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Abstract

The use of Problem Structuring Methods (PSMs) to address wicked problems (Rittel and Webber, Churchman), messes (Ackoff), swamps (Rosenhead), in a plural/complex context (Jackson) tends to go without question within the OR community. However, what other methodologies exist in sources outside the systems/PSM/Soft OR corpus that address the same type of problems and what might this say about their nature, their ontology? We approach this question through the use of citation analysis and present some details of alternative methodological approaches from different traditions. At the very least these suggest promising avenues for conversations to share experience by scholars and practitioners alike but also to prompt a re-evaluation of the scope of applicability of PSMs.

The Construction of Wicked Problems

Prof. Mike Yearworth & Prof. Leroy White
University of Exeter Business School, UK

IFORS 2021 Session WF-11
Wednesday, 25th August 2021 18:00-19:40 - Room 11

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Hello, My name is Professor Mike Yearworth, professor of management science at the University of Exeter business school in the UK I am presenting work with my colleague Professor Leroy White on the construction of wicked problems

Objectives

- Soft OR/PSMS (aka SORPS)
  - Grounded in questions about 'classical' problem formulation in OR based on Rittel & Weber, Ackoff, Schön, Checkland,… and as summarised by Rosenhead & Mingers (2001)
- The questions of problem formulation for Soft OR/PSMS have largely been taken for granted
  - Should we?
  - Do other research traditions?
- Is there agreement on an ontological basis for wicked (messy, swampy…) problems that would suggest a broader science of intervention (i.e. beyond OR scholars' concerns)?

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The classic introduction to Soft OR and Problem Structuring Methods (also called SORPS by some researchers) is Jonathan Rosenhead's edited volume Rational Analysis for a Problematic World published in 1989. A second edition was published in 2001 with additional editorial input from John Mingers. The rationale for the volume was…

We think it is reasonable to state that the question of problem formulation has remained fairly static and unexamined since then – perhaps we have taken for granted that there is a defined class of problems that we call variously wicked, messy, or swampy… and identification of such problem contexts then indicates the use of problem structuring methods. However, has that led to a divergence between the Soft OR/PSMs community and the rest of the OR – what we refer to as Hard OR. So rather than Ackoff's plea that the future of OR is past, as he wrote in 1979 in JORS, perhaps the issue facing scholars and practitioners alike was divergence. I want to tackle this issue by trying to establish whether there is sufficient solid ground under the notion of wicked, messy, or swampy problems, some sort of agreement that there is an ontology of such, that would suggest a broader science of intervention that exists beyond the concerns of OR scholars?

'Classic' OR – Problem Formulation

"Both the consumer's and the researchers' problem must be formulated. The research consumer is the person (or group) who controls the operations under study. (He is also referred to as the decision-maker.) In formulating the consumer's problem an analysis must be made of the system under his control, his objectives, and alternative courses of action. Others affected by the decisions under study must be identified and their pertinent objectives and courses of action must also be uncovered. What we have called the over-all viewpoint is closely connected with the attempt to define objectives. O.R. tries to take into account as broad a scope of objectives as possible. In most general terms, the research problem is to determine which alternative course of action is most effective relative to the set of pertinent objectives. Consequently, in formulating the research problem a measure of effectiveness must be specified and its suitability must be established."

Churchman, C.W., Ackoff, R.L., & Arnoff, E.L. (1957). *Introduction to Operations Research*. New York: John Wiley & Sons.

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To provide some background we think it is useful to go back to some early definitions of problem formulation in Operational Research. This is from Churchman, Ackoff and Arnoff in 1957 in their classic textbook Introduction to Operations Management. I wanted a baseline from which to work but was quite surprised on re-reading this definition to see the phrase "Others affected by the decisions under study must be identified and their pertinent objectives and courses of action must also be uncovered" and also that an "overall viewpoint" has been defined. It seems that any serious attempt to engage with this definition of problem formulation would, if the problem was sufficiently complex, have run into the reality of competing objectives, or differing viewpoints on the problem. Of course, this approach problem formulation clearly spells out that there will be alternative courses of action and the effectiveness of the action taken will be measured relative to a set of pertinent objectives, not a single one. It assumes that different courses of action can be specified and the "best" one chosen.

