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Soft OR Comes of Age – But Not Everywhere!

John Mingers
Kent Business School
University of Kent
Canterbury
Kent CT2 7PE

Email: j.mingers@kent.ac.uk
Phone: 01227 824008

Abstract

Over the last forty years new methods and methodologies have been developed to deal with wicked problems or “messes”. They are structured and rigorous but non-mathematical. Prime examples are: soft systems methodology (SSM), cognitive mapping/SODA and the strategic choice approach (SCA). Collectively they are known as Soft OR, Soft Systems, or Problem Structuring Methods (PSMs). Soft OR has now come of age in terms both of dealing with complex practical situations and having a presence in the academic literature. However, Soft OR is not recognised, or even seen as a legitimate part of OR, everywhere and this is especially so in the US where top journals such as *Operations Research* and *Management Science* do not publish Soft OR papers. The purpose of this paper is to generate an informed discussion and debate which may lead to a greater recognition of the contribution of Soft OR, and to it being seen to be a proper part of the OR discipline worldwide. In order to achieve this, the first section outlines the nature of Soft OR and describes briefly some of the main methods. The second section demonstrates that Soft OR has been successful both in practice and within the academic literature. The third section documents the invisibility of Soft OR within important sections of the OR literature, and the final section then suggests some explanations for this, and also proposes practical actions to try and alleviate the problem. It is not suggested that Soft OR is an alternative to traditional, mathematical OR but, rather, a complement.

Key words: Problem Structuring Methods, OR Journals, OR Practice, Soft OR, Soft Systems, Wicked Problems

Soft OR Comes of Age – But Not Everywhere

1. Introduction

When OR first developed in the 1940s it was a very practical and multidisciplinary activity. Although it was based on a natural science methodology, its aim was solving problems using whatever methods and data were appropriate or available [1]. As it became established in academia, especially in the US, it became more and more dominated by the development of mathematical techniques [2, 3]. However, the limitations of purely mathematical OR methods became apparent during the 1960s and 1970s. C. West Churchman, in an editorial in *Management Science* in 1967 [4], brought Rittel's concept of wicked problems to attention: "social problems which are ill-formulated, where the information is confusing, where there are many clients and decision-makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing". Ackoff's [5-7] searing critiques of the development of OR up to 1979 are well known, and it was during this period that the main methods that came to be known as "Soft OR" were developed by academic/practitioners in response to practical engagements with real problems. The primary examples are soft systems methodology (SSM) [8, 9], cognitive mapping which became strategic options development and analysis (SODA) and then JourneyMaking [10], and strategic choice analysis (SCA) [11] although, as will be discussed later, there are many others.

There was considerable debate at the time as to whether these approaches were either effective or a legitimate part of OR [12, 13] but they gradually became accepted, at least in the UK, and are routinely taught on graduate OR courses [14] and used in practice [15]. For a variety of reasons, as analysed by Kirby [16], they did not develop in the same way in the US. There has also been debate over the name: "Soft OR" is seen by many as having negative connotations within OR generally, implying imprecision and lack of rigor, and another term "problem structuring methods" (PSMs), first used by Pidd and Woolley [17], is sometimes used instead. However, there are also objections to the term PSMs since it seems to imply that these methods can only structure problems, not actually solve or resolve them and there are many examples of soft methods doing just that.

Reviewing the situation some thirty years after the birth of Soft OR, what do we see? The picture that this paper will portray is that in many ways Soft OR methods have come of age – they are well developed theoretically, have been used successfully in a wide variety of practical problem situations, and have generated an active scholarly literature. However, there is another side to this. The development has been almost exclusively within the UK (and UK-oriented countries such as Canada, New Zealand and Australia). There has been little work, under the Soft OR banner at least, in Europe and virtually none in the US.

The latter country is of particular concern since it has the largest number of operations researchers and also, from an academic perspective, publishes the two world-leading journals – *Operations Research* and *Management Science*. As this paper will document, these journals essentially limit OR, and therefore what they will publish (in one case explicitly), to work based on mathematical modelling. Neither has ever published a paper based on Soft OR methods. Were these just any two journals it would not be a problem, but as the world-leading journals for our discipline, which therefore have power and influence over such

things as promotions, tenure, and the evaluation of research generally, it is of significant concern for the future development of Soft OR and, we would argue, OR more generally.

So, the overall aim of this paper is to generate an informed discussion and debate which may lead to a greater recognition of the contribution of Soft OR, and to it being seen to be a proper part of the OR discipline worldwide. In order to achieve this, the first section will outline the nature of Soft OR and how it differs from traditional OR, and describe briefly some of the main methods. The next section will demonstrate that Soft OR has been successful both in practice and within the academic literature. The third section will document the invisibility of Soft OR within important sections of the OR literature, and the final section will then propose some explanations for this, and also suggest practical actions to try and alleviate the problem.

I am not arguing that Soft OR should replace traditional OR, or that mathematical methods are not useful in practice. In fact, quite the contrary: where there are features of a problem situation that are amenable to mathematical models without distorting or over-simplifying them, I would strongly encourage their use. I am in fact in favour of combining hard and soft methods [18]

2. The Development of Soft OR Methods

2.1 Messy problems and soft methods

In 2007, Brenda Dietrich, then President of INFORMS, wrote an article in *OR/MS Today* urging American OR practitioners to “Venture Outside the OR Comfort Zone” [19] and tackle the messy, strategic problems, such as environment and health care, that are not amenable to mathematical OR methods. It was significant that she did not mention Soft OR at all even though she described precisely the kinds of problem situations for which Soft OR was developed.

Here, I will describe four such problem situations (a term originally used by Checkland) in order to give the reader a feel for why these are so difficult for traditional OR methods to deal with. One involves children’s healthcare in the UK, one a polluted river system in India, one risk management for Europe’s largest Carnival, and one the reorganization of power generation in the UK. They have been chosen fairly randomly from many possible examples because they are reasonably typical of messy situations that have been tackled using Soft OR and because they have been written up in reputable journals or books. We will explain the general characteristics of such situations in more detail later, but we can see that these examples all involve: a range of stakeholders with potentially conflicting values or interests; a lack of reliable data; disagreement about the nature of the “problem”; and yet the need for agreement and commitment from the stakeholders. At the same time, they differ widely in terms of the problem domain, areas of concern, types of stakeholders involved, and even culture and country thus illustrating the wide flexibility and applicability of Soft OR methods.

In 1997 the Salford and Trafford Health Authority in Manchester (UK) wanted to develop a more integrated approach to its children’s services. Several consultation documents were produced and one of the organizations involved, Salford Community Trust, became the coordinator. A project was initiated to “consider further the shape of the Salford service, building on the work of the existing working group. The remit of the project would be to produce a service specification which operationalizes the proposals made by the Health Authority” [20].

Whilst this may sound straightforward, on investigation it turned out to be complex and messy [21]: there was no agreed definition of what a “service specification” was; there was no agreement about what services were to be included within the scope of the project; requirements on a whole range of issues were ambiguous; several different agencies were involved with children’s welfare and it was known that they disagreed about the future direction of children’s services as well as how the project should be tackled; and there were significant political aspects of the situation at both local and national levels.

