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Working Paper Series

Reaching the Problems that Traditional OR/MS Methods Cannot Reach

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Reaching the Problems that Traditional OR/MS Methods Cannot Reach

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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. 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). They have been accepted as an important part of OR everywhere except the United States which appears not to recognize them at all. This paper provides a brief history and overview of Soft OR and then demonstrates its success both in complex practical situations, and in the academic literature. It then documents the invisibility of Soft OR within the US before suggesting some reasons for that. It ends with some practical recommendations for actions which could begin to alleviate the problem. It is not suggested that Soft OR is an alternative for traditional, mathematical OR but, rather, a complement. The main purpose of the paper, within the OR Forum area, is to surface these concerns and initiate a debate which could lead to commitments to action. As such, it could itself be seen as an example of Soft OR.

Subject classifications: professional: journal policies, OR/MS education, OR/MS implementation, OR/MS philosophy

Area of review: OR Forum

I shall begin by describing four problematic situations which, I argue, are beyond the reach of the traditional, mathematical modeling methods of operations research. 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* or *problem structuring methods (PSMs)* and yet are very different from each other; and because they have been written up in reputable journals or books.

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" (Salford Community Trust 1998).

Whilst this may sound straightforward, on investigation it turned out to be complex and messy (Checkland and Winter 2006): there was no agreed definition of what a "service specification" was; there was no agreement about what services were to be include 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 (Bunch 2003). 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 behavior). 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 (Ormerod 1999). 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 (Horlick-Jones *et al.* 2001). 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”) which make the traditional mathematical modeling tools of OR ineffective (Brocklesby 1993; Rosenhead and Mingers 2001a). 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 or simulation could not be used.
- 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. It often involves facilitated workshops of concerned stakeholders.

These kind of complex and messy problem situations have long been recognized. Ackoff (1979a) termed them messes as opposed to problems; Rittel (1973) wicked as opposed to tame problems; Schon (1987) the swamp versus the high ground; Ravetz (1971) practical versus technical problems; and Checkland (2007) soft approaches as opposed to hard approaches. 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.

The argument that I will put forward in this paper is as follows:

- A variety of methods (sometimes called methodologies) have been developed to help tackle these messy strategic problems. They are not mathematical but they are nevertheless rigorous and they have been very successful in practice. Collectively they are known as “Soft OR”, “soft systems” or “problem structuring methods” (PSMs).
- Their general characteristics are (Rosenhead and Mingers 2001b): they allow a range of distinctive views and objectives without collapsing them into a single measure;

they encourage the active participation of stakeholders in the modeling process; models are generally non-quantitative and transparent to the participants; significant uncertainty is expected and tolerated; they aim for exploration, learning, and commitment rather than optimization.

- After some initial skepticism from the OR discipline they have now been fully accepted by both practitioners and academics throughout the world with the exception of the United States. Papers are published in highly reputable journals and they are included in OR Masters programmes.
- However, in the US Soft OR simply does not exist as far as major journals such as *Operations Research* and *Management Science*, and OR Masters, are concerned.
- This is an undesirable situation because it splits the discipline of OR into two, and because it denies US practitioners knowledge of these powerful methods which would help OR to “Venture Outside the OR Comfort Zone” as Brenda Dietrich (President of INFORMS) (Dietrich 2007) has recently urged.

My hope for the paper is that it generates an informed discussion and debate, carried out in a good spirit, which may lead to a healing of this unfortunate rift. **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 favor of combining hard and soft methods – see section 1.5 on multimethodology.**

1. The Development of Soft OR Methods

Limitations of traditional mathematical OR methods became apparent during the 1960s and 1970s. C. West Churchman, in an editorial in *Management Science* in 1967 (Churchman 1967), 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 (1977b; 1979a; 1979b) searing critiques of the development of OR up to 1979 are well known. And it was during this period that the main Soft OR methods were developed by academic/practitioners in response to practical engagements with real problems. The term “problem structuring” was used by Pidd and Woolley in 1980 (Pidd and Woolley 1980) and **there is debate about which is the most appropriate term. “Soft OR” is seen by many as having negative connotations within OR generally implying woolliness and lack of rigor while “PSM”, although accurate in part, suggests that the methods only structure problems whereas in fact they lead to action to alleviate or resolve them.**

In this section I will outline briefly the development of Soft OR methods and then demonstrate empirically their successful use in practice.