Soft Systems – Problem Formulation

"3.3 The thinking embodied in 'systems engineering' and 'systems analysis' is essentially the same. Analysis of many different accounts of these activities shows that they all assume that problems can be formulated as the making of a choice between alternative means of achieving a known end. The belief that real-world problems can be formulated in this way is the distinguishing characteristic of all 'hard' systems thinking."

Checkland, P. (1981). Systems thinking, systems practice. Chichester: John Wiley.

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If we fast forward to 1981 we get to Checkland's problem formulation for soft systems. He is of course pointing out the deficiencies of systems engineering and systems analysis, as they were conceived in the 1960s and 1970s, when applied to the complex problems of business and management that the consulting engagements undertaken by the team at the University Lancaster. However, his critique of systems engineering and systems analysis, expressed in the "arguments of the Book" section in "Systems Thinking, Systems Practice" is interesting precisely because it echoes the Churchman, Ackoff and Arnoff problem formulation. Making choices between alternative means of achieving known ends. Whilst his argument is not directed at OR, but it was nonetheless relevant to OR at the time in that it shared a similar objectivity in viewpoint to systems engineering and systems analysis - this is of course prior to the emergence of Soft OR and PSMs.

Soft Systems – Problem Formulation

"3.4 The success of systems engineering and systems analysis led to many attempts to use the concepts in problems of social systems, including those of formulating public policy. It was not always noticed that these problems could not necessarily be formulated as hard problems in the sense defined above (3.3). The results were on the whole disappointing, and this in turn led to polemic criticism of the whole idea of making the transfer."

Checkland, P. (1981). Systems thinking, systems practice. Chichester: John Wiley.

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Checkland's argument for the need for a soft systems problem formulation was a direct result of the failure of systems engineering and systems analysis to deal complex problems encompassing social systems and dealing with public policy. The polemic he refers to here is one of criticism of these "hard" methods and their failure to work, or more kindly – their disappointing outcomes, when used in these complex problem contexts.

Soft Systems – Problem Formulation

"3.5 The research described in Chapters 6 and 7 assumed that the concept of a human activity system would be relevant to tackling the 'soft' ill-structured problems of the real world, those before which the methodology of natural science is impotent. The idea was to apply one of the versions of hard systems thinking to real-world situations in which the actors perceived they had problems, in order to find out whether, why, and how the hard methodology was inadequate. The intention was to find a systems methodology for tackling problems which defy formulation in the hard sense, and also to enrich the concept human activity system in order to understand better the 'social systems' of the real world."

Checkland, P. (1981). Systems thinking, systems practice. Chichester: John Wiley.

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The remainder of Checkland's argument is to set out the discovery of a systems methodology for tackling problems that defy formulation in the hard sense. The means to tackle soft, 'ill-structured' problems. The epistemological framing is quite clear here - the difficulty exists in structuring the problem.

Rational Analysis for a Problematic World Revisited

- Posed problem characterisation through dichotomies that influence formulation
  - Wicked Problems vs Tame Problems
    - Rittel, H.W.J., & Webber, M.M. (1973). Dilemmas in a general theory of planning. Policy Sciences, 4(2), pp.155-169. doi: https://doi.org/10.1007/BF01405730
  - Messes vs Problems
    - e.g. Ackoff, R.L. (1981). The Art And Science Of Mess Management. Interfaces, 11(1), pp.20-26.
  - Swamp vs High Ground
    - e.g. Schön, D.A. (1987). Educating the reflective practitioner. San Francisco, CA: Jossey-Bass.
  - Soft Systems Thinking vs Hard Systems Thinking
    - e.g. Checkland, P. (1981). Systems thinking, systems practice. Chichester: John Wiley.

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Returning to Rational Analysis for a Problematic World – Revisited – Rosenhead and Mingers set out their rationale for a methodological approach to intervention in complex problem contexts as a set of dichotomies – Rittel and Webber's Wicked versus Tame problems as set out in their paper on the dilemmas in a general theory of planning in 1973. Ackoff's own articulation of Messes versus just problems in his Art and Science of Mess Management; Donald Schön's swamp versus high ground, which was latter written about by Rosenhead. And, as just reviewed, Checkland's problem formulation that sets out the difference between hard systems thinking and soft systems thinking. The implication from this positioning in rational analysis was that wicked, messy, swampy, soft were all of a similar character, all related, and that if the hard analytical methods of OR (similarly to systems engineering and systems analysis) were used in these contexts it would lead to failure – or at least quotes 'disappointing outcomes'. However, has this dichotomous thinking become entrenched in the field of Soft OR and PSMs?