Moving to India, the Cooum River in Chennai is slow-moving and polluted with debris, organic sludge, and raw sewage [22]. This is a long-standing problem which involves several Government agencies including: the Public Works Department, Chennai Metropolitan Development Authority, the Slum Clearance Board and Metrowater. Various attempts have been made to improve the situation but these have generally been piecemeal engineering projects that have worked locally and in the short-term but failed in the long-term. The situation is complex both in terms of the physical environment (drought/monsoon, flat topology, sand bars, tidal action) and the social environment (population growth, poverty, institutional culture, jurisdictional conflicts, people’s behaviour). There is also considerable uncertainty both about the main processes and relationships within the system, and about the availability and reliability of data. Attempts to improve this situation must go beyond the physical ecosystem to include the social and political interactions.

The next example concerns the power generation industry in the UK [23]. During the 1990s power supply in the UK was privatized, being split into four companies. PowerGen was one of the two generating companies operating a mix of coal and oil-fired stations. The newly formed organization had a series of ambitious aims. Their mission was to become the “best electricity company in the world” and this required a benchmarking exercise to discover where they were and where they had to get to. They were also about to launch a series of major IT projects but required an overall IS strategy to ensure that these genuinely met the business priorities. At the same time, the business needed to reduce costs. It had already done this at the power stations but now needed to do this at head office. These diverse requirements were rolled together in one major project, the overall aim of which was “to propose innovative process improvements which result in significant and rapid improvements to business performance” and which included sub-tasks such as deriving performance indicators, benchmarking, improving communications, sharing lessons learnt, and developing an IS strategy. Clearly this was a very complex project, involving all the different divisions of the company, and with many different actors with diverse aims and priorities.

Finally, an example concerning risk management at the Notting Hill Carnival [24]. The Carnival is a huge street party combining music, dancing, a procession and street trading organized by the West Indian community. It lasts three days, attracts over a million participants, is the largest street festival in Europe and is perhaps second only to Rio in the world. Clearly there are many interest groups associated with such an event, at least some of which may have historically antagonistic relationships: the Metropolitan Police, the W. Indian community (itself split in several ways), the local residents, the Local Authority, shop owners and the participants themselves. There are many risks associated with this situation including threats to public order (several Carnivals during the 1970/80s resulted in outbreaks of violence); public safety (e.g., through crushing); environmental health (toilet arrangements, food safety); and crime especially theft. The project itself developed in discussion with the main stakeholders to consider ways of redesigning the carnival to take

account of its changing nature and changes in expectations and legal requirements concerning such a major public event.

Although these examples are very different, they all exemplify particular characteristics of problem situations (a term I shall generally use instead of “problem”) that make the traditional mathematical modelling tools of OR ineffective [25, 26]. In particular:

- The “problem” itself is not well-defined with agreed objectives such that efficient means to achieve the objectives can be constructed. In the above examples even non-optimizing methods such as critical path analysis, decision analysis or simulation could not be used [27].
- The situations all involve several interested parties whether they are departments within the organization, or cooperating (or conflicting) external bodies. These generally hold different perspectives about the problem situation.
- There are many uncertainties and often a lack of reliable (or indeed any) data.
- “Success” requires the generation of a degree of agreement among the parties involved to undertaking particular courses of action, although agreement about the nature of the problem may then lead to more traditional OR activity. The process is primarily one of learning and negotiation rather than the technical solution of a problem.

These kind of complex and messy problem situations have long been recognized. Ackoff [6] termed them messes as opposed to problems; Rittel [28] wicked as opposed to tame problems; Schon [29] the swamp versus the high ground; Ravetz [30] practical versus technical problems; and Checkland [31] soft as opposed to hard. And, far from being the exception I would argue that they are in fact very common. The reader need only reflect on their own personal experience either as a manager or just in their personal and family life to see how seldom their problems can be dealt with through a mathematical model. I would also argue that these problems are usually important or significant – their resolution, or sometimes dissolution - has wide ranging effects. Or, put the other way round, it is usually strategic problems, i.e., those that are not short-term and narrowly-focused, that are complex and messy.

Given the nature of the problem situations, what are the characteristics of Soft OR methods that might help us deal with them [14]?

- The methods (or methodologies, see below) are not mathematical but they are nevertheless structured and rigorous. They are based on qualitative and often diagrammatic modelling procedures. Obviously numerical information may be included but not complex equations.
- They allow a range of distinctive views to be expressed and explored, and embrace multiple and conflicting objectives without collapsing them into a single, often financial, measure
- They encourage the active participation of stakeholders in the modelling process often through facilitated workshops of those affected by the problem. In order to encourage participation, models should be transparent to the participants. This is aided by the first point that they are generally non-mathematical.
- Significant uncertainty is expected and tolerated as is a lack of reliable quantitative data.
- They aim for exploration, learning, and commitment rather than optimization.

The rest of this section will cover a range of actual and potential Soft OR methods. First, I should just note that there is some confusion over the terms “method” and “methodology”. Generally, I would see a method as a fairly well defined process that leads to a specific output, for example drawing a cognitive map, or developing a root definition and conceptual model. A methodology is wider, often involving several different methods, and with a less well-defined output. In that sense, SSM and Journeymaking would both be methodologies. However, that distinction is not clear in the literature and, in the US, method is preferred to methodology. Hence in this paper I will use them inter-changeably.

The first three sections cover the original methods that precipitated the rise of Soft OR – SSM, cognitive mapping and strategic choice approach. Then, in Section 2.4, I will mention several other methods that conventionally fall within the domain of Soft OR. More detailed descriptions can be found in Flood and Jackson [32], Jackson [33] and Rosenhead and Mingers; [14]. Finally, in Section 2.5, I discuss a selection of other methods that have been suggested as arguably being in the spirit of Soft OR but not generally given that designation. They generally meet some, but not perhaps all, of the characteristics listed above.

2.2 *Soft Systems Methodology*

Peter Checkland was appointed as Professor of Systems at Lancaster University in 1969 and during the next ten years developed the foundations of Soft Systems Methodology (SSM) through a long series of industrial projects [34]. He saw his task as taking traditional, hard systems engineering methodologies, e.g., Hall [35], and transforming them to be able to deal with the humanness of human beings, highlighting the importance of irrationality, creativity and values [36]. The development of SSM has been well documented in three books [9, 37, 38], the second of which (*SSM in Action*) is wholly concerned with applications of SSM. Checkland’s “short, definitive account” was published in 2006 [39]. Intellectually, SSM draws on the work of Churchman [40] on dialectical inquiry; Vickers [41] on social processes; and, more generally, interpretive sociology. Indeed, Churchman’s early paper with Scheinblatt [42], considering the relationship between OR analyst and manager as one of “mutual understanding”, foreshadowed the Soft OR orientation.

In brief overview, the developed form of SSM involves the following stages (technical terms in italics):

- Discover as much as possible about the problem situation, especially its history, the nature of the engagement and possible issues, the prevailing culture, and the power and politics (*rich pictures, analyses 1,2,3*).
- Develop systemic models of purposeful activity which explicitly embody particular viewpoints or perspectives relevant to the situation (*Weltanschauungen*). Express these in terms of *root definitions* and *conceptual activity models*.
- Use the models as a way of questioning and exploring the situation to structure a debate between involved parties about desirable and feasible changes.
- Gain agreement on changes to the situation which the different perspectives or worldviews could accommodate.