1.1 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 (Mingers 2000a). He saw his task as taking traditional, hard systems engineering methodologies, e.g., Hall (1962), and transforming them to be able to deal with the humanness of human beings, highlighting the importance of irrationality, creativity and values (Checkland 1970). The development of SSM has been well documented in three books (Checkland 1981b; Checkland and Scholes 1990; Checkland and Holwell 1998), the second of which (*SSM in Action*) is wholly concerned with applications of SSM. Checkland’s “short, definitive account” was published in 2006 (Checkland and Poulter 2006). Intellectually, SSM draws on the work of Churchman (1971) on dialectical inquiry; Vickers (1968) on social processes; and, more generally, interpretive sociology.

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.

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.

1.2 Cognitive Mapping and SODA

Colin Eden and colleagues have also spent many years developing methods particularly aimed at strategic decision making. This began with a technique, cognitive mapping (Eden, Jones, and Sims 1983), which became part of a more general approach, Strategic Options Development and Analysis (SODA) (Eden and Ackermann 2001), and eventually a whole approach to strategy known as JOURNEY Making (Eden and Ackerman 1998).

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 (1955). A cognitive map is a representation of a particular person’s judgments about a situation in terms of bipolar constructs, one term being seen positively and the other negatively. These are then connected together in terms of the presumed causal relations that hold between them. The result is not unlike an influence diagram or causal loop diagram although it is explicitly subjective and uses constructs rather than variables.

Cognitive mapping then became a key tool within a wider process of strategy creation as follows (see especially (Eden and Ackerman 1998, 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.

1.3 Strategic Choice Approach

The Strategic Choice Approach (SCA) was developed by John Friend and colleagues (2006) 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 (1977, originally published 1969) and Friend and Hickling (2004) (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.

1.4 Overview of Other Methods

There are many other Soft OR methods some of which are briefly summarized in Table 1.

Table 1 about here

Practical guides to many of these methods can be found in Jackson (2003) and Rosenhead and Mingers (2001b). It can be seen that many of these methods are particularly useful in strategic decision making and they are often combined with more traditional hard strategic approaches (O'Brien and Dyson 2007).

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. Examples are: qualitative system dynamics (Lane and Oliver 1998; Powell and Coyle 2005), MCDA (Belton and Stewart 2001; Mendoza and Martins 2006a), the viable systems model (VSM) (Harnden 1989) and mathematical modeling generally (Bryant 1988).

1.5 Critical Systems and Multimethodology

By the 1980s there were a whole range of Soft OR methods and a new question emerged – which method should be used when? At the same time a third paradigm within OR and Systems began to develop known as Critical Systems Thinking (CST) or Critical Management Science (Mingers 1980; Ulrich 1983; Mingers 1984; Jackson 1985; Mingers 1992). This drew on the work of both Churchman (1971; 1979) and the sociologist Habermas (1978) and revolved around two meanings of the term “critical”.

The first, following Kant (1933), was epistemological and was concerned with the nature and limits of knowledge, and investigated the assumptions and limitations of both traditional “Hard” OR, and the newer Soft OR. From this developed frameworks (Jackson 1989; Jackson 1990) and a meta-methodology (Flood and Jackson 1991) for choosing appropriate methods to use in a particular situation. The second was more political and debated the nature and role of OR within society as a whole (Jackson 1991; Jackson 1993; Mingers 2000c) following on from earlier concerns about the social responsibility of OR (Ackoff 1974b; Chesterton *et al.* 1975; Rosenhead and Thunhurst 1982).

