. https://doi.org/10.1016/j.ejor.2011.07.014

Nastasi, B. K., Hitchcock, J. H., & Brown, L. M. (2010). An inclusive framework for conceptualizing mixed methods design typologies: Moving toward fully integrated synergistic research models. In A. Tashakkori & C. Teddlie (Eds.), *Sage handbook of mixed methods in social & behavioral research* (2nd ed., pp. 305–338). Sage. https://doi.org/10.4135/9781506335193.n13

Nelson, S. (2021, June 8). Accelerating public sector data science and visualisation. *Data in government*. https://dataingovernment.blog.gov.uk/2021/06/08/accelerating-data-visualisation/

Neves, L. P., Dias, L. C., Antunes, C. H., & Martins, A. G. (2009). Structuring an MCDA model using SSM: A case study in energy efficiency. *European Journal of Operational Research*, *199*(3), 834–845. https://doi.org/10.1016/j.ejor.2009.01.053

Nguyen L. K. N., Howick, S., & Megiddo, I. (2024). A framework for conceptualizing hybrid system dynamics and agent-based simulation models. *European Journal of Operational Research*, *315*(3), 1153–1166. https://doi.org/10.1016/j.ejor.2024.01.027

Nichol, A. J., Hastings, C., & Elder-Vass, D. (2023). Putting philosophy to work: Developing the conceptual architecture of research projects. *Journal of Critical Realism*, *22*(3), 364–383. https://doi.org/10.1080/14767430.2023.2217054

Nicholls, M. G., Clarke, S. A., & Lehaney, B. (Eds.). (2001). *Mixed-Mode modelling: Mixing methodologies for organisational intervention*. Springer. https://doi.org/10.1007/978-1-4613-0289-6

Nijs, H. De. (2010). *Concept Development and Experimentation Policy and Process: How Analysis Provides Rigour* (Publication No. RTO-MP-SAS-081). North Atlantic Treaty Organisation. https://apps.dtic.mil/sti/pdfs/ADA584337.pdf

Noorain, S. (2024). *Towards facilitated optimisation* [Doctoral dissertation, University of Kent]. Kent Academic Repository. https://doi.org/10.22024/UniKent/01.02.105892

Noorain, S., Kotiadis, K., & Scaparra, M. P. (2019). Application of discrete-event simulation for planning and operations issues in mental healthcare. In *Proceedings of the 2019 Winter Simulation Conference (WSC)* (pp. 1184-1195). IEEE. https://doi.org/10.1109/WSC40007.2019.9004749

North Atlantic Treaty Organization. (2012a). *NATO guide for judgement-based operational analysis in defence decision making. Analyst-Oriented volume: Code of best practice for 'soft' operational analysis* (Publication No. RTO TR-SAS-087). https://www.researchgate.net/publication/314238515_RTO_Technical_Report_TR-SAS-087_NATO_Guide_for_Judgement-_Based_Operational_Analysis_in_Defence_Decision_Making_Analyst-Oriented_Volume_Code_of_Best_Practice_for_Soft_Operational_Analysis

North Atlantic Treaty Organization. (2012b). *NATO guide for judgement-based operational analysis in defence decision making. Client-Oriented volume.* (Publication No. RTO-SAS-087). https://www.researchgate.net/publication/314238249_RTO_Publication_SAS-087_NATO_Guide_for_Judgement-_Based_Operational_Analysis_in_Defence_Decision_Making_Client-Oriented_Volume

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods*, *16*(1), 1–13. https://doi.org/10.1177/1609406917733847

O'Brien, F. A. (2011). Supporting the strategy process: A survey of UK OR/MS practitioners. *Journal of the Operational Research Society*, *62*(5), 900–920. https://doi.org/10.1057/jors.2011.2

O'Brien, F. A. (2015). On the roles of OR/MS practitioners in supporting strategy. *Journal of the Operational Research Society*, *66*(2), 202–218. https://doi.org/10.1057/jors.2013.130 O'Brien, F. A., & Dyson, R. G. (Eds.). (2007). *Supporting strategy: Frameworks, methods and models*. Wiley. https://www.wiley.com/en-gb/Supporting+Strategy%3A+Frameworks%2C+Methods+and+Models-p-9780470057179

O'Brien, F. A., & Meadows, M. (2013). Scenario orientation and use to support strategy development. *Technological Forecasting and Social Change*, *80*(4), 643–656. https://doi.org/10.1016/j.techfore.2012.06.006

O'Mahoney, J., O'Mahoney, H., & Al-Amoudi, I. (2017). How can the loggerhead sea-turtle survive? Exploring the journeys of the Caretta caretta using ANT and critical realism. *Organization*, *24*(6), 781–799. https://doi.org/10.1177/1350508416672738

Okoli, C. (2022). *Mapping typical theoretical conceptualizations to critical realism: Variance and process theories*. SSRN. https://doi.org/10.2139/ssrn.4244251

Oliver, D. G., Serovich, J. M., & Mason, T. L. (2005). Constraints and opportunities with interview transcription: Towards reflection in qualitative research. *Social Forces*, *84*(2), 1273–1289. https://doi.org/10.1353/sof.2006.0023

Onwuegbuzie, A. J. (2023). Receiving the baton for the Journal of Mixed Methods Studies. *Journal of Mixed Methods Studies*, *2022*(6), 0–2. https://doi.org/10.59455/jomes.2022.6.1

Onwuegbuzie, A. J., & Hitchcock, J. H. (2019). Toward a fully integrated approach to mixed methods research via the 1 + 1 = 1 integration approach: Mixed research 2.0. *International Journal of Multiple Research Approaches*, *11*(1), 7–28. https://doi.org/10.29034/ijmra.v11n1editorial2

Onwuegbuzie, A. J., & Hitchcock, J. H. (2022). Towards a comprehensive meta-framework for full integration in mixed methods research. In J. H. Hitchcock & A. J. Onwuegbuzie (Eds.), *The Routledge handbook for advancing integration in mixed methods research* (pp. 565–606). Routledge. https://doi.org/10.4324/9780429432828-43

The Operational Research Society. (n.d.-a). *Full course list: Courses / Problem Structuring & Systems Thinking*. Retrieved March 5, 2024, from https://www.theorsociety.com/training/full-course-list/?2-traversablecategories=3

The Operational Research Society. (n.d.-b). *Professional development*. Retrieved July 14, 2022, from https://www.theorsociety.com/training/

The Operational Research Society. (n.d.-c). *The Operational Research Society*. Retrieved May 17, 2023, from https://www.theorsociety.com

The Operational Research Society. (2023, May 26). *Simulation Workshop 2023 - Mixing methods reflections for simulation, Professor Susan Howick* [Video]. YouTube. https://www.youtube.com/watch?v=C4SgevvP4bU

Ormerod, R. J. (1995). Putting soft OR methods to work—Information systems strategy development at Sainsbury's. *Journal of the Operational Research Society*, *46*(3), 277–293. https://doi.org/10.1057/jors.1995.43

Ormerod, R. J. (1996a). Combining management consultancy and research. *Omega*, *24*(1), 1-12. https://doi.org/10.1016/0305-0483(95)00043-7

Ormerod, R. J. (1996b). On the nature of OR—Entering the fray. *Journal of the Operational Research Society*, *47*(1), 1–17. https://doi.org/10.1057/jors.1996.1

Ormerod, R. J. (1997a). The design of organisational intervention: Choosing the approach. *Omega*, *25*(4), 415–435. https://doi.org/10.1016/S0305-0483(97)00006-6