2.2 *Cognitive Mapping/ SODA/ Journeymaking*

Colin Eden and colleagues have also spent many years developing methods particularly aimed at strategic decision making. This began with a technique, *cognitive mapping* [10],

which became part of a more general approach, Strategic Options Development and Analysis (SODA) [43], and eventually a whole approach to strategy known as *JOURNEY Making* [44].

Cognitive mapping was developed as a tool to help understand how different people involved in a situation made sense of it, or understood it, for themselves. Messy problems are often messy precisely because people understand and interpret them differently and often do not realize it. Cognitive mapping draws on the psychological theory of “*personal constructs*” developed by Kelly [45]. A cognitive map is a representation of a particular person’s perceptions about a situation in terms of bipolar constructs where the terms are seen as a contrast with each other, for example, “study for an exam ... enjoy a warm and sunny day”. These are then connected together in terms of the presumed causal relations that hold between them, e.g., “study for exam ...” may lead to “pass exam ... fail exam”. The result is not unlike an influence diagram or causal loop diagram although it is explicitly subjective and uses constructs rather than variables [46]. These individual maps can then be used as negotiation devices between the participants, and can lead to the creation of an agreed group map.

Cognitive mapping then became a key tool within a wider process of strategy creation as follows (see especially [44, Ch. C10]):

- Surface the emergent strategy of the organization in terms of strategic issues, aspirations and taken-for-granted beliefs using cognitive maps and the Oval Mapping Technique. This involves individual interviews and facilitated workshops.
- Undertake intensive group discussions and negotiations to develop agreements for action: JOintly Understanding, Reflecting, and NEgotiating strategY (JOURNEY-making) using facilitated workshops, group strategy maps and specially created decision support software (Decision Explorer, Banxia Software).
- Monitor progress of the strategy and gain organizational learning.

2.3 Strategic Choice Approach

The Strategic Choice Approach (SCA) was developed by John Friend and colleagues [47] beginning during the 1960s at the Institute for Operational Research, a joint venture between the Operational Research Society and the Tavistock Institute of Human Relations. It initially arose out of work with public sector organizations, especially local authorities and town planning departments, and was particularly informed by the social science approach of the Tavistock and the concerns of the professional decision-makers who were clients. It is documented in Friend and Jessop [11, originally published 1969] and Friend and Hickling [48] (which includes many applications) and the work has been taken up by planners in Canada, Brazil and the Netherlands.

The approach can be seen as a “soft” version of decision analysis which recognizes differing stakeholders and viewpoints, and significant elements of uncertainty and lack of information. It generally begins with a set of related decision problems that are under consideration and consists of four stages:

- The shaping mode: initially decision-makers will consider the various decision areas in terms of their inter-relationships and relative importance or urgency. The aim is to select a subset that will form an appropriate focus or boundary for the project.

- The designing mode: for each decision area, possible options are identified and debated. The options are then examined in pairs to see which are mutually incompatible. It is then possible to consider all the possible combinations of options to arrive at a set of potentially feasible decision schemes which cover all the decision areas. In both these stages areas of uncertainty will become apparent, especially concerning the decision environment, other related decisions that have not included, and values and political considerations.
- The comparing mode: the feasible decision schemes are now compared by evaluating them in terms of several comparison areas or criteria identified by the participants. These will reflect a range of different values possibly held by different stakeholders, and they may well be qualitative and judgmental. A pair wise comparison of the decision schemes is undertaken using a comparative advantage grid which identifies where the advantage lies on each dimension of choice, and the extent of uncertainty about this.
- The choosing mode: finally, choices have to be made and different stakeholders have to reach accommodations. At this time the uncertainties identified earlier must be addressed and some of the agreements may involve delaying some decisions until exploratory actions have occurred to reduce the uncertainty. The agreed combination of commitments and future explorations to reduce uncertainty are expressed in a commitment package.

As with the other methods, this is a participative methodology usually carried out through facilitated workshops of involved parties. For all three of these methods, it is considered preferable for much of the activity to be carried out by the participants in the situation, with the OR practitioner acting as a facilitator, as they are the ones who have a detailed understanding and it is they who must eventually commit themselves to taking action.

2.4 Overview of Other Soft OR Methods

There are several other methods that are generally included within the domain of Soft OR and some are briefly summarized in Table 1.

Table 1 about here

One other point to make is that traditional “hard” techniques are also being used in “soft” ways. In other words, instead of assuming that the model is an objective representation of a given reality, the model(s) are seen as representations of particular peoples’ beliefs or views about that reality [49]. Examples are: qualitative system dynamics [50, 51], MCDA [52, 53], the viable systems model (VSM) [54] and mathematical modelling generally [55].

2.5 Other Related Methods

As well as the methods discussed above, there are a whole range of OR approaches or methods that are related to Soft OR in sharing many of the same aims. Indeed, it could be said that some of these are essentially Soft OR but not under that name. These will be split

into methods that were clearly developed within OR/management science generally - such as analytic hierarchy process (AHP), decision analysis and multiple criteria decision analysis/aid (MCDA), and those coming from other disciplines such as public policy making. It is not possible to create a hard and fast demarcation between Soft and Hard methods, and it may often depend as much on the attitude and approach of the practitioner as the actual method itself, so in the following analysis I shall not always come to a definite conclusion one way or the other.

The OR methods are all related in the sense that they aim to help decisions makers with complex decisions where there are several or many alternatives, and a range of conflicting criteria, values or stakeholders. They could generally be grouped under a very broad heading of decision analysis but there is a degree of debate and conflict between different schools within that umbrella term. For instance, Belton and Stewart [53] actually cover most of the methods in a single book, but under the banner of MCDA, and their approach is very compatible with Soft OR – indeed they have chapters in the book that cover problem structuring as part of their overall methodology. Whereas, from an alternative perspective in 2004 a new INFORMS journal, *Decision Analysis*, started up and Keefer and Kirkwood [56] outlined what they saw as the boundaries of decision analysis. Interestingly, they excluded both AHP and MCDA from the purview of decision analysis, and they actually defined it as “a set of quantitative methods for analyzing decisions based on the *axioms of consistent choice*” (p. 4). This would seem somewhat incompatible with Soft OR both in its emphasis on quantitative methods and its basis in the axioms of consistent choice which is often not a characteristic of real decision making, as was pointed out by Hamalainen [57] in the same issue.

The first of these approaches to be considered is Saaty’s Analytic Hierarchy Process (AHP) [58]. This is a well-known and widely used process for helping decision-makers make choices between alternatives where there are multiple criteria and so is seen as an example of multi-criteria decision analysis (MCDA) [59, 60].

Why might it be considered as a soft method? Forman and Gass [61] argue that it is more than simply an analysis tool as it has three generic functions: structuring complexity, measuring preferences, and synthesizing. Structuring is carried out by casting the problem in the form of a hierarchy with goals at the top and specific alternatives at the bottom. AHP then has a formal method for transforming the preferences of one or more decision makers into a set of ratio-scale weights using pair-wise comparisons. Finally, these are combined together to create an overall ordering of alternatives. It is certainly a very general approach that has been used in a variety of complex situations, often with groups of decision-makers who may well have diverse views [62].