The epistemological debate eventually moved from the question of selecting a single method to recognizing the value of combining together different methods, not just soft but especially employing both hard and soft methods together. This is known as multimethodology (Mingers and Gill 1997; Mingers 2000b; Nicholls, Clarke, and Lehaney 2001; Mingers 2006) or coherent pluralism (Midgley 1992; Jackson 1999). It is argued that this allows the practitioner to address both the quantitative and qualitative aspects of a complex situation and that different methods can better address the different phases of an intervention (Mackenzie *et al.* 2006). Some examples are: combining DEA and GSS (Casu, Shaw, and Thanassoulis 2005), MCDA with conflict analysis (Losa and Belton 2006), cognitive mapping with system dynamics (Ackerman, Eden, and Williams 1997), SSM and data mining (Brown, Cooper, and Pidd 2006) and simulation with SSM (Kotiadis and Mingers 2006).

2. 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 (1992) 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 (Ledington and Donaldson 1997) with similar results. In 2000, in a paper in *ITOR*, Mingers (2000b) carried out a literature search for published applications of Soft OR methods. This found 49 examples up till 1998.

In 2002 Munro and Mingers (2002) 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.

Finally, in 2007 van der Water *et al* (2007) 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 US – 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* and *Google Scholar* 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., “OR” in Soft OR, and “drama theory” and “cognitive mapping” are used in other disciplines. All searches where this might be the case included the term “operational research” to try and restrict the range. As would be expected, WoS numbers are much smaller as it only includes papers in those journals that are in the ISI database whereas *Scholar* has a much wider range of sources including books and conference papers. 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 (Mingers and Rosenhead 2004) 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 (Hirsch 2005) 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 (Hirsch 2005); US information scientists between 5 and 20 (Cronin and Meho 2006), and UK information scientists between 5 and 31 (Oppenheim 2007).

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 US 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 (Checkland 1981b).*

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

3. Soft OR in the United States

In this section of the paper I will show that Soft OR has been marginalized, if not completely ignored, within the OR community in the US, a situation that is unfortunate for both US OR practitioners and the discipline as a whole. I will then put forward some possible explanations for this, and the implications for trying to improve the situation.

Table 4 takes the keyword data from Table 2 and splits it by particular journals – *JORS* and *EJOR* together with three US 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*, a practice oriented journal of lower rank than the other two. 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 US.

Table 4 about here

With regard to editorial policy, I can point to the following. In 2006 the new Editor of *Operations Research* published in *OR/MS Today* (Simchi-Levy 2006) 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). So, if it is not mathematical it is not OR.

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.

Although papers may not be published, to what extent is the literature on Soft OR cited within these journals? Table 5 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 5 about here

We can see other evidence of the non-visibility of Soft OR. Searching the *INFORMS* website, for example, reveals only three mentions of Soft OR. One is to work by Richard Ormerod, a UK Soft OR practitioner/academic, whose work on IT strategy for Sainsbury's supermarket was short listed for the Edelman prize in 1995 (Ormerod 1996); one is to the design of an MBA course in Iceland; and the third is a career profile for someone who took their Masters in London. Apart from those, a resounding silence. In a recent article in *OR/MS Today*, Brenda Dietrich, the current president of *INFORMS*, wrote an article titled "Venture Outside the OR Comfort Zone" (Dietrich 2007) calling for OR to have a greater role within the world by tackling new and more complex problems such as the environment and health care. These are often just the kind of messy problems Soft OR deals with yet there was no mention of Soft OR, or problem structuring, in the whole article. Finally, we can consider the appearance of Soft OR on Masters Courses. An admittedly ad hoc search of US 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" (Kirby 2003, p. 1138). The same could be said for Soft OR in general.

4. Why is Soft OR Invisible in the US?

So far, this paper has shown that Soft OR is alive and very successful except in the US where it is virtually invisible. This section will explore possible reasons for this unhappy situation.