Ormerod, R. J. (1997b). The role of OR in shaping the future: smart bits, helpful ways and things that matter. *Journal of the Operational Research Society*, *48*(11), 1045–1056. https://doi.org/10.1057/palgrave.jors.2600465

Ormerod, R. J. (1998). Viewpoint: JORS editorial policy. *Journal of the Operational Research Society*, *49*(11), 1221–1223. https://doi.org/10.1057/palgrave.jors.2600652

Ormerod, R. J. (2001). The success and failure of methodologies—A comment on Connell (2001): Evaluating soft OR. *Journal of the Operational Research Society*, *52*(10), 1176–1179. https://doi.org/10.1057/palgrave.jors.2601194

Ormerod, R. J. (2002). On the nature of OR: Taking stock. *Journal of the Operational Research Society*, *53*(5), 475–491. https://doi.org/10.1057/palgrave.jors.2601343

Ormerod, R. J. (2004). The practice of UK OR practitioners. *Journal of the Operational Research Society*, *55*(1), 90–93. https://doi.org/10.1057/palgrave.jors.2601669

Ormerod, R. J. (2005). Comments on the classification of management science methods by Mingers. *Journal of the Operational Research Society*, *56*(4), 463–465. https://doi.org/10.1057/palgrave.jors.2601891

Ormerod, R. (2006a). The history and ideas of pragmatism. *Journal of the Operational Research Society*, *57*(8), 892–909. https://doi.org/10.1057/palgrave.jors.2602065

Ormerod, R. J. (2006b). The OR/MS contribution to strategy development and policy-making. *Journal of the Operational Research Society*, *57*(1), 117–120. https://doi.org/10.1057/palgrave.jors.2602063

Ormerod, R. J. (2008a). Evaluating PSMs. *Journal of the Operational Research Society*, *59*(1), 137–138. https://doi.org/10.1057/palgrave.jors.2602496

Ormerod, R. J. (2008b). The transformation competence perspective. *Journal of the Operational Research Society*, *59*(11), 1435–1448. https://doi.org/10.1057/palgrave.jors.2602482

Ormerod, R. J. (2014a). The mangle of OR practice: Towards more informative case studies of 'technical' projects. *Journal of the Operational Research Society*, *65*(8), 1245–1260. https://doi.org/10.1057/jors.2013.78

Ormerod, R. J. (2014b). OR competences: The demands of problem structuring methods. *EURO Journal on Decision Processes*, *2*(3–4), 313–340. https://doi.org/10.1007/s40070-013-0021-6

Ormerod, R. J. (2016). Writing practitioner case studies to help behavioural OR researchers ground their theories: Application of the mangle perspective. *Journal of the Operational Research Society*, *68*(5), 507–520. https://doi.org/10.1057/s41274-016-0011-8

Ormerod, R. J. (2018). The logic and methods of OR consulting practice: Towards a foundational view. *Journal of the Operational Research Society*, *69*(9), 1357–1378. https://doi.org/10.1080/01605682.2017.1392407

Ormerod, R. (2021a). The fitness and survival of the OR profession in the age of artificial intelligence. *Journal of the Operational Research Society*, *72*(1), 4–22. https://doi.org/10.1080/01605682.2019.1650619

Ormerod, R. J. (2021b). Pragmatism in professional practice. *Systems Research and Behavioral Science*, *38*(6), 797–816. https://doi.org/10.1002/sres.2739

Ormerod, R. J., & Ulrich, W. (2013). Operational research and ethics: A literature review. *European Journal of Operational Research*, *228*(2), 291–307. https://doi.org/10.1016/j.ejor.2012.11.048

Ormerod, R. J., Yearworth, M., & White, L. (2023). Understanding participant actions in OR interventions using practice theories: A research agenda. *European Journal of Operational Research*, *306*(2), 810–827. https://doi.org/10.1016/j.ejor.2022.08.030

Ostern, N., & Rosemann, M. (2021). *A framework for digital affordances* [Conference presentation]. Twenty-Ninth European Conference on Information Systems (ECIS 2021), Marrakesh, Morocco. https://www.researchgate.net/profile/Nadine-Ostern-2/publication/352836406_A_FRAMEWORK_FOR_DIGITAL_AFFORDANCES/links/60dc291e299bf1ea9ecf1221/A-FRAMEWORK-FOR-DIGITAL-AFFORDANCES.pdf

Overmeer, W. J. A. M., Corbett, C. J., & Van Wassenhove, L. N. (1998). Cooperation between strands of practice: Challenges and opportunities for the renewal of OR. *Journal of the Operational Research Society*, *49*(4), 369–380. https://doi.org/10.1057/palgrave.jors.2600557

Oxford University Press. (n.d.). Affordance. In *Oxford English Dictionary*. Retrieved February 28, 2024, from https://www.oed.com/dictionary/affordance_n?tab=meaning_and_use

Paroutis, S., Franco, L. A., & Papadopoulos, T. (2015). Visual interactions with strategy tools: Producing strategic knowledge in workshops. *British Journal of Management*, *26*(S1), S48–S66. https://doi.org/10.1111/1467-8551.12081

Parr, M., & Mingers, J. (2015). *Application for ESRC South East DTC Studentship* [Unpublished]. Kent Business School, University of Kent.

Paulus, T. M., Lester, J. N., & Dempster, P. G. (2015). Transcribing audio and video data. In T. M. Paulus, J. N. Lester, P. G. Dempster, *Digital tools for qualitative research* (pp. 93–113). Sage. https://doi.org/10.4135/9781473957671

Pawson, R., & Tilley, N. (1997). *Realistic evaluation*. Sage. https://uk.sagepub.com/en-gb/eur/realistic-evaluation/book205276

Petropoulos, F., Laporte, G., Aktas, E., Alumur, S. A., Archetti, C., Ayhan, H., Battarra, M., Bennell, J. A., Bourjolly, J.-M., Boylan, J. E., Breton, M., Canca, D., Charlin, L., Chen, B., Cicek, C. T., Cox, L. A., Jr., Currie, C. S. M., Demeulemeester, E., Ding, L., … Zhao, X. (2024). Operational research: Methods and applications. *Journal of the Operational Research Society*, *75*(3), 423–617. https://doi.org/10.1080/01605682.2023.2253852

Pettigrew, A. M., Woodman, R. W., & Cameron, K. S. (2001). Studying organizational change and development: Challenges for future research. *Academy of Management Journal*, *44*(4), 697–713. https://doi.org/10.2307/3069411

Phillips, L. D., & Bana e Costa, C. A. (2007). Transparent prioritisation, budgeting and resource allocation with multi-criteria decision analysis and decision conferencing. *Annals of Operations Research*, *154*(1), 51–68. https://doi.org/10.1007/s10479-007-0183-3

Phillips, C. J. (2024, 30 June–July 3). *The 'je ne sais quoi' of algorithms that foster human centric analytics design* [Conference presentation abstract]. 33rd European Conference on Operational Research and Management Science (EURO 2024), Copenhagen, Denmark. http://www.euro-online.org/conf/euro33/treat_abstract?paperid=3653

Pidd, M. (1996). Viewpoint: OR/MS and strategic management. *Journal of the Operational Research Society*, *47*(3), 473–474. https://doi.org/10.1057/jors.1996.51

Pidd, M. (2004a). Complementarity in systems modelling. In M. Pidd (Ed.), *Systems modelling: Theory and practice* (pp. 1–20). Wiley. https://www.wiley.com/en-us/Systems+Modelling%3A+Theory+and+Practice-p-9780470867310

Pidd, M. (2004b). Contemporary OR/MS in strategy development and policy-making: Some reflections. *Journal of the Operational Research Society*, *55*(8), 791–800. https://doi.org/10.1057/palgrave.jors.2601748