However, whilst AHP may well be useful in unstructured situations, I would argue that it is not properly a Soft OR method. Certainly U.S. academics put it squarely within the traditional decision analysis camp [59, 61] and Banuelas and Antony [60, p. 29] state “[t]raditional AHP as a “hard” operational research technique has a dominant tendency to look for technical solutions to well-structured problems in which desirable ends can be easily stated”.

In terms of the characteristics of PSMs stated in the introduction, AHP recognizes different criteria but is essentially a method for combining them all into one; it does involve decision-makers but only at one point and has to generate a consensus between them ; it is clearly

quantitative, the whole point being to force subjective and often fuzzy preferences into ratio-scale numbers; some parts of the process are reasonably transparent but the algorithms are clearly not; uncertainty is not catered for; and it does aim for a single, best ranking rather than maintaining and allowing alternatives. My overall conclusion is that it is a hard method that could potentially be used in a soft way in particular, well-defined circumstances.

Ralph Keeney has developed an approach he calls value-focused thinking [63]. In an application in British Columbia Gas (BCG) [64] much of the work involved eliciting a whole range of objectives and values through discussions with key stakeholders; structuring these into means and ends; and investigating measures of performance and stakeholder views on tradeoffs where they conflicted. Methods used included workshops, workbooks, and influence-type diagrams. Interestingly, the final results were subjected to a court hearing. Equally, a standard textbook by Robert Clemen [65] has chapters on structuring decisions (e.g., using a form of influence diagram) and on conflicting objectives.

Considering the BCG example, the early stages are certainly very much in the Soft OR mould, the diagram (Figure 1 in the paper) being similar in intention to a strategy map within JOURNEY-making. Where it perhaps differs, and this is true of the textbook as well, is that the ultimate aim is always to quantify everything in order to get it into a model. From a soft perspective, we would expect that there are factors which cannot be forced into quantitative measurement without distortion and we would be happy working with a mixture of quantitative and qualitative judgements. Strategic Choice Analysis, for instance, is very much oriented towards making difficult decisions without having to reduce everything to financial or even quantitative terms. Options are compared pairwise on each criteria and the differences are ranked on a qualitative scale of “relative advantage” ranging from “extreme” to “negligible”. Ultimately, the decisions will be made by people’s judgements not purely by the outputs of models, no matter how mathematically sophisticated. The models contribute, in whatever way they can, to the final judgement. It is interesting to note the appearance of naked politics in BCG when the models were taken to court, to the extent of the Chair being forced to step down for having participated in the modelling process. To what extent would, or could, this have been included in a traditional mathematical model? Overall, in terms of the Soft OR criteria, I think that this approach could well be included within Soft OR.

A second decision analysis approach, initiated by the work of Phillips [66, 67], is known as decision conferencing. In this approach, as originally conceived, an intensive workshop is held over several days with the main participants from the problematic situation. This was facilitated and a form of decision analytic software (e.g., *Equity*) was used to model the decision options. The role of the facilitator was seen as primarily to do with managing the group processes rather than the direct content of the problem. The DA modelling was likewise seen as a mechanism to help the group understand the alternatives and consequences rather than a model to determine the correct answer. Recent developments vary the format of the decision conference [68] and also widen the modelling approach to include MCDA [69]. Given the strong orientation towards facilitated group decision making with the quantitative modelling simply as an aid to the process, I would regard this approach as quite compatible with Soft OR.

We can also consider approaches to decision analysis, particularly MCDA, that have been developed in Europe under the names of ELECTRE [70, 71] and PROMETHEE [72-74]. These are both “outranking” methods, that is, they work on the basis of comparing the

alternatives in pairs to see which one outranks the other in terms of being at least as good as the other on most if not all of the various criteria.

ELECTRE includes a range of versions that have been developed to solve different types of problems, e.g., selecting the best alternative (ELECTRE I), producing a ranking of alternatives (ELECTRE II), or sorting alternatives into categories (ELECTRE TRI) [75]; and of increasing sophistication, e.g., different forms of criteria (ELECTRE III). There is software available to support the use of these methods with real decision makers. Much of the academic literature concentrates on theoretical developments to the methods but a selection of applications can be found in Jacquet-Lagrèze and Siskos [76]. PROMETHEE is in many ways similar to ELECTRE in working with pairwise comparison of alternatives and generating measures of the degree to which certain alternative outrank others although its particular measures and algorithms are different. It can also be combined with a graphical methods of displaying the results (GAIA) that is similar in its results to factor analysis [72].

In considering the extent to which these methods may be considered part of Soft OR, I would argue that it very much depends on the actual way in which they are used. If they are used as part of a facilitated engagement with decision-makers, and are seen clearly as “aiding” the decision rather than making it, then it could be regarded as Soft OR. But, Belton and Stewart warn that “In view of the complexities and potential for counter-intuitive results ... it seems that the outranking methods may not generally be suitable for use in the decision workshop mode ... in which the decision analyst works directly with the decision makers” [53, p. 259]. It is also interesting that there are several examples of these methods being used *with* conventional Soft OR methods [77-79].

Finally in this section I will outline some methods for dealing with soft, complex problems that have developed outside of OR.

- Within the political arena there is a movement towards what is known as “deliberative democracy” [80-83] which aims to effectively engage ordinary citizens and stakeholders in political issues. There are several methods for trying to facilitate this [84], for example: citizen’s juries [85] where a representative sample of those concerned convene together for a day or more to discuss a well-defined issue, and can call experts or witnesses; consensus conferences [86] where a panel of ordinary citizens are convened in public on a specific controversial topic.
- Another example is group support systems that are specifically aimed at facilitating large group interactions such as nominal group technique (NGT) or Future Search [87].
- There are also some examples of very general approaches to trying to resolve conflicts and competitive situations through collaborative and participative means, for example concerning the use of natural resources [88] and in public disputes [89].

3. How Effective are Soft OR Methods?

We have shown that many new methods were developed to deal with wicked problems but what is the evidence that they are actually successful? Clearly many projects carried out by practitioners are never written up and published so the evidence that I shall describe is to some extent only the tip of the iceberg.

First I will discuss published surveys of Soft OR use. The first was probably Mingers and Taylor [90] who surveyed OR and systems practitioners (some of whom were also academics) about their practical use of SSM. Over 90 users of SSM responded to the survey (which had a 47% response rate) and 66% had used SSM more than once. The most common benefit was that SSM provided a coherent structure both for managing the project and for dealing with the complexity of the situation. 63% evaluated their success with SSM as “good” or “very good”. This study was replicated in Australia [91] with similar results. In 2000, in a paper in ITOR, Mingers [18] carried out a literature search for published applications of Soft OR methods. This found 49 examples up till 1998.

In 2002 Munro and Mingers [92] carried out a survey into the use of multimethodology (i.e., combinations of methods) in practice with 64 practitioners responding, describing 167 projects involving at least two methods. Again, the success was rated highly (median of 6 out of 7) albeit by the practitioners themselves. One interesting finding was that most combinations were either all soft methods or all hard, but rarely a mixture of hard and soft. I believe this reflects the fact that through both psychology and culture individuals tend to feel comfortable in one camp or the other but not both.

