Understand, reduce, respond. Project complexity management theory and practice.

Purpose:

This paper contributes to the understanding of complexity and its management from an OM perspective, building on and extending the systematic literature review published in this journal in 2011, and provides a foundation for exploring the interactions between complexities and responses.

Design methodology / approach:

The paper takes a subjective view of complexity, focusing on the 'lived experience' of managers. It takes an updated systematic literature review, and demonstrates the comprehensiveness of a framework to classify complexities of projects. It reports the findings from 43 workshops with over 1100 managers.

Findings:

Firstly, the complexity framework is effective in aiding understanding. Secondly, and somewhat unexpectedly, managers were able to identify strategies to reduce the majority of complexities that they faced. Thirdly, the workshops identified a typology of responses to residual complexities.

Research limitations / implications:

The framework has demonstrated its utility and a gap in understanding emergent complexities is identified. The framework further presents the opportunity to explore the recursive nature of complexity and response.

Practical implications:

This paper provides a framework that is both comprehensive and comprehensible. We demonstrate that complexities can be reduced and provide a means to assess responses to residual complexities, including potentially matching managers to projects.

Originality / value:

This work extends the previous systematic review combined with extensive empirical data to generate findings that are having impact in practice, and have the potential to strengthen a relatively neglected area within OM. A research agenda is suggested to support this.

1 Introduction: a journey in complexity

The point of departure for this journey was the work of Stacey (1993) in organisational strategy, and subsequently Williams (2005). The former was highly vocal in the discussion of complexity in business and management, and how organisations displayed many of the characteristics of complex systems. The latter considered how organisations were responding to complexities in the context of projects. This is particularly relevant to project-based operations as they are noted to be, in many cases, highly dependent on attempts at standardised processes (Geraldi, Maylor and William, 2011) despite being defined in OM terms by high variety of process and low volume of throughput (Slack and Brandon-Jones, 2015).

'Complex responsive processes' (Stacey, 2001) subsequently became popular topics in strategy. These went beyond mechanistic notions of strategy, with linear conceptions of cause and effect in organisations supplemented by a more evolutionary, organic conceptualisation. The approach provided better explanation of observed behaviours of organisational systems than had been achieved previously. Organisations were shown to be increasingly complex systems as a result of ever more dynamic environments, extended control loops and ongoing addition of system constraints such as legislation and corporate social responsibility requirements.

Related to this development was the application of analogies for social systems with other complex systems that proved insightful, including weather systems, mathematical systems (e.g. Mandelbrot sets) and ant colonies (Doerner et al, 2006). These insights included sensitivity to initial conditions, the role of 'weak signals', unpredictability of cause and effect and a boundary region, the *edge of chaos*. On this last insight, Pascale et al. (2001, pp. 61) note that, *"The edge [of chaos] is not the abyss. It's the sweet spot for productive change."* Kaufmann's NKC (Kaufmann, 1993; Vidgen and Wang, 2006) also provided some interesting discussions and a language around complexity landscapes and co-evolution of systems.

Williams (2005) subsequently provided the challenge to *"understand what makes projects complex to manage and to provide a common understanding of the 'lived experience' of managing in a project context. This will provide both academics and practitioners with a shared language to name and make sense of …how to both shape and respond to this complexity. Such a common language will enable us to connect findings experiences and knowledge accumulated in different environments… as well as in different parts and phases of projects."* (paraphrased in Geraldi et al, 2011, pp. 968).

Pursuant to Williams' challenge were our own investigations into the complexity of projects. We observed project practitioners struggling with the complexity of their work, and noted how organisations appeared to be able to create complexities for project delivery, rather than manage them effectively. Indeed, managers we worked with said that they perceived complexity growing in projects at a faster rate than the capability to work with this complexity was evolving. Although subjective and therefore difficult to quantify, this represents a potential *complexity crisis*; delivery of vital projects was (and still is) hampered by the sheer complexity of the challenge placed before managers.

In attempting to apply the insights from complexity science to help with this challenge of managing complexity more effectively, there were some particular issues. Notably, the notion of complexity itself was not well understood in the project context (Vidal and Marle, 2008), with arguments prevailing about whether something is 'complex' or 'complicated'. Typically, these arguments generate much heat but little light; one person's complex was another's complicated. In addition,

whilst the analogies initially yielded insight, they became increasingly distant from the problems of practice. Social systems are not equivalent to weather systems, mathematical systems or biological systems, even if some of the characteristics are comparable.