Pidd, M. (Ed.). (2004c). *Systems modelling: Theory and practice*. Wiley. https://www.wiley.com/en-us/Systems+Modelling%3A+Theory+and+Practice-p-9780470867310

Pidd, M. (2006). Reply to R Ormerod. *Journal of the Operational Research Society*, *57*(1), 120–121. https://doi.org/10.1057/palgrave.jors.2602064

Pidd, M. (2009). *Tools for thinking: Modelling in management science* (3rd ed.). Wiley. https://www.wiley.com/en-us/Tools+for+Thinking%3A+Modelling+in+Management+Science%2C+3rd+Edition-p-9780470721421

Pidd, M., & Woolley, R. N. (1980). A pilot study of problem structuring. *Journal of the Operational Research Society*, *31*(12), 1063–1068. https://doi.org/10.1057/jors.1980.201

Plakoyiannaki, E., & Budhwar, P. (2021). From convention to alternatives: Rethinking qualitative research in management scholarship. *British Journal of Management*, *32*(1), 3–6. https://doi.org/10.1111/1467-8551.12464

Plano Clark, V. L., & Badiee, M. (2015). Research questions in mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), *SAGE handbook of mixed methods in social & behavioral research*. https://doi.org/10.4135/9781506335193.n12

Plano Clark, V. L., & Ivankova, N. V. (2015). *Mixed methods research: A guide to the field*. Sage. https://doi.org/10.4135/9781483398341

Pollack, J. B. (2005). *Project pluralism: Combining the hard and soft paradigms in IS/IT strategy development in the NSW public sector* [Doctoral dissertation, University of Technology, Sydney]. OPUS. https://opus.lib.uts.edu.au/handle/2100/294

Pollack, J. B. (2009). Multimethodology in series and parallel: Strategic planning using hard and soft OR. *Journal of the Operational Research Society*, *60*(2), 156–167. https://doi.org/10.1057/palgrave.jors.2602538

Popper, K. (2003). The problem of induction. In G. Delanty & P. Strydom (Eds.), *Philosophies of social science: The classic and contemporary readings* (pp. 42–47). Open University Press. (Original work published 1934).

Porpora, D. V. (2016). *Reconstructing sociology*. Cambridge University Press. https://doi.org/10.1017/CBO9781316227657

Porter, S. (2015). Realist evaluation: An immanent critique. *Nursing Philosophy*, *16*(4), 239–251. https://doi.org/10.1111/nup.12100

Poth, C. N. (2018). The curious case of complexity: Implications for mixed methods research practices. *International Journal of Multiple Research Approaches*, *10*(1), 403–411. https://doi.org/10.29034/ijmra.v10n1a27

Poth, C. N. (Ed.). (2023). *The Sage handbook of mixed methods research design*. Sage. https://doi.org/10.4135/9781529614572

Powell, J. H., & Mustafee, N. (2017). Widening requirements capture with soft methods: An investigation of hybrid M&S studies in health care. *Journal of the Operational Research Society*, *68*, 1211–1222. https://doi.org/10.1057/s41274-016-0147-6

Pratt, M. G., Kaplan, S., & Whittington, R. (2020). Editorial essay: The tumult over transparency: Decoupling transparency from replication in establishing trustworthy qualitative research. *Administrative Science Quarterly*, *65*(1), 1–19. https://doi.org/10.1177/0001839219887663

Pratten, S. (2023). The concept of function in social positioning theory. *Journal for the Theory of Social Behaviour*, *53*(4), 560–582. https://doi.org/10.1111/jtsb.12389

Proudlove, N. C., Bisogno, S., Onggo, B. S., Calabrese, A., & Ghiron, N. L. (2017). Towards fully-facilitated discrete event simulation modelling: Addressing the model coding stage. *European Journal of Operational Research*, *263*(2), 583–595. https://doi.org/10.1016/j.ejor.2017.06.002

Pula, B. (2021). The logico-formalist turn in comparative and case study methods: A critical realist critique. *International Journal of Social Research Methodology*, 24(6), 739–51. https://doi.org/10.1080/13645579.2020.1823063

PwC. (n.d.). *What is a capability?* Retrieved June 27, 2023, from https://www.strategyand.pwc.com/gx/en/about/media/videos/2015-and-older/what-is-a-capability.html

The Quality Assurance Agency for Higher Education. (2024). *The frameworks for higher education qualifications of UK degree-awarding bodies* (2nd ed.). https://www.qaa.ac.uk/docs/qaa/quality-code/the-frameworks-for-higher-education-qualifications-of-uk-degree-awarding-bodies-2024.pdf?sfvrsn=3562b281_11

The Qualitative Data Repository. (n.d.). *De-Identification*. Retrieved February 28, 2024, from https://qdr.syr.edu/guidance/human-participants/deidentification

Quine, W. V. O. (2003). Two dogmas of empiricism. In G. Delanty & P. Strydom (Eds.), *Philosophies of social science: The classic and contemporary readings* (pp. 57–62). Open University Press. (Original work published 1951).

Ragin, C. C. (1987). *The comparative method: Moving beyond qualitative and quantitative strategies*. California University Press.

Rajagopalan, R. (2016). *Immersive systemic knowing: rational analysis and beyond* [Doctoral dissertation, University of Hull]. Repository@Hull. https://hull-repository.worktribe.com/OutputFile/4221254

Rajagopalan, R. (2020). *Immersive systemic knowing: Advancing systems thinking beyond rational analysis*. Springer. https://doi.org/10.1007/987-3-030-49135-2

Rajagopalan, R., & Midgley, G. (2015). Knowing differently in systemic intervention. *Systems Research and Behavioral Science*, *32*(5), 546–561. https://doi.org/10.1002/sres.2352

Ranyard, J. C., Fildes, R., & Hu, T.-I. (2015). Reassessing the scope of OR practice: The influences of problem structuring methods and the analytics movement. *European Journal of Operational Research*, *245*(1), 1–13. https://doi.org/10.1016/j.ejor.2015.01.058

Ranyard, J. C., Hopes, J., & Murray, E. (2022). *Reinvigorating soft OR*. https://www.theorsociety.com/media/6856/reinvigorating-soft-or-for-practitioners-report-to-horaf-v12.pdf

Reed, M. I. (2009). Critical realism in critical management studies. In M. Alvesson, T. Bridgman, & H. Willmott (Eds.), *The Oxford handbook of critical management studies* (pp. 52–75). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199595686.013.0003

Reed, M. S. (2022, November 22). Alternatives to the word 'stakeholder'. *Fast Track Impact*. https://www.fasttrackimpact.com/post/alternatives-to-the-word-stakeholder

Reed, M. S., Bryce, R., & MacHen, R. (2018). Pathways to policy impact: A new approach for planning and evidencing research impact. *Evidence and Policy*, *14*(3), 431–458. https://doi.org/10.1332/174426418X15326967547242

Reed, M. S., & Curzon, R. (2015). Stakeholder mapping for the governance of biosecurity: A literature review. *Journal of Integrative Environmental Sciences*, *12*(1), 15–38. https://doi.org/10.1080/1943815X.2014.975723

Reisach, U. (2016). The creation of meaning and critical ethical reflection in operational research. *EURO Journal on Decision Processes*, *4*(1–2), 5–32. https://doi.org/10.1007/s40070-014-0029-6

Reynolds, E. (2017). How autoethnography based upon a small student experiment assisted a novice researcher in developing the design of a larger study. In M. Schoop, & D. M. Kilgour (Eds.), *Proceedings of the 17th International Conference on Group Decision and Negotiation, Hohenheim Discussion Papers in Business, Economics and Social Sciences, 16-2017*, (pp. 405–414). University of Hohenheim Faculty of Business, Economics and Social Sciences. https://hdl.handle.net/10419/168041

Reynolds, E. (2021). *Discovering everyday problem structuring* [Doctoral dissertation, University of Warwick]. WRAP. http://wrap.warwick.ac.uk/178300

Reynolds, M., & Holwell, S. (Eds.). (2020). *Systems approaches to making change: A practical guide* (2nd ed.). Springer. https://doi.org/10.1007/978-1-4471-7472-1

Richards, L. (2014). *Handling qualitative data: A practical guide* (3rd ed.). Sage.