In 2007, van der Water et al [93] produced a classification scheme for applications of SSM based on published articles. They discovered over 110 papers on SSM. The main areas of application were ecology and environment, information and communication technology, and action research although a significant number were concerned with discussing SSM itself. Of particular interest for this paper is the fact that only 7% of the papers originated from the U.S. – the majority were from the UK and Australia which is not surprising given the origins of SSM at Lancaster.

Next I shall consider more directly the extent of papers and citations in the literature.

Table 2 shows the results of searching *ISI Web of Science (WoS)*, *Scopus* and *Google Scholar (GS)* with particular key-words related to Soft OR. These results should only be taken as indicative since some of these search terms are difficult – e.g., the “OR” in Soft OR is not accepted as a search term in WoS, and “drama theory” and “cognitive mapping” are used in other disciplines. All searches where this might be the case included the term “operational research” and generally the disciplines were restricted to “Management” and “Management Science/OR” to try and restrict the range. As would be expected, WoS and Scopus numbers are much smaller than GS as they only includes papers in those journals that are in the database (and now some conferences) whereas Scholar has a much wider range of sources including books, conference papers and websites generally. There is good consistency: Scholar results are around ten times larger than WoS and the ordering of the topics is almost identical. SSM has a very large response in Scholar reflecting both the major influence Checkland’s writings have had and the take up of SSM in a wide range of other disciplines. Overall, the results show a very significant degree of coverage of Soft OR in the scholarly literature. The *European J. Operational Research* had a special issue in 2004 including an invited review [15] and the *J. of the Operational Research Society* has recently had two special issues on Problem Structuring Methods (Vol 57., no. 7, 2006 and Vol. 58, no. 5, 2007) which discuss future developments.

Table 2 about here

Apart from the number of papers, the impact of an author or theory can be measured in terms of the number of citations they receive. Measuring the total number of citations that an author receives can be very inaccurate, especially if the name is common, so looking at the works that have received the greatest number of citations is more reliable. There is a relatively new citation-based metric that measures both the impact and quantity of an author's output in one number. This is the "h-index" or Hirsch index developed by a physicist in 2005 [94] which is defined as follows:

"A scientist has index h if h of his/her N papers have at least h citations each, and the other $(N-h)$ papers have no more than h citations each".

This is a very simple and robust measure which can be applied to individuals, journals, or research groups. If a person has an h-index of 20 it means that 20 of their publications each have 20 or more citations. It thus measures both the impact and the quantity of their work. Studies have shown that top physical scientists have h-indices from 60 upwards, with Nobel physicists between 22 and 79 [94]; U.S. information scientists between 5 and 20 [95], and UK information scientists between 5 and 31 [96].

Table 3 shows the h-index and the maximum number of citations for a single publication of a selection of the main Soft OR authors and, for comparison, some senior U.S. Hard OR academics. Ackoff and Churchman were included in the Soft category and the (Hard) comparator academics were chosen, somewhat randomly, as all being current editors of Operations Research or Management Science. As can be seen, there is little difference between the two groups in rank ordering on either the h-index or the max. citations showing that the research output of Soft OR academics is equivalent to that of others. Indeed the biggest difference in the Table is the huge number of citations for Checkland's original book Systems Thinking, Systems Practice [9].

Table 3 about here

To summarize, I believe the evidence presented in this section shows conclusively that Soft OR methods are successful in practice and well represented in the literature, and that Soft OR academics make as strong a contribution as other OR academics. I would also mention that Soft OR is taught on all the main Masters courses in OR in the UK

4. The (Lack of) Dissemination of Soft OR

We have shown that Soft OR has developed strongly in the UK but to what extent has it been disseminated elsewhere in the world?

Table 4 shows the country of origin of the lead author for those papers in Table 2 that are in Web of Science.

Table 4 about here

It could be said that it is not surprising that 50% of the papers come from England given that is where the methods originated. However, if we consider the two major OR regions as being America and Europe then there is very little from Europe, and only a small amount from the US. When the latter is examined in detail, it is either papers in non-OR journals, e.g. information systems or organizational behaviour; US authors publishing in European journals; or papers in *Interfaces*, which is the only US journal to publish Soft OR papers. (Some recent responses to this situation, following debates in *OR/MS Today*, will be discussed below). So the picture seems to be that Soft OR as such has not penetrated into either the US or Europe and remains a very UK oriented activity. Analysis by year shows little change over time. Paucar-Caceres [97] surveyed papers published in *Omega*, a US-edited journal, and found only 16 papers in 35 years of a non-traditional OR nature.

In the rest of this section we will concentrate on the lack of dissemination in the US particularly. This is for three reasons: i) as stated above, the US has the world-leading journals and the greatest number of OR academics; ii) the US is a single country whereas Europe has many countries to which different factors may apply; iii) there is considerable documentation of the historical split between US and UK OR.

Table 5 takes the keyword data from Table 2 and splits it by particular journals – *JORS* and *EJOR* together with three U.S. ones, *Interfaces*, *Management Science* and *Operations Research*. Two things are immediately apparent: first, *JORS* is by far the major outlet for Soft OR work, which is not surprising as it originated in the UK, and second that there is virtually no mention at all of Soft OR in either *Management Science* or *Operations Research*, with just some in *Interfaces* which is clearly a practice-oriented journal. This is clearly not a matter of chance but must be the result of a lack of submissions and/or the rejection of those that are submitted. These factors in turn will be influenced by the editorial policies of the journals and the extent of Soft OR work in the U.S..

Table 5 about here

With regard to editorial policy, I can point to the following. In 2006 the new Editor of *Operations Research* (David Simchi-Levi) published, in *OR/MS Today* [98], his view of the mission and scope of the journal. This began well stating that: “My objective is thus to broaden the journal content, and consequently the field, by publishing material that covers the entire spectrum of problems of interest to the community and by identifying new and emerging areas”. However, the implicit exclusion of Soft OR becomes apparent when we see that none of the 16 areas of coverage includes Soft OR or anything like it, and that the Editor “would like to see *Operations Research* attracting and publishing high quality managerial or technical papers that are based on rigorous mathematical models” (my emphasis). In 2009, a letter signed by 49 OR academics from around the world complaining at the exclusion of Soft OR was published in *OR/MS Today* [99]. In response (p. 21), Simchi-Levi reiterated that, “When [techniques] are not based on rigorous mathematical models *Operations Research* is not the appropriate outlet for such papers.” Were *Operations Research* to be titled *Mathematical Operations Research* and not claim to represent the entire community, this would not be a problem.

The editorial statements of *Management Science* are less clear-cut, but again none of the 13 departments makes any reference to Soft OR or problem structuring and most contain statements about mathematical models and rigorous scientific validation which is certainly biased towards traditional OR. It was not, perhaps, always so as we will discuss later. Both Ackoff (eight between 1955 and 1971) and Churchman (seven between 1965 and 1970) published papers in *Management Science* (and *Operations Research*) that would nowadays be counted as Soft OR.