Other Constructions

- Complexity science, knowledge management and organisational narratives (Cynefin framework)
  - Kurtz, C.F., & Snowden, D.J. (2003). The new dynamics of strategy: Sense-making in a complex and complicated world. *IBM Systems Journal, 42*(3), pp.462-483. doi: https://doi.org/10.1147/sj.423.0462
- Actor Network Theory (ANT) and Science and Technology Studies
  - Callon, M. (1981). Struggles and Negotiations to Define What is Problematic and What is Not. In K. D. Knorr, R. Krohn & R. Whitley (Eds.), *The Social Process of Scientific Investigation* (pp. 197-219). Dordrecht: Springer Netherlands. doi: https://doi.org/10.1007/978-94-009-9109-5_8
  - Callon, M., Lascoumes, P., & Barthe, Y. (2009). *Acting in an uncertain world : an essay on technical democracy*. Cambridge, Mass. ; London: MIT.

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Looking outside OR there are some examples and traditions of characterising complex problems and problem formulation that I know about from reading and teaching. The first is the Cynefin framework published in the IBM systems journal by Cynthia Kurtz and David Snowden and grounded in complexity science, knowledge management and organisational narratives around complexity. The second is Actor Network Theory and its position within science and technology studies. I think Cynefin is less well known in the OR field but was discussed in Mike Jacksons latest textbook "critical systems thinking and the management of complexity". ANT was brough to the attention of OR scholars by Paul Keys and then more recently by Leroy White and then myself with Leroy. Using these two sources combined with the sources mentioned previously from rational analysis I have carried out some preliminary co-citation of keyword analysis in the articles that cite them.

Set	Description	Article Count	Count of citations of texts						
			Wicked[1] Tame	Messes[2] Problems	Swamp[3] High Ground	Soft[4] Hard	Cynefin[5]	Callon[6]	Problem Formulation
R ∩ P	SORPs in OR journals	542	65	35 (23+12)	16 (14+2)	13	5	16 (0+4+12)	31 (5.7%)
R' ∩ P	SORPs outside OR journals	1,509	139	24 (16+6)	25 (24+1)	11	10	9 (0+1+8)	69 (4.6%)
A-W	All citing articles of Wicked...	7449[§]	-	15 (13+2)	60 (57+3)	5	18	23 (1+6+16)	100 (1.3%)
A-M	All citing articles of Messes...	77[±]	9	-	4 (4+0)	3	9	0	8 (10.4%)
A-S	All citing articles of Swamp...	48[&]	10	6 (6+0)	-	1	1	2 (0+1+1)	2 (4.2%)
K	All citing articles of Kurtz & Snowden	649	61	4 (3+1)	5 (5+0)	1	-	1 (0+0+1)	3 (0.5%)
C	All citing articles of Callon	684[*]	7	0	2 (2+0)	0	1	-	16 (2.3%)

[1] cites of "Dilemmas in a general theory of planning"
[2] cites of either "The Art and Science Of Mess Management" or "Optimization + objectivity = opt out"
[3] cites of either "Educating the reflective practitioner" or "Into the Swamp - The Analysis of Social-Issues"
[4] cites " "Classic" OR and "soft" OR - an asymmetric complementarity"
[5] cites of "The new dynamics of strategy: Sense-making in a complex and complicated world"
[6] cites of "Struggles and Negotiations to Define What is Problematic and What is Not" or "Acting in an uncertain world: an essay on technical democracy" or "Some elements of a sociology of translation: Domestication of the scallops and the fishermen of St Brieuc Bay"
[§] Only top 2000 highest cited analysed (Scopus limit)
[±] Note that the INFORMS article is not indexed by Scopus
[&] Note that "Educating the reflective practitioner" is not indexed in Scopus
[*] Note that only "Some elements of a sociology of translation..." in the Sociological Review is indexed in Scopus

We have embarked on a detailed co-citation analysis of articles about problem structuring and problem formulation based on the sources mentioned. However, these analyses are ongoing and in the interests of time I will skim over this table and get to the preliminary summary of findings...