Richardson, K. A., Mathieson, G. L., & Cilliers, P. (2003). *Complexity thinking and military operational analysis*. https://www.researchgate.net/profile/Kurt-Richardson-2/publication/2559003_Complexity_Thinking_and_Military_Operational_Analysis/links/5581790708ae47061e60dba7/Complexity-Thinking-and-Military-Operational-Analysis.pdf

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, *4*(2), 155–169. https://doi.org/10.1007/BF01405730

Robinson, A. P. (2023, November). Dstl Perceptions from OR65 – A co-sponsor's reflections. *Inside OR*, *630*, 12. https://www.theorsociety.com/media/7831/ior-november-2023-edition-digital.pdf

Robinson, A. P., Pickburn, G. A., & Forder, R. A. (2004). Complementarity in Ministry of Defence OR practice. In M. Pidd (Ed.), *Systems modelling: Theory and practice* (pp. 177–196). Wiley. https://www.wiley.com/en-us/Systems+Modelling%3A+Theory+and+Practice-p-9780470867310

Robinson, S., Radnor, Z. J., Burgess, N., & Worthington, C. (2012). SimLean: Utilising simulation in the implementation of lean in healthcare. *European Journal of Operational Research*, *219*(1), 188–197. https://doi.org/10.1016/j.ejor.2011.12.029

Rodríguez-Ulloa, R. A., Montbrun, A., & Martínez-Vicente, S. (2011). Soft system dynamics methodology in action: A study of the problem of citizen insecurity in an Argentinean province. *Systemic Practice and Action Research*, 24(4), 275–323. https://doi.org/10.1007/s11213-010-9187-z

Rosenhead, J. (Ed.). (1989). *Rational analysis for a problematic world: Problem structuring methods for complexity, uncertainty and conflict* (1st ed.). Wiley.

Rosenhead, J. (1992a). Comment on the content of MSc operational research courses. *Journal of the Operational Research Society*, *43*(6), 645. https://doi.org/10.1057/jors.1992.95

Rosenhead, J. (1992b). Into the swamp: The analysis of social issues. *Journal of the Operational Research Society*, *43*(4), 293–305. https://doi.org/10.1057/jors.1992.44

Rosenhead, J. (1996). What's the problem? An introduction to problem structuring methods. *INFORMS Journal on Applied Analytics*, *26*(6), 117–131. https://doi.org/10.1287/inte.26.6.117

Rosenhead, J., & Mingers, J. (2001a). A new paradigm of analysis. In J. Rosenhead & J. Mingers (Eds.), *Rational analysis for a problematic world revisited: Problem structuring methods for complexity, uncertainty and conflict* (2nd ed., pp. 1–20). Wiley. https://www.wiley.com/en-us/Rational+Analysis+for+a+Problematic+World+Revisited%3A+Problem+Structuring+Methods+for+Complexity%2C+Uncertainty+and+Conflict%2C+2nd+Edition-p-9780471495239

Rosenhead, J., & Mingers, J. (Eds.). (2001b). *Rational analysis for a problematic world revisited: Problem structuring methods for complexity, uncertainty and conflict* (2nd ed.). Wiley. https://www.wiley.com/en-us/Rational+Analysis+for+a+Problematic+World+Revisited%3A+Problem+Structuring+Methods+for+Complexity%2C+Uncertainty+and+Conflict%2C+2nd+Edition-p-9780471495239

Roy, B., & Słowiński, R. (2013). Questions guiding the choice of a multicriteria decision aiding method. *EURO Journal on Decision Processes*, *1*(1–2), 69–97. https://doi.org/10.1007/s40070-013-0004-7

Royston, G. (2013, June). Systems improvement science. *Inside OR*, *511*, 26–27.

Runde, C. (2020). *Exploring the role of management and project team diversity and inclusion on product development and commercial performance* [Doctoral dissertation, University of Sydney]. Sydney eScholarship Repository. https://ses.library.usyd.edu.au/handle/2123/23536

Rutten, R. (2024). *Qualitative comparative analysis: Learning from cases*. Edward Elgar.

Sabherwal, S., & Sharma, N. (2022, May 18). Launching our experimental policy design methods - Policy Lab. *Policy Lab Blog*. https://openpolicy.blog.gov.uk/2022/05/18/launching-our-experimental-policy-design-methods/

Sacco, S., Zizzania, P., Poli, G., & Cerreta, M. (2024, 30 June–July 3). *Exploring participatory approaches: Integrating AI with collective intelligence in the Archivio Atena project* [Conference presentation abstract]. 33rd European Conference on Operational Research and Management Science (EURO 2024), Copenhagen, Denmark. http://www.euro-online.org/conf/euro33/treat_abstract?paperid=2779

Sachdeva, R., Williams, T., & Quigley, J. (2007). Mixing methodologies to enhance the implementation of healthcare operational research. *Journal of the Operational Research Society*, *58*(2), 159–167. https://doi.org/10.1057/palgrave.jors.2602293

Saldaña, J. (2015). *The coding manual for qualitative researchers* (3rd ed.). Sage. https://uk.sagepub.com/en-gb/eur/the-coding-manual-for-qualitative-researchers/book273583

Sale, J. E. M., Lohfeld, L. H., & Brazil, K. (2002). Revisiting the quantitative-qualitative debate: Implications for mixed-methods research. *Quality & Quantity*, *36*, 43–53. https://doi.org/10.1023/A:1014301607592

Salhi, S., & Boylan, J. (2022). *The Palgrave handbook of operations research*. Palgrave Macmillan. https://doi.org/10.1007/978-3-030-96935-6

Sandelowski, M. (2012). The weakness of the strong/weak comparison of modes of inquiry. *Research in Nursing and Health*, *35*(4), 325–327. https://doi.org/10.1002/nur.21475

Saunders, M. N. K., & Townsend, K. (2016). Reporting and justifying the number of interview participants in organization and workplace research. *British Journal of Management*, *27*(4), 836–852. https://doi.org/10.1111/1467-8551.12182

Sayer, A. (1992). *Method in social science: A realist approach* (1st ed.). Routledge.