4.1 Soft OR is not Real OR

The first possible reason is simply a genuinely held belief, within the US, 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 (1980) scathing viewpoint about a case study (Eden and Jones 1980) 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-US 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” (Ackoff 1977b). There is not the space here to go over these arguments again but 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* (Kirby 2000; Kirby 2003). These, together with a selection of classic papers (Churchman and Schainblatt 1965; Churchman 1967; Churchman 1970; Bonder 1973; Dando, Defrenne, and Sharp 1977; Dando and Sharp 1978; Ackoff 1979a; Ackoff 1979b; Bonder 1979; Checkland 1981a; Checkland 1985; Eden 1989) should make the case more eloquently than I can.

In fact, the view that Soft OR is not real OR is actually official. As a referee 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” (INFORMS 2008).

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”.

If the referee (and INFORMS) want to *define* OR as the application of mathematical models then I cannot stop them, but I believe it to be very short-sighted, and to confuse 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, they did not just mechanistically apply mathematical models, witness Ackoff’s solution of

complaints about waiting time for a lift with the installation of mirrors (Ackoff 1962) rather than the use of queuing theory!

It has also been suggested to me that the term “soft” is very much against the American ethos:

“Our culture is so engrained with the physical. The measurable. The quantitative. And competitive ... If it can't be seen, touched, measured, ***and won*** it does not have meaning. The USA builds things. Cars, steel, plants, ships. Or at least that is the mythos and national psyche. ... When one says “soft” in the US – well the perception is that there is going to be navel gazing and silly feel-good seminars” (personal communication from a referee)

My own view is that Soft and Hard OR are not alternatives but are complements to each other (Mingers and Brocklesby 1997; Mingers 2000b; Mingers 2001). 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 although in my own personal experiences of real projects the non-quantifiable aspects often dominate.

4.2 Soft OR Happens in Other Disciplines

A variant or development of the above argument is that Soft OR does happen in the US 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” (Mitroff and Linstone 1993) 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 (Nelson 2003; Nelson and Stolterman 2003). Churchman's work in inquiring systems has also been used in developing information and knowledge management systems (Richardson, Courtney, and Paradise 2001; Richardson and Courtney 2004)

Cognitive mapping is used by John Bryson (1995; 2000; 2004), 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 (Bryson *et al.* 2004). Similarly, Richardson and Andersen (1997; 2006) use a range of soft techniques, especially cognitive mapping, in generating mental models for system dynamics. Cognitive mapping is also used in other management areas such as strategy and organization studies (Barr, Stimpert, and Huff 1992; Fiol and Huff 1992; Reger and Huff 1993; Boland, Tenkasi, and Teeni 1994; Reger and Palmer 1996; Carley 1997; Acar and Druckenmiller 2006) and information systems (Lee, Courtney, and O'Keefe 1992; Massey and Wallace 1996; Nelson *et al.* 2000; Tegarden and Sheetz 2001; Conklin 2005; Siau and Tan 2006; Johnson and Lipp 2007)

Soft systems methodology too has its adherents, especially within information systems (Hirschheim and Klein 1994; Baskerville and Stage 1996; Kettinger, Teng, and Guha 1997; Iivari, Hirschheim, and Klein 1998; Ravichandran and Rai 2000; Baskerville and Myers 2002; Markus, Majchrzak, and Gasser 2002; Den Hengst and De Vreede 2004; Iversen, Mathiassen, and Nielsen 2004; Fruhling and De Vreede 2006) but also in ecology/environment (Daniels, Lawrence, and Alig 1996; Walker *et al.* 2002; Mendoza and Martins 2006b; Young *et al.* 2006) and health (Rosenfield and Rubinson 1985; Buckeridge *et al.* 2002; Cassidy *et al.* 2006; Suarez-Balcazar *et al.* 2007).

What this shows is that many US 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*, *MISQ* and *Strategic Management Journal*. If these people find Soft OR valuable should not OR people?