Summary

- Problem formulation articles are not highly cited
- Reject further analysis of Kurtz & Snowden's Cynefin framework as there is little reference to problem formulation in citing works
- Ackoff, in calling attention to 'Opt Out' and 'Future of OR is past', signalled a worrying direction of travel for OR
- Rosenhead, in Rational Analysis…, framed problem formulation dichotomously and set the path of PSM development with this viewpoint

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One thing was immediately clear - Problem formulation articles are not highly cited – although Soft OR and PSM papers, as expected, make the most reference. On the whole, we think it is reasonable to state that Publications are probably skewed toward methodological contributions, with less of a focus on theories or categorisation of types of problem context.

From our preliminary analysis we can also exclude further analysis of the Cynefin framework as there is little reference to problem formulation in the citing works even though it is a useful sense-making device. Ackoff, in calling attention to 'Opt Out', and the future of OR is past signalled a worrying direction of travel for OR. In framing problem formulation dichotomously in Rational Analysis Rosenhead perhaps set the path of PSM development in such a way as to adhere too rigidly to the dichotomies. We believe this adherence to a dichotomous framing in OR has both positive and negative consequences…

Consequences of dichotomous framing

- Examples of Ontological Errors/Category Mistakes
  - Declaring that it is possible to solve or cure a wicked problem – there are no 'solutions', 'cures'… [Rittel & Webber]
  - Assuming to possess an objective viewpoint and thus know what is e.g. optimal, best, right, smart, … [Checkland]
  - Misrepresenting or ignoring plurality e.g. "The public…" [Checkland]
- Fallacy of Composition
  - Solving the solvable part of the problem solves the whole problem – is false [Ackoff]

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We see positive consequences in terms of a number of strong assertions we can make. The first set of assertions can be thought of as relating to possible category mistakes or ontological errors. For example, A Declaration or assertion that it is possible to solve or cure a wicked problem is a category mistake or ontological error and arises directly from Rittel and Webber - within this framing there can be no 'solutions' or 'cures' to wicked problems. In Another example, Assuming to possess an objective viewpoint and thus know what is e.g. optimal, best, right, smart, is another category mistake and arises from Checkland's rejection of the existence of a single objective viewpoint, Similarly to reject or ignore plurality is also a category mistake. There is also the fallacy of composition - which can be seen when we consider Ackoff's opt out paper. Believing that Solving the solvable part of the problem solves the whole problem falls for the fallacy of composition. Whilst these statements are true in this dichotomous framing of complex problems - what if this framing is suspect and has negative consequences? At a recent OR Society PSM Special Interest Group meeting there were some quite clear opinions expressed by both scholars and practitioners that problems should not be framed dichotomously. We should in fact see problems as wholes and not separable. A good example of this has been put forward by Simon French in his recent JORS paper. This leads us back to considering Callon's work in Actor Network theory

More on Callon and Problematisation

- Callon draws our focus to the simultaneity of perspectives and that problematisation (problem formulation) must deal with problematic situations that are *simultaneously* problematic i.e. wicked *and* tame, hard *and* soft, swamps *and* high ground… not a position on a continuum or at either end. → "an abundance of problematisations" (Callon, 1981)
- Callon proposes a general structure of problematisations
    1. A frontier emerges between what is analysed and what is suppressed, forming a closed domain with its own coherence and logic; a division between the property of the scientist (analyst) and what is left for outsiders
    2. A second frontier emerges between what is intangible, taken for granted, and what is problematised or unknown
- "Problematisation culminates in configurations characterised by their relative singularity. There is not *one* single way of defining problems, identifying and organising what is certain, repressing what cannot be analysed"
- Each problematisation leads to a problematic situation with specific demarcations – the un-analysed, the network of certainties, and the area of suspicion

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Callon very specifically draws our focus to the simultaneity of perspectives and that problematisation (problem formulation) must deal with problematic situations that are *simultaneously* problematic i.e. wicked *and* tame, hard *and* soft, swamps *and* high ground… not a position on a continuum or at either end. Leading as he says in his work to an "an abundance of problematisations".