Scaparra, M. P., Ngo, C. C., Dang, T. P., & Tran, T. H. (2019). Community perceptions of social, economic and environmental impacts of flooding in central districts of Hanoi, Vietnam. *Journal of the British Academy*, *7*(S2), 137–154. https://doi.org/10.5871/jba/007s2.137

Scholten, L., Schuwirth, N., Reichert, P., & Lienert, J. (2015). Tackling uncertainty in multi-criteria decision analysis - An application to water supply infrastructure planning. *European Journal Of Operational Research*, *242*(1), 243–260. https://doi.org/10.1016/j.ejor.2014.09.044

Schoonenboom, J., Johnson, R. B., & Froehlich, D. E. (2018). Combining multiple purposes of mixing within a mixed methods research design. *International Journal of Multiple Research Approaches*, *10*(1), 271–282. https://doi.org/10.29034/ijmra.v10n1a17

Schreier, M. (2018). Sampling and generalization. In U. Flick (Ed.), *The SAGE handbook of qualitative data collection* (pp. 84-97). Sage. https://doi.org/10.4135/9781526416070

Schultz, M., & Hatch, M. J. (1996). Living with multiple paradigms: The case of paradigm interplay in organizational culture studies. *Academy Of Management Review*, *21*(2), 529–557. https://doi.org/10.5465/AMR.1996.9605060221

Scott, R. J., Cavana, R. Y., & Cameron, D. (2013). Evaluating immediate and long-term impacts of qualitative group model building workshops on participants' mental models. *System Dynamics Review*, *29*(4), 216–236. https://doi.org/10.1002/sdr.1505

Shan, Y., & Williamson, J. (2021). Applying evidential pluralism to the social sciences. *European Journal for Philosophy of Science*, *11*(96). https://doi.org/10.1007/s13194-021-00415-z

Shan, Y., & Williamson, J. (2023). *Evidential pluralism in the social sciences*. Routledge. https://doi.org/10.4324/9781003143000

Shaw, D., Smith, C. M., & Scully, J. (2017). Why did Brexit happen? Using causal mapping to analyse secondary, longitudinal data. *European Journal of Operational Research*, *263*(3), 1019–1032. https://doi.org/10.1016/j.ejor.2017.05.051

Shaw, D., Smith, C. M., & Scully, J. (2019). From Brexit to Article 50: Applying critical realism to the design and analysis of a longitudinal causal mapping study. *European Journal of Operational Research*, *276*(2), 723–735. https://doi.org/10.1016/j.ejor.2019.01.030

Shephard, R. W. (1963). War gaming as a technique in the study of operational research problems. *Journal of the Operational Research Society*, *14*, 119-130. https://doi.org/10.1057/jors.1963.20

Sibbesen, L. K., & Leleur, S. (2006). *Decision support and multimethodology: Different strategies for combination of OR methods*. https://www.researchgate.net/profile/Steen-Leleur/publication/310450498_Decision_Support_and_Multimethodology_Different_Strategies_for_Combination_of_OR_Methods.pdf

Sim, J., Saunders, B., Waterfield, J., & Kingstone, T. (2018). Can sample size in qualitative research be determined a priori? *International Journal of Social Research Methodology*, *21*(5), 619–634. https://doi.org/10.1080/13645579.2018.1454643

Sims, D., Eden, C., & Jones, S. (1981). Facilitating problem definition in teams. *European Journal of Operational Research*, *6*(4), 360–366. https://doi.org/10.1016/0377-2217(81)90302-7

Sinuany-Stern, Z. (2022). Foundations of operations research: From linear programming to data envelopment analysis. *European Journal of Operational Research*. *306*(3), 1069–1080. https://doi.org/10.1016/j.ejor.2022.10.046

Small, A., & Wainwright, D. (2014). SSM and technology management: Developing multimethodology through practice. *European Journal of Operational Research*, *233*(3), 660–673. https://doi.org/10.1016/j.ejor.2013.08.049

Small, A., & Wainwright, D. (2018a, July 8–11). *Applying a context and action framework to evaluate the interactions between the context, content, and process of problem structuring methods* [Conference presentation abstract]. 29th European Conference on Operational Research and Management Science (EURO 2018), Valencia, Spain.

Small, A., & Wainwright, D. (2018b). Privacy and security of electronic patient records – Tailoring multimethodology to explore the socio-political problems associated with role based access control systems. *European Journal of Operational Research*, *265*(1), 344–360. https://doi.org/10.1016/j.ejor.2017.07.041

Small, M. L. (2009). How many cases do I need?' On science and the logic of case selection in field-based research. *Ethnography*, *10*(1), 5-38. https://doi.org/10.1177/1466138108099586

Smith, C. M., & Shaw, D. (2019). The characteristics of problem structuring methods: A literature review. *European Journal of Operational Research*, *274*(2), 403–416. https://doi.org/10.1016/j.ejor.2018.05.003

Smith, V. L. (1991). *The content of MSc OR courses*. *Journal of the Operational Research Society*, *42*(10), 924–926. https://doi.org/10.1057/jors.1991.179

Smith, V. L. (1992). *Comment on the content of MSc operational research courses: Response*. *Journal of the Operational Research Society*, *43*(6), 645–646. https://doi.org/10.1057/jors.1992.96

Snowden, D. J., & Boone, M. M. E. (2007). A leader's framework for decision making. *Harvard Business Review*, *85*(11), 68–76.

Solly, R. (2015, January 27). *Planning for an uncertain future* [Conference presentation]. Calculating and Communicating Uncertainty Conference, London, UK.

Sommer, K. A., & Mabin, V. J. (2016). Insights into the eldercare conundrum through complementary lenses of Boardman's SSM and TOC's Evaporating Cloud. *European Journal of Operational Research*, *248*(1), 286–300. https://doi.org/10.1016/j.ejor.2015.06.033

Stake, R. E. (2008). Qualitative case studies. In N. K. Denzin & Y. S. Lincoln (Eds.), *Strategies of qualitative inquiry* (3rd ed., pp. 119–150). Sage.

Stansfield, R. G. (1989). OR and social sciences: A story of on-off relationships. In M. C. Jackson, P. Keys, & S. A. Cropper (Eds.), *Operational research and the social sciences* (pp. 139–144). Plenum Press. https://doi.org/10.1007/978-1-4613-0789-1_18

Steenmans, I. (2017). *Integrated infrastructure systems: Strategic planning practice and problem structuring support* [Doctoral dissertation, University College London]. UCL Discovery. https://discovery.ucl.ac.uk/id/eprint/1553325/

Stendal, K., Thapa, D., & Lanamaki, A. (2016). Analyzing the concept of affordances in information systems. In *Proceedings of the 2016 49th Annual Hawaii International Conference on System Sciences (HICSS)* (pp. 5270–5277). https://doi.org/10.1109/HICSS.2016.651

Stenfors, S., Tanner, L., Syrjanen, M., Seppala, T., & Haapalinna, I. (2007). Executive views concerning decision support tools. *European Journal of Operational Research*, *181*(2), 929–938. https://doi.org/10.1016/j.ejor.2006.06.024 Stephens, A., Taket, A., & Gagliano, M. (2019). Ecological justice for nature in critical systems thinking. *Systems Research and Behavioral Science*, *36*(1), 3–19. https://doi.org/10.1002/sres.2532

Sterman, J. (2000). *Business dynamics: Systems thinking and modeling for a complex world*. McGraw Hill. https://www.mheducation.co.uk/business-dynamics-systems-thinking-and-modeling-for-a-complex-world-int-l-ed-9780071179898-emea

Stewart, T. J., French, S., & Rios, J. (2013). Integrating multicriteria decision analysis and scenario planning-Review and extension. *Omega*, *41*(4), 679–688. https://doi.org/10.1016/j.omega.2012.09.003

Stoecker, R., & Avila, E. (2021). From mixed methods to strategic research design. *International Journal of Social Research Methodology*, *24*(6), 627–640. https://doi.org/10.1080/13645579.2020.1799639

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (2nd ed.). Sage. https://doi.org/10.1177/1350507600314007

Sydelko, P., Midgley, G., & Espinosa, A. (2021). Designing interagency responses to wicked problems: Creating a common, cross-agency understanding. *European Journal of Operational Research*, *294*(1), 250–263. https://doi.org/10.1016/j.ejor.2020.11.045