4.3 OR Modelers Deal with Soft Factors Anyway

It may be said that experienced mathematical modelers are well aware of soft factors and work on resolving these as part of their approach. We can look, for example, at the area of decision analysis where at least some workers recognize the complex, pluralistic nature of difficult decisions. Ralph Keeney is one who has developed an approach he calls value-focused thinking (Keeney 1992). In an application in British Columbia Gas (Keeney 1999) 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 (Clemen 1996) has chapters on structuring decisions (e.g., using a form of influence diagram) and on conflicting objectives.

To the extent that this is true then I welcome it. Indeed, given the argument of this paper that complex problems always involve a range of non-quantitative elements it could not really be otherwise. But this is in fact an argument in favor of Soft OR methods not against them for they are well-proven tools that can be used precisely to help out with these aspects of an intervention. Rather than dismiss them, embrace them.

Considering the BC 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 hard 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 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?

4.4 The US has Other Soft OR Methods

An alternative view might be that OR in the US has its own soft methods that are different to the traditional ones discussed above. The most likely candidate here is Saaty’s Analytic Hierarchy Process (AHP) (Saaty 1980). 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) (Smith and von Winterfeldt 2004; Banuelas and Antony 2007). Another one might be the Theory of Constraints (TOC), an application of which won the Edelman Award in 2006 (Srinivasan, Best, and Chandrasekaran 2007), but here I will consider AHP.

Why might it be considered as a soft method? Forman and Gass (2001) 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 (Vargas 1990).

However, whilst AHP may well be useful in unstructured situations, I would argue that it is not properly a Soft OR method. Certainly US academics put it squarely within the traditional decision analysis camp (Forman and Gass 2001; Smith and von Winterfeldt 2004) and Banuelas and Antony (2007, 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.

4.5 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 US. 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 (Kirby 2000) 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* (Churchman and Schainblatt 1965; Churchman 1967; Churchman 1970; Ackoff 1971; Ackoff 1973; Ackoff 1977a) 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 US, 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. After the 1970s OR in the US moved inexorably to become, at least within universities and top journals, a primarily theoretical, applied mathematical endeavor. This has been documented in a series of publications within the US itself, e.g., the Past Presidents’ Symposium papers in *Operations Research* during 1987 (Borsting 1987; Miser 1987; Pierskalla 1987); Corbett and van Wassenhove’s (1993) “natural drift” of OR away from practice; Reisman and Kirschnick’s (1994) analysis of the content of OR journals; Abbot’s (1988) analysis of the development of professions that predicted OR/MS would inevitably become increasingly mathematical; and Geoffrion’s (1992) analysis of the dispersal of and apathy towards OR groups in industry. Kirby (2007) provides an interesting historical

analysis of this period and argues that the US 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 center 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 center 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 US 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 US 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. 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 US.

There is a precedent for this within the discipline of information systems. For many years the situation was much the same with the top (US) 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 (Introna 2001). 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 (White 2006).

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 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

In the first three sections of this paper I outlined a problematic situation: Soft OR has developed as a very successful part of the OR discipline, helping to deal with messy and wicked problems in a rigorous way. In most parts of the world it is fully accepted in both journals and courses. However, this is not the case in the US where it is, to all intents and purposes, invisible being neither published in the main journals nor taught on OR/MS courses. The view put forward in the paper is that this is unfortunate both for the OR discipline and for the practice of OR in the US. Section 4 explored different explanations or viewpoints as to why this situation might have arisen and suggested 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 US, to generate commitments for change.

Described in this way, the paper has clear similarities to the Soft OR approach itself. Indeed, I would go so far as to claim that it has been carried out in the spirit if not the letter of such a method. One difference is that it has been carried out at a distance, not involving significant participants. A positive step might therefore be to hold a facilitated workshop, at a US conference, to explore and debate these issues and hopefully agree some actions.