Callon proposes a general structure of problematisations
1. A frontier emerges between what is analysed and what is suppressed, forming a closed domain with its own coherence and logic; a division between the property of the scientist (analyst) and what is left for outsiders
2. A second frontier emerges between what is intangible, taken for granted, and what is problematised or unknown

"Problematisation culminates in configurations characterised by their relative singularity. There is not *one* single way of defining problems, identifying and organising what is certain, repressing what cannot be analysed"
Each problematisation leads to a problematic situation with specific demarcations – the un-analysed, the network of certainties, and the area of suspicion

What Callon is articulating is a "Description of mechanisms through which reality is problematised" what he goes on to describe as the "Forces of problematisation'" and the "Analysis of the relationships various forces of problematisation"
This Switches focus from problem categorisation to observation and analysis of the 'forces of problematisation' → "problematic situation is a dual process of construction and de-construction"

Conclusions

- This suggests Actor Network Theory (ANT) provides us with (all?) the theoretical (common) ground we need for a broader science of intervention that encompasses OR Practice
- Keys and then White (and others) have been advocating for this position – these are not new conclusions
- We propose that more attention needs to be paid to these ideas of problematisation from Actor Network Theory with a view to dismantling the dichotomisation of problem formulation in OR and attempt to re-unify Soft and Hard OR.

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This suggests Actor Network Theory (ANT) provides us with perhaps all? the theoretical (common) ground we need for a broader science of intervention that encompasses OR Practice

Keys and then White (and others) have been advocating for this position. However, these are not new conclusions

What are the ways forward for this work? Our final conclusion is that We propose more attention needs to be paid to these ideas of problematisation from Actor Network Theory with a view to dismantling the dichotomisation of problem formulation in OR and attempt to re-unify Soft and Hard OR. There is a wider agenda to be pursued in management scholarship where what we know about problematisation, problem structuring and design of intervention methods for dealing with complex problems might be foregrounded in new, and perhaps more acceptable ways, using Actor Network Theory.

Any Questions?

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Research Questions

1. Is there an agreed categorisation for wicked/messy/swampy/soft problems? Are such problems real enough for agreement about problem formulation across OR?
2. Do other research traditions define a similar class of problems (even if not called as such)?
3. If there is a meaningful shared categorisation, what can we say about the science of intervention in such problem contexts?

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Re-formulating these objectives as a set of research questions we have
1. Is there an agreed categorisation for wicked/messy/swampy/soft problems? Are such problems real enough for agreement about problem formulation across OR?
2. Do other research traditions define a similar class of problems (even if not called as such)?
3. If there is a meaningful shared categorisation, what can we say about the science of intervention in such problem contexts?

RIS Data Sets (including references)

1. All articles in OR Journals likely to publish on Soft OR/PSMs – **R** {49,587 Documents}
2. All articles in any journals that mention ("Problem structuring method*" OR "Soft Operation* research") – **S** {2,051 Documents}
3. **R∩P** {542 Documents}
4. **R'∩P** {1,509 Documents}
5. All citing articles of Rittel & Webber– **A-W** {7,449 Documents} [note only top 2000 highest cited analysed]
6. All citing articles of Messes – **A-M** {77 Documents}
7. All citing articles of "Into the swamp" – **A-S** {48 Documents}
8. All citing articles of Kurtz & Snowden – **K** {649 Documents}
9. All citing documents of Callon's "Some elements…" – **C** {684 Documents}