Taket, A., & White, L. (1993). After OR: An agenda for postmodernism and poststructuralism in OR. *Journal of the Operational Research Society*, *44*(9), 867–881. https://doi.org/10.1057/jors.1993.156

Taket, A., & White, L. (1996). Pragmatic pluralism—An explication. *Systems Practice*, *9*, 571–586. https://doi.org/10.1007/BF02169214

Taket, A., & White, L. (2023). PANDA (participatory appraisal of needs and development of action): A multi methodological framework. *Journal of Systems Thinking*. https://doi.org/10.54120/jost.0000027

Tako, A. A., & Kotiadis, K. (2015). PartiSim: A multi-methodology framework to support facilitated simulation modelling in healthcare. *European Journal of Operational Research*, *244*(2), 555–564. https://doi.org/10.1016/j.ejor.2015.01.046

Tako, A. A., & Kotiadis, K. (2018). Participative simulation (PartiSim): A facilitated simulation approach for stakeholder engagement. In M. Rabe, A. A. Juan, N. Mustafee, A. Skoogh, S. Jain, & B. Johansson (Eds.), *Proceedings of the 2018 Winter Simulation Conference (WSC)* (pp. 192–206). IEEE. https://doi.org/10.1109/WSC.2018.8632434

Tan, N., & White, L. (2024, 30 June–July 3). *Augmenting leadership development with generative artificial intelligence: Perspectives, research methods, and future directions* [Conference presentation abstract]. 33rd European Conference on Operational Research and Management Science (EURO 2024), Copenhagen, Denmark. http://www.euro-online.org/conf/euro33/treat_abstract?paperid=3666

Tavella, E. (2018). On novice facilitators doing research—Research in problem structuring methods as autoethnography. *Systems Research and Behavioral Science*, *35*(1), 58–75. https://doi.org/10.1002/sres.2438

Tavella, E., & Papadopoulos, T. (2015). Novice facilitators and the use of scripts for managing facilitated modelling workshops. *Journal of the Operational Research Society*, *66*(12), 1967–1988. https://doi.org/10.1057/jors.2015.7

Tavella, E., & Papadopoulos, T. (2017). Applying OR to problem situations within community organisations: A case in a Danish non-profit, member-driven food cooperative. *European Journal of Operational Research*, *258*(2), 726–742. https://doi.org/10.1016/j.ejor.2016.08.065

Teddlie, C., & Tashakkori, A. (2009). *Foundations of mixed methods research: Integrating quantitative and qualitative approaches in the social and behavioral sciences* (1st ed.). Sage.

Thompson, J. P., Howick, S., & Belton, V. (2015). Critical learning incidents in system dynamics modelling engagements. *European Journal of Operational Research*, *249*(3), 945–958. https://doi.org/10.1016/j.ejor.2015.09.048

Tian, Y., Basran, J., Stempien, J., Danyliw, A., Fast, G., Falastein, P., & Osgood, N. D. (2023). Participatory modeling with discrete-event simulation: A hybrid approach to inform policy development to reduce emergency department wait times. *Systems*, *11*(7), 362. https://doi.org/10.3390/systems11070362

Tolk, A., Harper, A., & Mustafee, N. (2021). Hybrid models as transdisciplinary research enablers. *European Journal of Operational Research*, *291*(3), 1075–1090. https://doi.org/10.1016/j.ejor.2020.10.010

Tomlinson, R. C. (1984). Rethinking the process of systems analysis and operational research: From practice to precept – and back again. In R. C. Tomlinson & I. Kiss (Eds.), *Rethinking the process of operational research and systems analysis* (pp. 205–223). Pergamon Press. https://doi.org/10.1016/b978-0-08-030830-2.50018-0

Torres, J. P., Kunc, M., & O'Brien, F. A. (2017). Supporting strategy using system dynamics. *European Journal of Operational Research*, *260*(3), 1081–1094. https://doi.org/10.1016/j.ejor.2017.01.018

Tully, P., White, L., & Yearworth, M. (2019). The value paradox of problem structuring methods. *Systems Research and Behavioral Science*, *36*(4), 424–444. https://doi.org/10.1002/sres.2557

UK Government. (n.d.). *Departments, agencies and public bodies*. Retrieved February 28, 2024, from https://www.gov.uk/government/organisations

UK Government. (2017). *Guidance: Project and programme management*. Retrieved March 11, 2024, from https://www.gov.uk/guidance/project-and-programme-management

UK Government. (2021). *Global Britain in a competitive age: The integrated review of security, defence, development and foreign policy* (Publication No. CP 403). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/969402/The_Integrated_Review_of_Security__Defence__Development_and_Foreign_Policy.pdf

UK Government. (2023). *Integrated review refresh 2023: Responding to a more contested and volatile world* (Publication No. CP 811). https://assets.publishing.service.gov.uk/media/641d72f45155a2000c6ad5d5/11857435_NS_IR_Refresh_2023_Supply_AllPages_Revision_7_WEB_PDF.pdf

Ulrich, W. (2003). Beyond methodology choice: Critical systems thinking as critically systemic discourse. *Journal of the Operational Research Society*, *54*(4), 325–342. https://doi.org/10.1057/palgrave.jors.2601518

Ulrich, W. (2005). *A brief introduction to critical systems heuristics (CSH)*. ECOSENSUS Project, Open University. Retrieved March 18, 2024, from http://projects.kmi.open.ac.uk/ecosensus/publications/ulrich_csh_intro.pdf

Ulrich, W. (2007). Philosophy for professionals: Towards critical pragmatism. *Journal of the Operational Research Society*, *58*(8), 1109–1113. https://doi.org/10.1057/palgrave.jors.2602336

Ulrich, W., & Reynolds, M. (2020). Critical systems heuristics: The idea and practice of boundary critique. In M. Reynolds & S. Holwell (Eds.), *Systems approaches to making change: A practical guide* (2nd ed., pp. 255–306). Springer. https://doi.org/10.1007/978-1-4471-7472-1_6

The University of Kent. (2023). *Academic regulations for research courses of study (including new route PhD courses)*. https://www.kent.ac.uk/education/documents/regulations-research/research-regulations.docx

Valbø, B. (2021). The IS-notion of affordances: A mapping of the application of affordance theory in information systems research. In *Selected Papers of the IRIS*, *12*(2). Association for Information Systems Electronic Library (AISeL). https://aisel.aisnet.org/iris2021/2

Van Antwerpen, C., & Curtis, N. J. (2016). A data collection and presentation methodology for decision support: A case study of hand-held mine detection devices. *European Journal of Operational Research*, *251*(1), 237–251. https://doi.org/10.1016/j.ejor.2015.11.009

Van Burg, E., Cornelissen, J., Stam, W., & Jack, S. (2020). Advancing qualitative entrepreneurship research: Leveraging methodological plurality for achieving scholarly impact. *Entrepreneurship Theory and Practice*, *46*(1), 3–20. https://doi.org/10.1177/1042258720943051

Van De Water, H., Schinkel, M., & Rozier, R. (2007). Fields of application of SSM: A categorization of publications. *Journal of the Operational Research Society*, *58*(3), 271–287. https://doi.org/10.1057/palgrave.jors.2602156

Van Wassenhove, L. N., & Besiou, M. (2013). Complex problems with multiple stakeholders: How to bridge the gap between reality and OR/MS? *Journal of Business Economics*, *83*(1), 87–97. https://doi.org/10.1007/s11573-012-0643-3

Velez-Castiblanco, J., Brocklesby, J., & Midgley, G. (2016). Boundary games: How teams of OR practitioners explore the boundaries of intervention. *European Journal of Operational Research*, *249*(3), 968–982. https://doi.org/10.1016/j.ejor.2015.08.006