In fact, there has been a significant response from other parts of the US OR community to the letter published in OR/MS Today. For example, the *Wiley Encyclopaedia of Operations Research and Management Science*, which is edited by Jim Cochran [100], includes several entries on a range of Soft OR topics, and a Special Issue of *INFORMS Transactions on Education* (<http://www.informs.org/Pubs/ITE>) devoted to teaching Soft OR is scheduled for publication in 2011. Indeed, a lack of teaching material on Soft OR in the vast majority of standard OR textbooks, or even a mention, is a problem that needs to be overcome.

Although papers may not be published, to what extent is the literature on Soft OR cited within these journals? Table 6 shows the number of citations in the same journals as Table 4 for some of the main Soft OR authors. Again it is clear that there is much citation activity for all authors in *JORS* and *EJOR*, and some in *Interfaces*. In *Management Science* and *Operations Research* there are citations for Ackoff and Churchman (although the majority comes from pre-1985) but virtually none for the UK authors.

Table 6 about here

Finally, we can consider the appearance of Soft OR on Masters Courses. An admittedly *ad hoc* search of U.S. Masters courses in OR/MS from the INFORMS database failed to find any which appeared to cover these areas. This deprives both academics and practitioners of useful knowledge of these valuable methods.

As Maurice Kirby, Professor of History at Lancaster University who has studied the history of OR, said about Ackoff: “The inevitable impression, rightly or wrongly, is that Ackoff has been ‘air-brushed’ out of the history of American OR” [3, p. 1138]. The same could be said for Soft OR in general.

5. Why is Soft OR Invisible in the U.S.?

So far, this paper has shown that Soft OR is alive and very successful but that it is virtually invisible in the US.

5.1 Soft OR is not Real OR

The first possible reason is simply a genuinely held belief, within the U.S., that Soft OR is not really OR and, indeed, that it may be detrimental to OR. We can find an early expression of this view in Machol’s [12] scathing viewpoint about a case study [101] of what would now

be called Soft OR, but I would like to illustrate it with a more recent referee's report I received on a paper I submitted to *Operations Research* (which was rejected) in 1998.

“In my experience, the use of these soft methodologies only serves to mask the preconceived notions and prejudices of the investigator. I believe that they are at the root of current cynicism that has surfaced about segments of our profession, particularly in the public sector: ‘What is the answer to our problem? What would you like the answer to be?’ ... Only if and when some successes can be highlighted might the approach described in this paper be addressed.”

Apart from the fact that the review is itself a good example of the “preconceived notions and prejudices” that the referee decries, it does make two points: that Soft OR lacks the “objectivity” of traditional OR and licenses an “anything goes” attitude; and that it has not been demonstrably successful. The latter point could only be made by someone not familiar with the non-U.S. literature as documented above, but it is worth considering the first point.

It is certainly one of the main philosophical differences between Soft and Hard OR that Soft OR tends to take an “internal” view of the problem situation, recognizing and valuing the viewpoints of those most closely involved. In its developed form, Soft OR sees its role as one of informed facilitation of key participants using rigorous and structured methods to elicit and debate differing worldviews. In this sense it does pay heed to the preconceptions and prejudices, not of the investigator but of the stakeholders. From the viewpoint of traditional OR this could be seen as a weakness for OR always claimed its legitimacy from its scientific approach, its mathematical models, and its supposed external objectivity. I would argue that this view of the validity of OR became untenable many years ago, and is neatly summarized in Ackoff's paper “Optimization + Objectivity = Opt Out” [5]. Traditional OR cannot even start with its mathematical modelling, until some form of “problem” has been defined, but the definition or, I would say, *construction* of the problem can *never* be objective. Problems are never given, simply waiting there to be “solved”. They are always the result of decisions and judgements, made by the OR practitioner and the client, concerning the boundaries to be used – which aspects of the situation are to be included and which excluded; the timescale; the symptoms of concern; the values and objectives to be met; and so on. These essentially subjective decisions, usually influenced by considerations of the time and resources available; the knowledge and skill set of the practitioner, and the commitment and understanding of client, determine the nature of the problem that eventually gets to be tackled. Hence, I would argue, OR is actually intrinsically Soft, and it is only after some, perhaps implicit, problem structuring has occurred that any form of modelling can occur.

Much more could be said about this and I would refer the reader to two papers by Maurice Kirby about the history of OR at this time, one in fact published in *Operations Research* [2, 3]. These, together with a selection of classic papers [4, 6, 7, 13, 42, 102-108] should make the case more eloquently than I can.

In fact, the view that Soft OR is not real OR is official. As a referee of an earlier version of this paper pointed out, according to the INFORMS definition, OR is:

“the discipline of applying advanced analytical methods to help make better decisions. By using techniques such as mathematical modelling to analyze complex situations, operations research gives executives the power to make more effective decisions and build more productive systems” [109].

The referee thence concluded, “qualitative approaches are not OR since they lack the hallmark use of mathematical models. Therefore, it is not surprising that OR journals are not prepared to publish the work”. However, I would argue that “applying advanced analytical methods to help make better decisions” is precisely what requires us to involve Soft OR methods.

I would argue that this type of definition confuses the means with the ends. To use an analogy, one could define Western medicine as the application of modern drugs to fight illness. However, I am sure that most doctors do not only give out lots of pills – they also give reassurance, recommend counselling, psychotherapy, and nowadays even complementary medicine such as acupuncture. The actual aim of medicine is improving the well-being of patients by whatever means are appropriate. The same is true of OR, its aim since the beginning has been the improvement of management decision making - mathematical models are but one way of achieving that. The OR pioneers worked in an imaginative and inter-disciplinary manner to solve the problems they were faced with, witness Ackoff’s solution of complaints about waiting time for a lift with the installation of mirrors [110] rather than the use of queuing theory or simulation!

My own view is that Soft and Hard OR are not alternatives but are complements to each other [18, 111, 112]. Every complex real-world situation has aspects that are amenable to quantitative analysis and other aspects - such as culture, power and politics - that are simply not. The two approaches can therefore usefully be combined together (in what is generally termed “multimethodology” [113, 114]) although in my own personal experiences of real projects the non-quantifiable aspects often dominate. So far, such combinations have been relatively rare [92] but as OR practitioners increasing become trained in both areas I am convinced that such combinations will become commonplace.

5.2 Soft OR Happens in Other Disciplines

A variant or development of the above argument is that Soft OR does happen in the U.S. but not within OR departments. There is certainly some truth to this as the following examples show.

Churchman’s ideas of dialectical inquiry and whole systems formed the basis of Mason and Mitroff’s SAST approach as mentioned above. They have also been used by Harold Linstone, working in the areas of technological forecasting and change from a systems perspective, as part of his development of “unbounded systems thinking”. He combined with Mitroff and wrote a well known book called “The Unbounded Mind” [115] which involves many Soft OR themes such as varying perspectives, multiple realities and many possible solutions. Another person drawing on Churchman’s ideas is Harold Nelson, who is co-founder of the Advanced Design Institute, and is well known in the areas of design and planning [116, 117]. Churchman’s work in inquiring systems has also been used in developing information and knowledge management systems [118, 119]

Cognitive mapping is used by John Bryson [120], at the Institute of Public Affairs, in the public policy area for creating shared strategic visions and he has a book jointly authored with Colin Eden [121]. Similarly, Richardson and Andersen [122] use a range of soft techniques, especially cognitive mapping, in generating mental models for system dynamics.