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I generated a number of data sets based on queries to Scopus.
Set 1 is basically All articles in the OR Journals likely to publish on Soft OR/PSMs – which I call set R and consists of 49,587 Documents
Set 2 is all articles that mention "Problem structuring methods*" OR "Soft Operational research", which yields a set of 2,051 documents
Set 3 is the intersection of set 1 with set 2 and this generates a set with 542 Documents
 R∩P {542 Documents}
 Set 4 is just all the articles on PSMs/Soft OR that are outside OR journal, of which there are 1,509 Documents
And then I have all the citing articles of
All citing articles of Rittel & Webber– **A-W** {7,449 Documents} [note only top 2000 highest cited analysed]
All citing articles of Messes – **A-M** {77 Documents}
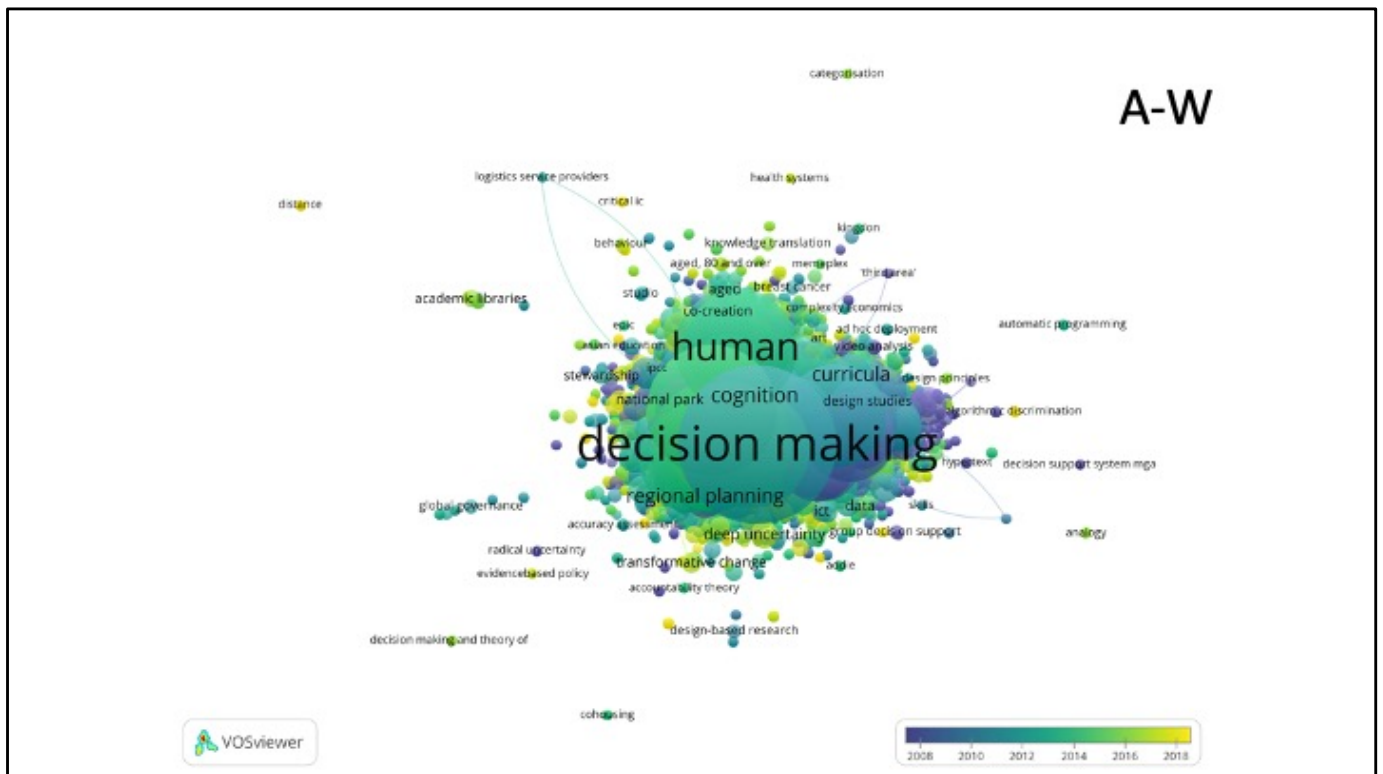All citing articles of "Into the swamp" – **A-S** {48 Documents}
All citing articles of Kurtz & Snowden – **K** {649 Documents}
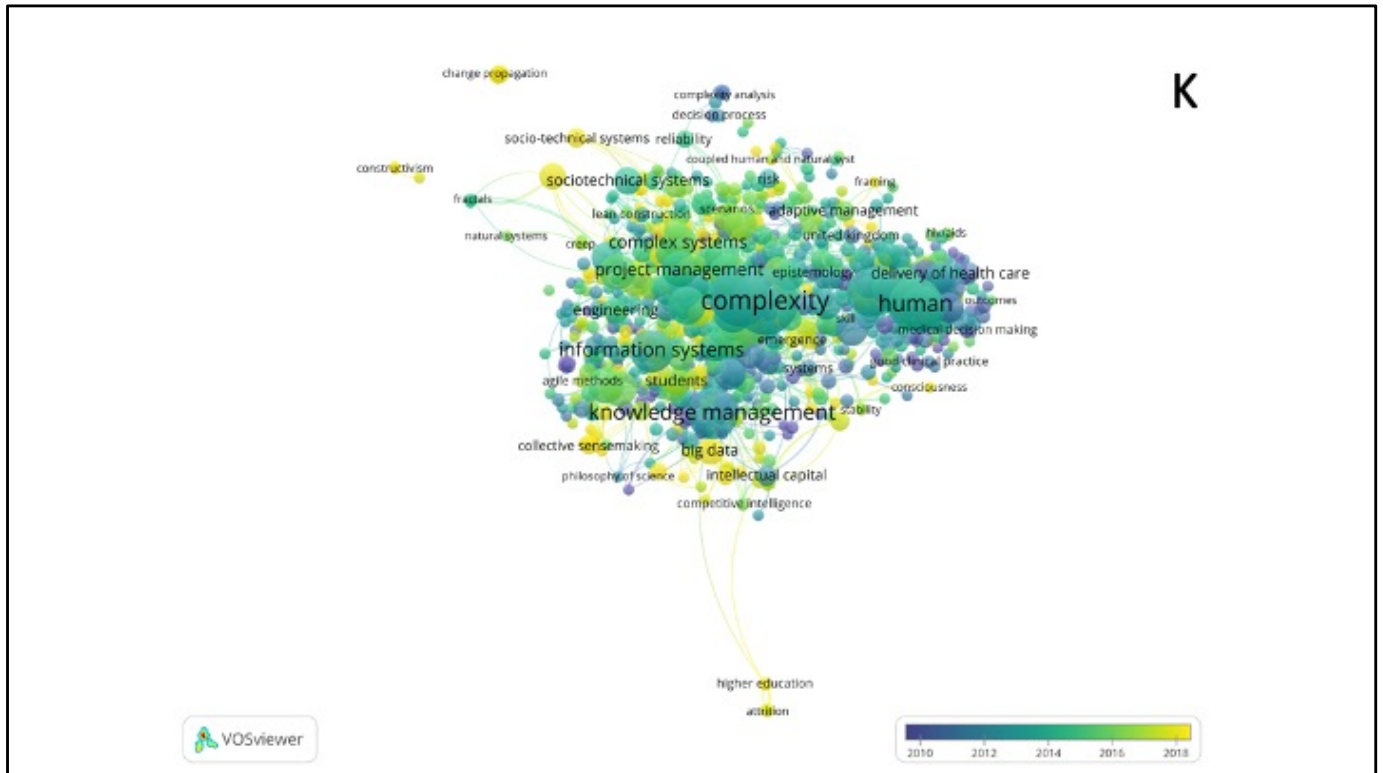All citing documents of Callon's "Some elements " – **C** {684 Documents}