Vennix, J. A. M. (1996). *Group model building: Facilitating team learning using system dynamics*. Wiley. https://www.wiley.com/en-us/Group+Model+Building+%3A+Facilitating+Team+Learning+Using+System+Dynamics-p-9780471953555

Vennix, J. A. M. (1999). Group model-building: Tackling messy problems. *System Dynamics Review*, *15*(4), 379–401. https://doi.org/10.1002/(SICI)1099-1727(199924)15:4<379::AID-SDR179>3.0.CO;2-E

Viana, J., Brailsford, S. C., Harindra, V., & Harper, P. R. (2014). Combining discrete-event simulation and system dynamics in a healthcare setting: A composite model for Chlamydia infection. *European Journal of Operational Research*, *237*(1), 196–206. https://doi.org/10.1016/j.ejor.2014.02.052

Vidoni, M. (2021). Beyond hard and soft OR: Operational research from a software engineering perspective engineering perspective. *Journal of the Operational Research Society*, *73*(4), 693–715. https://doi.org/10.1080/01605682.2020.1865848

Vogl, S., Schmidt, E. M., & Zartler, U. (2019). Triangulating perspectives: Ontology and epistemology in the analysis of qualitative multiple perspective interviews. *International Journal of Social Research Methodology*, *22*(6), 611–624. https://doi.org/10.1080/13645579.2019.1630901

Volkoff, O., & Strong, D. M. (2013). Critical realism and affordances: Theorizing IT-associated organizational change processes. *MIS Quarterly*, *37*(3), 819–834. https://doi.org/10.25300/MISQ/2013/37.3.07

Volkoff, O., Strong, D. M., & Elmes, M. B. (2007). Technological embeddedness and organizational change. *Organization Science*, *18*(5), 832–848. https://doi.org/10.1287/orsc.1070.0288

Wadham, H., & Warren, R. C. (2014). Telling organizational tales: The extended case method in practice. *Organizational Research Methods*, *17*(1), 5–22. https://doi.org/10.1177/1094428113513619

Walport, M. (2015). *A review of MOD's science & technology capability (Executive summary)*. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/458623/20150414-MOD_Science_Capability_Review_Executive_Summary.pdf

Wang, H., Wang, J., & Tang, Q. (2018). A review of application of affordance theory in information systems. *Journal of Service Science and Management*, *11*(1), 56–70. https://doi.org/10.4236/jssm.2018.111006

Wang, W., Liu, W., & Mingers, J. (2015). A systemic method for organisational stakeholder identification and analysis using Soft Systems Methodology (SSM). *European Journal of Operational Research*, *246*(2), 562–574. https://doi.org/10.1016/j.ejor.2015.05.014

Wątróbski, J., Jankowski, J., Ziemba, P., Karczmarczyk, A., & Zioło, M. (2018). Generalised framework for multi-criteria method selection. *Omega*, *86*, 107–124. https://doi.org/10.1016/j.omega.2018.07.004

Watts, S. (2013). User skills for qualitative analysis: Perspective, interpretation and the delivery of impact. *Qualitative Research in Psychology*, *11*(1), 1–14. https://doi.org/10.1080/14780887.2013.776156

Weaver, M. W., Tan, H., & Crossan, K. (2020). Systems and systemic approaches for attaining the SDGs across partnerships. In W. Leal Filho, A. M. Azul, L. Brandli, A. Lange Salvia, & T. Wall (Eds.), *Partnerships for the Goals: Encyclopedia of the UN Sustainable Development Goals.* Springer. https://doi.org/10.1007/978-3-319-71067-9_92-1

Westcombe, M., Franco, L. A., & Shaw, D. (2006). Where next for PSMs—A grassroots revolution? *Journal of the Operational Research Society*, *57*(7), 776–778. https://doi.org/10.1057/palgrave.jors.2602161

Westhorp, G. (2019). Understanding mechanisms in realist evaluation and research. In N. Emmel, J. Greenhalgh, A. Manzano, M. Monaghan, & S. Dalkin (Eds.), *Doing realist research* (pp. 41–58). Sage. https://dx.doi.org/10.4135/9781526451729

White, L. (2006). Evaluating problem-structuring methods: Developing an approach to show the value and effectiveness of PSMs. *Journal of the Operational Research Society*, *57*(7), 842–855. https://doi.org/10.1057/palgrave.jors.2602149

White, L. (2009). Understanding problem structuring methods interventions. *European Journal of Operational Research*, *199*(3), 823–833. https://doi.org/10.1016/j.ejor.2009.01.066

White, L. (2016a). Behavior Beyond the Model. In M. H. Kunc, J. Malpass, & L. White (Eds.), *Behavioral operational research: Theory, methodology and practice* (pp. 65–84). Palgrave Macmillan. https://doi.org/10.1057/978-1-137-53551-1

White, L. (2016b). Behavioural operational research: Towards a framework for understanding behaviour in OR interventions. *European Journal of Operational Research*, *249*(3), 827–841. https://doi.org/10.1016/j.ejor.2015.07.032

White, L. (2018). A Cook's tour: Towards a framework for measuring the social impact of social purpose organisations. *European Journal of Operational Research*, *268*(3), 784–797. https://doi.org/10.1016/j.ejor.2017.06.015

White, L. (2024, 30 June–July 3). *AI and problem structuring* [Conference presentation abstract]. 33rd European Conference on Operational Research and Management Science (EURO 2024), Copenhagen, Denmark. https://www.euro-online.org/conf/euro33/treat_abstract?paperid=3118

White, L. & Bourne, H. (2007). Voices and values: Linking values with participation in OR/MS in public policy making. *Omega*, *35*(5), 588–603. https://doi.org/10.1016/j.omega.2005.11.002

White, L., Burger, K., & Yearworth, M. (2016). Understanding behaviour in problem structuring methods interventions with activity theory. *European Journal of Operational Research*, *249*(3), 983–1004. https://doi.org/10.1016/j.ejor.2015.07.044

White, L., Kunc, M. H., Burger, K., & Malpass, J. (Eds.). (2020). *Behavioral operational research: A capabilities approach*. Palgrave Macmillan. https://doi.org/10.1007/978-3-030-25405-6

White, L., & Taket, A. (1997). Critiquing multimethodology as metamethodology: Working towards pragmatic pluralism. In J. Mingers & A. Gill (Eds.), *Multimethodology: The theory and practice of combining management science methodologies* (pp. 379–405). Wiley. https://www.wiley.com/en-gb/Multimethodology%3A+Towards+Theory+and+Practice+and+Mixing+and+Matching+Methodologies-p-9780471974901

White, L., & Taket, A. (2000). Exploring the use of narrative analysis as an operational research method: A case study in voluntary sector evaluation. *Journal of the Operational Research Society*, *51*(6), 700–711. https://doi.org/10.1057/palgrave.jors.2600959

White, L., Yearworth, M., & Burger, K. (2015). Understanding PSM interventions through sense-making and the mangle of practice lens. In B. Kamiński, G. E. Kersten, & T. Szapiro (Eds.), *Outlooks and insights on group decision and negotiation. GDN 2015. Lecture notes in business information processing*, *218*, 13–27. Springer. https://doi.org/10.1007/978-3-319-19515-5_2

Wijnmalen, D. J. D., & Curtis, N. J. (2013). A code of best practice for judgement-based operational research. *OR Insight*, *26*(4), 291–308. https://doi.org/10.1057/ori.2013.10