Soft systems methodology too has its adherents, especially within information systems [123-125] but also in ecology/environment [126] and health [127].

What this shows is that many U.S. academics in several disciplines find Soft OR to be of value to their work and, as can be seen from the references, they publish in prestigious journals such as *Organization Science* (an INFORMS but non-OR journal), *MIS Quarterly* and *Strategic Management Journal*. If these people find Soft OR valuable should not OR people?

5.3 Disciplining the Discipline

An alternative perspective is to take a more historical and sociological view and look at how OR/MS has developed as a discipline within the U.S.. We shall then be able to see how a set of mutually reinforcing feedback loops has come into being which maintains the status quo and impedes the development or dissemination of Soft OR ideas.

I do not intend to rehearse the history of the “crisis” in OR during the 1970s as that has been done [2] but I do need to establish a couple of points. During the 1960s and 1970s Ackoff and Churchman regularly published in both *Management Science* and *Operations Research* [4, 42, 105, 128-130] and these papers were often critical of the prevailing view of OR and could be classed as forerunners to Soft OR. The main criticisms were that OR, particularly in the U.S., had become intensely theoretical and mathematical, and had lost contact with practical problems in the real world. After the 1970s neither published any more in these journals but they did publish in European journals, often highly critically.

So, up to this time there were debates within the OR discipline but not such a clear fissure as is now evident. Having said that, at the first international conference in OR in 1957 there was a report in the Economist: “The American approach to operational research, as was evident at this week’s conference at Oxford, differs significantly from the British ...” [131]. After the 1970s OR in the U.S. moved inexorably to become, at least within universities and top journals, a primarily theoretical, applied mathematical endeavour. This has been documented in a series of publications within the U.S. itself, e.g., the Past Presidents’ Symposium papers in *Operations Research* during 1987 [132-134]; Corbett and van Wassenhove’s [135] “natural drift” of OR away from practice; Reisman and Kirschnick’s [136] analysis of the content of OR journals; Abbot’s [137] analysis of the development of professions that predicted OR/MS would inevitably become increasingly mathematical; and Geoffrion’s [138] analysis of the dispersal of and apathy towards OR groups in industry. Kirby [16] provides an interesting historical analysis of this period and argues that the U.S. did not follow the path of the UK for a complex of both cultural and economic reasons.

Moving to the situation today, my own view is represented in the cognitive map shown in Figure 1.

Figure 1 about here

At the centre of the Figure is the fact that currently the number of Soft OR publications in *Operations Research* and *Management Science* is low if not non-existent. This is both an

effect and a cause: it is the centre of several reinforcing loops that maintain the system as it is.

Loop A Publications: where a journal is known to publish in a particular area it attracts new submissions. Here, lack of previous publications discourages submissions.

Loop B Editorial policy: the choice is also affected by the editorial policy which discourages Soft OR publications. This is influenced by the view that Soft OR is not proper OR, which is reinforced by the lack of publications in top journals.

Loop C Soft OR unknown: submissions are also low because Soft OR work is rare in the U.S. because Soft OR is not well known, because it is not published.

Loop D Esteem: Soft OR is held in low esteem both because of the lack of publications and the “not proper OR” view which also leads to there being little Soft OR work.

Loop E Tenure/promotion: these are extremely important in the U.S. system and the lack of top publications and the low esteem mean that Soft OR is seen as hindering rather than helping.

Loop F Success in practice: Soft OR is very successful practically but because of the editorial policy about Soft OR in general and also seldom publishing application papers this is not known. If it were it would contribute to Soft OR being seen as “proper” OR. Writing up Soft OR cases is also harder as they require a greater degree of contextual information.

5.4 What Can Be Done?

Several things become clear from Figure 1. First, all the loops work in the same direction – maintaining the low status and low visibility of Soft OR. To change this something needs to be done from outside to break in to the loops and set them in the other direction. Second, the importance of publications in the top journals is clear for without this its status and validity will remain questionable. Third, some of the factors represented are more controllable than others, and these are the levers of control.

So, if one wants to change this system I would suggest two things: explicitly changing the editorial policy of both *Management Science* and *Operations Research* to include, and indeed encourage, high quality papers concerning Soft OR of both a theoretical and practical nature; and having INFORMS, as the premier OR Society also explicitly acknowledge the status and value of Soft OR. Taken together, with other initiatives such as encouraging conference streams and tutorials, Soft OR could become known and valued enough for it to gain a legitimate place within OR in the U.S..

There is a precedent for this within the discipline of information systems. For many years the situation was much the same with the top (U.S.) journals – *MIS Quarterly* and *Information Systems Research* – only publishing positivist, quantitative research whilst the rest of the world also produced good qualitative work. After a degree of debate and soul-searching, the value of qualitative research was recognized and certainly *MISQ* positively sought it, appointing qualitative editors and having special issues [139]. Although qualitative research is still in the minority in these journals, it is at least properly recognized within the discipline.

Another practical step would be to initiate a serious research program to evaluate the contribution of qualitative OR approaches to problem solving and decision making in complex situations. This would examine a range of real projects where soft, hard, combined, or indeed no decision-aiding methods were used to estimate the relative contribution of each

approach and the circumstances in which they are effective. Such a research program would itself be complex because of the difficulty of measuring success and then apportioning it to the methodology used [140].

The other aspect that I believe is crucial is OR education. There is a powerful argument that training young OR analysts only in (mathematical) techniques, without giving them an awareness of the realities of the organizational and management context, is doing them a huge disservice. Certainly this was true for me – I learnt more of practical importance in my first six months of work than I did in three years at university. Intelligent, numerate graduates can pick up extra mathematical techniques (given a basic grounding) relatively easily but they will not be prepared for the messiness of the real world unless they are guided towards it, and Soft OR is a good entry point.

6. Conclusions

The purpose of this paper has been to highlight an anomaly within the worldwide OR community. Over a period of forty years, a range of methods have been developed to tackle complex, wicked problems that the traditional, mathematically-based tools of OR are unable to deal with. Together, these methods form what is known as Soft OR. The paper has documented the extent to which these are both successful in practice and recognised within the academic literature such that we can say that Soft OR has come of age.

However, the anomaly arises because such methods are not well-known, at least under that term, around the world but are primarily restricted to the UK, and some UK-oriented countries, where they were almost all developed. There are, in fact, related methods, especially in the decision analysis area, and the paper discusses the extent to which they could or should be seen as belonging to the Soft OR camp. The conclusion is that several could well be included as Soft OR, especially MCDA, Keeney's value-focussed thinking, and Phillips decision conferencing, provided that the practitioners using them adhered to the principles of Soft OR.

The paper argues that it is of particular concern that Soft OR methods as such are virtually invisible within the US, being neither published in the main journals (except *Interfaces*) nor taught on OR/MS courses. The US is the largest country for operational researchers, and two American journals – *Management Science* and *Operations Research* – are the two leading world journals which claim to represent the whole OR community so to ignore Soft OR is unfortunate both for the OR discipline and for the practice of OR.