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	(Mason 1969; Mason and Mitroff 1981)
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	(Ulrich 1983; Ulrich 2000)
Hypergames, metagames, drama theory	Soft game theory used in situations of competition and conflict	Game theory	(Howard 1971; Bennett 1977; Howard 1994; Bennett, Bryant, and Howard 2001)
Robustness analysis	Used to decide on commitments now in the light of their robustness to uncertain futures.	Decision analysis, planning methodologies	(Rosenhead 2001)
Interactive planning	Used to assist participants design a desirable future for their organization and bring it about	Pragmatism, systems theory	(Ackoff 1974a; Ackoff 1981b; Ackoff 1981a)
Theory of Constraints	Used to identify a common or core factor underlying problems through structured discussion	Operations management	(Rizzo 2001; Mabin and Balderstone 2003; Mabin, Davies, and Balderstone 2005)

Table 1 Other Soft OR and Problem Structuring Methods

Key-word Search Term	Soft Systems Methodology	Problem Structuring	Cognitive Mapping/SODA	Soft OR	Strategic Choice Approach	Critical Systems	Drama Theory, Hypergames, Metagames
Results in Web of Science	186	122	93	80	21	18	45
Results in Google Scholar	4680	1170	844	670	254	224	175

Table 2 Numbers of Occurrences of Key-Words in Search of Web of Science and Google Scholar (August 2007)

Name	Institution	h-index	Max Cites
Zipchin	Duke University	29	364
Eden	Strathclyde University	28	230
Mingers	Kent University	28	252
Ackoff	Warton	27	455
Checkland	Lancaster University	26	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	14	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>. It was accessed during August 2007

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 4 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 5 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**

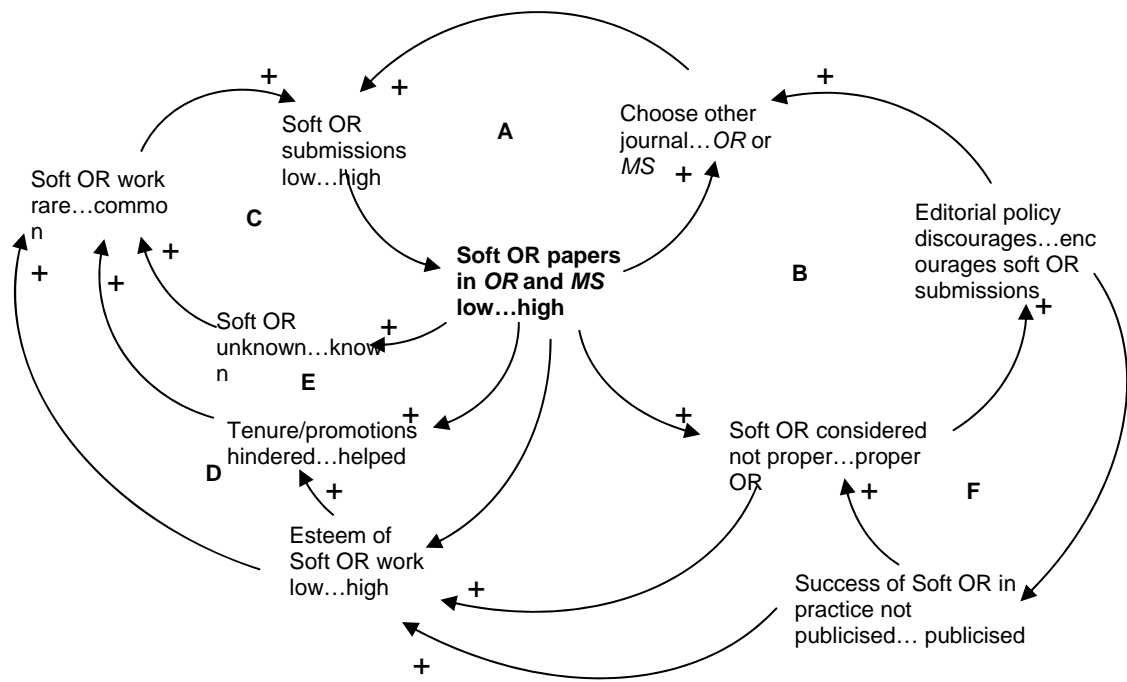


Figure 1 Cognitive Map of Soft OR Publications in the US

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