Sets 1 to 4 are in the realm of what I know about, or might reasonably be expected to know about as a researcher in the field of Soft OR and PSMs. However, sets 5 to 7 are exploratory and designed to look at keywords of articles that cite these sources.

|		Article Count	Wicked/ Tame	Messes/ Problems	Swamp/ High Ground	Soft/ Hard	Cynefin	Callon	Problem Formulation
R ∩ P	SORPs in OR journals	542	12.0%	6.5%	3.0%	2.4%	0.9%	3.0%	5.7%
R' ∩ P	SORPs outside OR journals	1,509	9.2%	1.6%	1.7%	0.7%	0.7%	0.6%	4.6%
A-W	All citing articles of Wicked...	7449		0.2%	0.8%	0.1%	0.2%	0.3%	1.3%
A-M	All citing articles of Messes...	77	11.7%		5.2%	3.9%	11.7%	0.0%	10.4%
A-S	All citing articles of Swamp...	48	20.8%	12.5%		2.1%	2.1%	4.2%	4.2%
K	All citing articles of Kurtz & Snowden	649	9.4%	0.6%	0.8%	0.2%		0.2%	0.5%
C	All citing articles of Callon	684	1.0%	0.0%	0.3%	0.0%	0.1%		2.3%

This is shown in this modification of the previous table where the rows have been normalised to article count, expressed as percentages, and the whole table shaded from highest (in orange) to lowest with no shading. Its clear that citations of Rittell and Webber's work dominate these data. But there are some interesting relationships to be explored between Wicked and Messy problem formulation and both Swamps and messes. However, most of these counts are quite low and there isn't much to be gleaned from the citations of the Cynefin framework and Callon's work and their relation to most of the other complex problem formulation works, apart from Rittel and Webber in the case of Cynefin.