The final section of the paper explores different explanations or viewpoints as to why this situation might have arisen and suggests some courses of action to improve the situation. The purpose of the paper as a whole is to initiate and structure a debate within the OR community, especially in the U.S., to generate commitments for change. In fact, as mentioned, changes are occurring following the debate in *OR/MS Today* with a special issue in an INFORMS journal, and entries in the US-produced *Encyclopaedia of OR/MS*. Further positive steps might include: holding facilitated workshops at U.S. conferences to explore and debate these issues and hopefully agree some actions; to hold teaching sessions or master classes on PSMs also at US conferences; to keep up the pressure on US journals by submitting strong papers in which Soft OR is at least an element; pressing to get more UK academics on the editorial boards of the US journals, and demonstrating where ever possible the strength and power of soft methods for dealing with wicked problems.

Method	Description	Theoretical Underpinning	References
Strategic Assumption Surfacing and Testing (SAST)	Used to challenge deeply held assumptions by surfacing them and challenging them with their opposites	Churchman's dialectical approach	[141, 142]
Critical Systems Heuristics (CSH)	Used to challenge the boundaries drawn up to circumscribe the focus of planning or design	Churchman's dialectical approach Habermas's critical theory	[143, 144]
Hypergames, metagames, drama theory	Soft game theory used in situations of competition and conflict	Game theory	[145-148]
Robustness analysis	Used to decide on commitments now in the light of their robustness to uncertain futures.	Decision analysis, planning methodologies	[149]
Interactive planning	Used to assist participants design a desirable future for their organization and bring it about	Pragmatism, systems theory	[150-152]

Table 1 Other Soft OR and Problem Structuring Methods

Key-word Search Term	Soft Systems Methodology	Problem Structuring Methods	Cognitive Mapping/ SODA	Soft OR	Strategic Choice Approach	Critical Systems Thinking	Drama Theory, Hypergames, Metagames
Results in Web of Science	271	231	204	112	25	127	30
Results in Scopus	358	249	296	251	23	143	28
Results in Google Scholar	7200	1270	1310	1070	521	602	207

Table 2 Numbers of Occurrences of Key-Words in Search of Web of Science, Scopus and Google Scholar (October 2009)

Name	Institution	h-index	Max Cites
Zipkin	Duke University	28	364
Eden	Strathclyde University	28	230
Mingers	Kent University	28	252
Ackoff	Warton	27	455
Checkland	Lancaster University	25	2692
Simchi-Levi	MIT	23	379
Oren	Berkeley	22	131
Daskin	Northwestern	20	291
Jackson	Hull University	19	357
Hopp	Michigan University	18	799
West Churchman	Berkeley	17	379
Ackermann	Strathclyde University	16	133
Trick	Carnegie Mellon	16	127
Rosenhead	LSE London	15	298
Hazen	Northwestern	10	145

Table 3 Citation Measures for Selected Soft and Hard OR Academics (Soft in bold)
The h-index was calculated using Publish or Perish software available from <http://www.harzing.com/pop.htm>. Data was accessed during August 2007

Country	% of papers
England	49%
USA	12%
Australia	10%
Scotland	3%
New Zealand	3%
Japan	3%
Netherlands	2%
Brazil	2%
N. Ireland	2%
S. Africa	2%
India	2%
PR China	2%
Sweden	2%
Denmark	1%
Ireland	1%
Other	4%

Table 4 Country of Lead Author for the Web of Science papers in Table 2

Key-word Search Term	Soft Systems Methodology	Problem Structuring	Cognitive Mapping/SODA	Soft OR	Strategic Choice Approach	Critical Systems	Drama Theory, Hypergames, Metagames
JORS	34	55	13	98	4	18	7
EJOR	5	11	6	30	2	2	6
Interfaces	2	2	0	6	0	0	0
Operations Research	0	0	0	0	0	0	2
Management Science	0	0	0	0	0	0	0

Table 5 Numbers of Occurrences of Key-Words in Search of Web of Science for Particular Journals (August 2007)

	Checkland	Eden	Mingers	Ackoff	Churchman
JORS	192	180	149	82	70
EJOR	65	71	22	58	44
Interfaces	19	20	8	35	69
Operations Research	4	2	0	7	17
Management Science	2	0	0	52*	68*

Table 6 Citations of Soft OR Authors in Various Journals from Web of Science (August 2007)

***Includes citations in Management Science Series A and B which were discontinued in 1975**

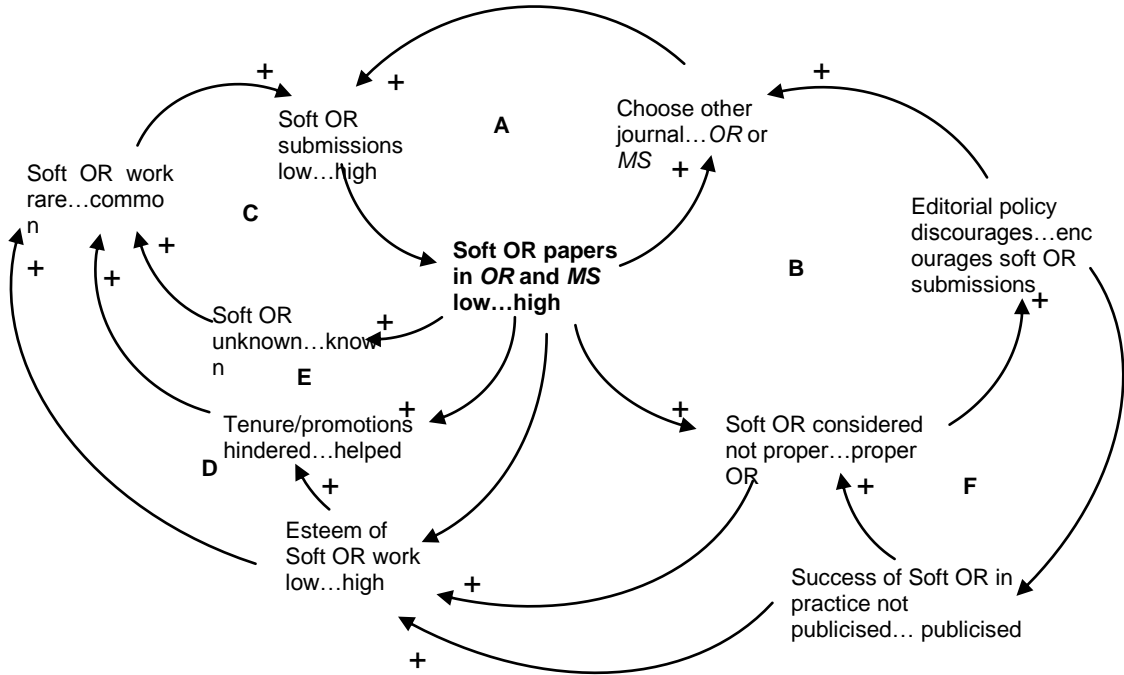


Figure 1 Cognitive Map showing the Feedback Loops Preventing Soft OR Publications in the U.S.

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