Willemain, T. R. (1994). Insights on modeling from a dozen experts. *Operations Research*, *42*(2), 213–222. https://doi.org/10.1287/opre.42.2.213

Williams, T. (2008). *Management science in practice*. Wiley. https://www.wiley.com/en-gb/Management+Science+in+Practice-p-9780470026649

Williams, B., & Hummelbrunner, R. (2010). *Systems concepts in action: A practitioner's toolkit*. Stanford University Press. https://doi.org/10.1515/9780804776554

Wiltshire, G., & Ronkainen, N. (2021). A realist approach to thematic analysis: making sense of qualitative data through experiential, inferential and dispositional themes. *Journal of Critical Realism*, *20*(2), 159–180. https://doi.org/10.1080/14767430.2021.1894909

Winch, G. M. (2017). The morphogenesis of socio(-)material relations in organizations. In *Proceedings of the 38th International Conference on Information Systems (ICIS 2017)*, *3*. Association for Information Systems Electronic Library (AISeL). http://aisel.aisnet.org/icis2017/ResearchMethods/Presentations/3

Winch, G. M. (2023). From duality to dualism in complex project organizing: Structuration and morphogenetic theory. In G. M. Winch, M. Brunet, & D. Cao (Eds.), *Research handbook on complex project organizing* (pp. 148–157). Edward Elgar. https://doi.org/10.4337/9781800880283.00025

Woolley, R. N., & Pidd, M. (1981). Problem structuring—A literature review. *Journal of the Operational Research Society*, *32*(3), 197–206. https://doi.org/10.1057/jors.1981.42

Wright, G., Cairns, G., O'Brien, F. A., & Goodwin, P. (2019). Scenario analysis to support decision making in addressing wicked problems: Pitfalls and potential. *European Journal of Operational Research*, *278*(1), 3–19. https://doi.org/10.1016/j.ejor.2018.08.035

Wynn, D. E., Jr., Volkoff, O., Williams, C. K., & Strong, D. M. (2013, August 15–17). *Critical realism and mechanisms: Moving from the philosophical to the empirical in the search for causal explanations* [Conference panel submission]. Proceedings of the 19th Americas Conference on Information Systems (AMCIS 2013), *7*. Association for Information Systems Electronic Library (AISeL). https://aisel.aisnet.org/amcis2013/Panels/PanelSubmissions/7/

Wynn, D. E., Jr., & Williams, C. K. (2012). Principles for conducting critical realist case study research in information systems. *MIS Quarterly*, *36*(3), 787–810. https://doi.org/10.2307/41703481

Wynn, D. E., Jr., & Williams, C. K. (2020). Recent advances and opportunities for improving critical realism-based case study research in IS. *Journal of the Association for Information Systems*, *21*(1), 50–89. https://doi.org/10.17705/1jais.00592

Xu, W., & Zammit, K. (2020). Applying thematic analysis to education: A hybrid approach to interpreting data in practitioner research. *International Journal of Qualitative Methods*, *19*, 1–9. https://doi.org/10.1177/1609406920918810

Yates, A., & Burke, M. (2001, June 19–21). *Improving evaluations of military organisations* [Symposium presentation]. 6th International Command and Control Research and Technology Symposium (6th ICCRTS). http://www.dodccrp.org/events/6th_ICCRTS/Tracks/Papers/Track6/005_tr6.pdf

Yearworth, M. (2022a, July 3–6). *From problem formulation to problem structuring and back* [Conference presentation]. 32nd European Conference on Operational Research and Management Science (EURO 2022), Espoo, Finland. http://hdl.handle.net/10871/130142

Yearworth, M. (2022b, September 13–15). *Problem structuring in OR practice* [Conference presentation]. 64th Annual Conference of the Operational Research Society (OR64), Warwick, UK. https://theorsociety.eventsair.com/or64-annual-conference/programme

Yearworth, M. (2024). *Problem structuring: Methodology in practice*. Wiley. https://doi.org/10.1002/9781119744856

Yearworth, M., Edwards, G., Davis, J., Burger, K., & Terry, A. (2013). Integrating problem solving and research methods teaching for systems practice in engineering. *Procedia Computer Science*, *16*, 1072–1081. https://doi.org/10.1016/j.procs.2013.01.113

Yearworth, M., & White, L. (2013). The uses of qualitative data in multimethodology: Developing causal loop diagrams during the coding process. *European Journal of Operational Research*, *231*(1), 151–161. https://doi.org/10.1016/j.ejor.2013.05.002

Yearworth, M., & White, L. (2014). The non-codified use of problem structuring methods and the need for a generic constitutive definition. *European Journal of Operational Research*, *237*(3), 932–945. https://doi.org/10.1016/j.ejor.2014.02.015

Yearworth, M., & White, L. (2018). Spontaneous emergence of Community OR: Self-Initiating, self-organising problem structuring mediated by social media. *European Journal of Operational Research*, *268*(3), 809–824. https://doi.org/10.1016/j.ejor.2018.01.024

Yearworth, M., & White, L. (2021, August 22–27). *The construction of wicked problems* [Conference presentation]. 22nd Conference of the International Federation of Operational Research Societies (IFORS 2021), Seoul, Korea. http://hdl.handle.net/10871/126711

Yeomans, M., Boland, F. K., Collins, H. K., Abi-Esber, N., & Brooks, A. W. (2023). A practical guide to conversation research: How to study what people say to each other. *Advances in Methods and Practices in Psychological Science*, *6*(4). https://doi.org/10.1177/25152459231183919

Yin, R. K. (2014). *Case study research: design and methods* (5th ed.). Sage.

Yolles, M. I. (1996). Critical systems thinking, paradigms, and the modelling space. *Systems Practice* (*9*), 549–570. https://doi.org/10.1007/BF02169213

Zabell, T., Long, K. M., Scott, D., Hope, J., McLoughlin, I., & Enticott, J. (2021). Engaging healthcare staff and stakeholders in healthcare simulation modeling to better translate research into health impact: A systematic review. *Frontiers in Health Services*, *1*, 644831. https://doi.org/10.3389/frhs.2021.644831

Zachariadis, M., Scott, S., & Barrett, M. (2013). Methodological implications of critical realism for mixed-methods research. *MIS Quarterly*, *37*(3), 855–879. https://doi.org/10.25300/MISQ/2013/37.3.09

Zheng, Y., Wang, W., Liu, W., & Mingers, J. (2018). A performance management framework for the public sector: The balanced stakeholder model. *Journal of the Operational Research Society*, *5682*(4), 1–13. https://doi.org/10.1080/01605682.2018.1448247

Zhu, Z. (1998). Conscious mind, forgetting mind: Two approaches in multimethodology. *Systemic Practice and Action Research*, *11*(6), 669–690. https://doi.org/10.1023/A:1022140405046

Zhu, Z. (2011). After paradigm: why mixing-methodology theorising fails and how to make it work again. *Journal of the Operational Research Society*, *62*(4), 784–798. https://doi.org/10.1057/jors.2010.31

Zhu, Z. (2022). Paradigm, specialty, pragmatism: Kuhn's legacy to methodological pluralism. *Systems Research and Behavioral Science*, *39(*5), 895–*912*. https://doi.org/10.1002/sres.2881

Zhu, Z. (2023). WSR: A Chinese Systems Approach. *Journal of Systems Thinking*. https://doi.org/10.54120/jost.0000025

Zolfagharian, M., Romme, A. G. L., & Walrave, B. (2018). Why, when, and how to combine system dynamics with other methods: Towards an evidence-based framework. *Journal of Simulation*, *12*(2), 98–114. https://doi.org/10.1080/17477778.2017.1418639