Co-citation of keyword analysis has also commenced using VOSviewer but as yet there is little to conclude apart from the prevalence of decision making as the most frequent keyword in Sets 3

Set 4

And Set 5

The keyword co-citation analysis of the Cynefin framework citations are all firmly rooted in Complexity, not decision making
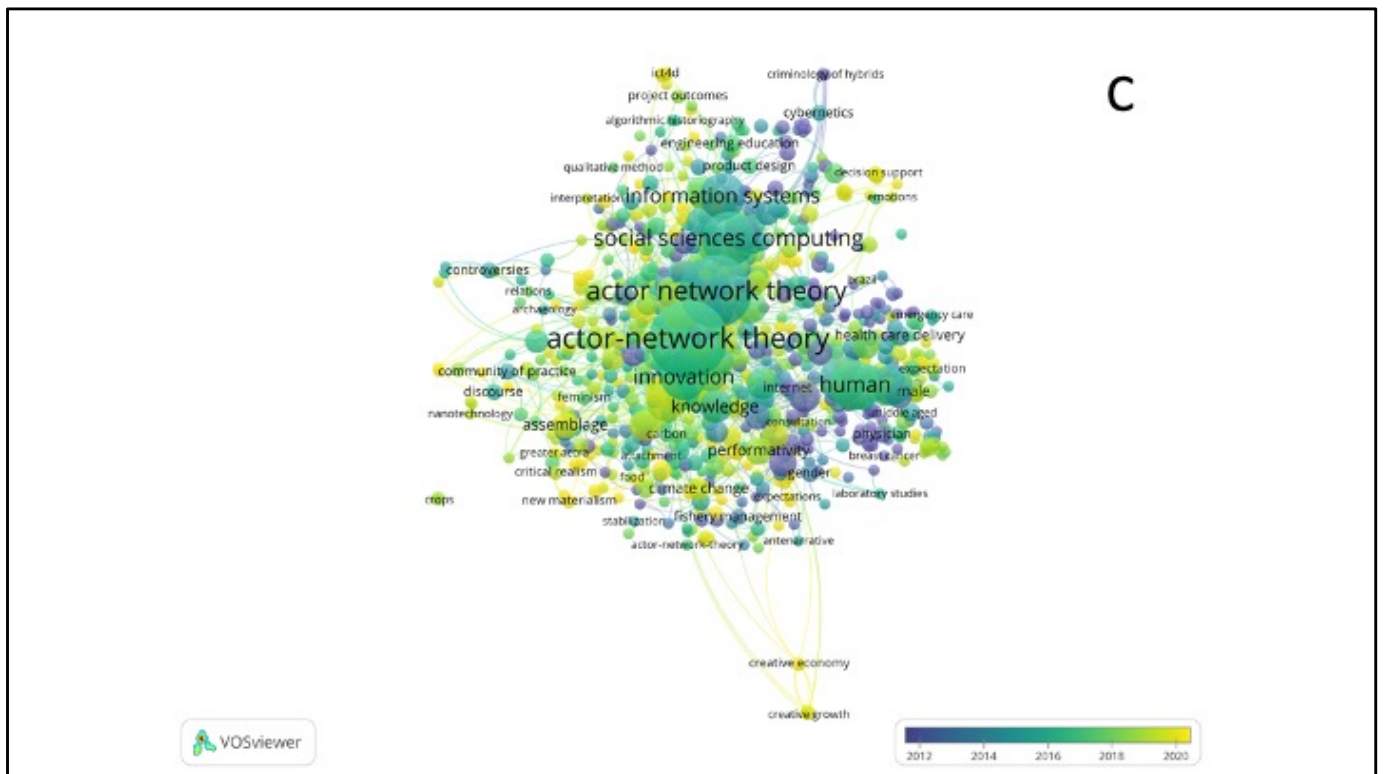
And Callon's citations are mostly about Actor Network Theory.

Discussion

Problem formulation articles are not highly cited – SORPS papers, as expected, make the most reference	Co-occurrence of keyword analysis of $R \cap P$, $R' \cap P$ and A-W all show the dominance of "decision making", whereas K shows dominance of "complexity"	A-W particularly highlights "human" and "decision making"
C clearly highlights "actor network theory"	Better tools are needed for this type of systematic literature analysis e.g. support for co-citation queries	Publications are probably skewed toward methodological contributions, with less of a focus on theories or categorisation of types of problem context

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However, one thing is immediately clear - Problem formulation articles are not highly cited – although Soft OR and PSM papers, as expected, make the most reference. On the whole, I think it is reasonable to state that Publications are probably skewed toward methodological contributions, with less of a focus on theories or categorisation of types of problem context.