We were assisted in our journey by Cicmil et al. (2009) who used the classification of complexity **in** projects and the complexity **of** projects to describe two approaches to complexity in the PM literature. The first denoted a rationalist approach to the phenomenon, objectifying complexity and the application of the body of work of complexity science. The second, 'complexity of', is a subjective approach, representing the lived experience of managers of what *they* termed 'complexity.' Our work has developed in this latter vein. This trajectory has echoes of the development of quality management in OM, where initial work focused on quality as an objective construct, defined by *conformance to standard*. The result was a concept of quality management that focused on ensuring such compliance through objective measurement. The assumed goodness of the standard was never questioned. The work of Garvin (1984) broadened the concepts to initially include perceived quality – moving beyond the objective and measurable into subjective and perceptual. Parasuraman et al (1985) subsequently expanded this into a whole range of measures for service quality. Similarly, these rely on a subjective approach to the topic of interest being taken.

Our initial conceptual model is shown in Figure 1 and places 'complexity of project' as the independent variable, with the managerial response being a function of that complexity. We reasoned (Geraldi et al., 2011) that if we understood this independent variable, then we could make an input to the call for greater understanding of contingency in practice, for OM (Sousa and Voss, 2008), project management (Thomas and Mengel, 2008) and more widely in organisational studies (Brown and Eisenhardt, 1997).

[INSERT FIG 1 HERE]

The first stage in the complexity journey is **understand**: understanding the independent variable, Williams' 'lived experience' or Cicmil et al.'s complexity *of* projects. The framework used here has been derived from both a systematic literature review (Geraldi et al, 2011, updated here) and extensive empirical work (Maylor, Turner and Murray-Webster, 2013). It comprises the dimensions of *structural, socio-political* and *emergent* complexities.

The second stage in the complexity journey is an intervening step in our original conceptual model – **reduce**. The nature of our work is to be highly engaged with practice and practitioners, and during this work the discussion emerged concerning how complexity itself is 'managed' (or not), or has potential for being managed. Subsequently, workshops with over 1100 managers demonstrated that the majority of complexities they faced could either be removed or reduced. We were surprised by the strength of this finding, but encouraged that it demonstrated the value for practitioners of having a nuanced understanding of complexities, beyond the debates of complex *vs* complicated.

The third stage in the complexity journey was again from the initial challenge – **respond**. This was to explore how the residual complexities can be conceptualised as providing the basis for the managerial 'response' and thus to understand better one aspect of contingency in this domain. We report how this has been explored in its impact on project-level practices. Finally, we reflect on how this response can be framed from a complexity perspective, and provide interesting avenues pedagogically and for further research.

This work is important because projects continue to exhibit Flyvbjerg's performance paradox (Flyvbjerg et al, 2003) with the level of performance being in contrast to the levels of importance of

projects to organisations. Their complexity is rated as one of the reasons for this performance, indeed reinforcing the notion of a *complexity crisis*.

This paper is structured as follows. The following section presents the results of the investigation into the construct: complexity of projects. A summary of and an update to the systematic literature review (Geraldi et al., 2011) published in this journal on complexity **of** projects is presented. It describes the framework derived for understanding complexities and demonstrates that there have been no additional concepts added in work published in the intervening years. The workshop approach for the study in the management of complexity is described and the results presented. The discussion then considers the response to the complexities and we conclude with practical and research implications.

2. Literature review

The purpose of this review is not to repeat the systematic review of Geraldi et al (2011), which is summarised here. Instead, our question to the literature was highly specific: considering the complexity of projects, have there been any additions to the conceptual basis of 'the complexity *of* projects' since 2011? We eliminated the complexity science approaches and mathematical modelling of specific contexts (including transport systems and shipbuilding) as these did not meet the criteria of being relevant to complexity *of* projects.

The new search was based on peer-reviewed English-language journal articles from 2011 to April 2016. The first stage of the search, using the EBSCO database was for "complex*" AND "project management" in the subject (35 responses). We subsequently searched for the keyword 'complex*' in International Journal of Operations and Production Management (9 responses) the International Journal of Project Management (34) and Project Management Journal (9). We eliminated any non-peer-reviewed work (notably book reviews) and the overlaps between the second stage of the search and the first.

Main findings from 2011 review

By conducting a temporal analysis of the literature on complexity *of* projects, the findings were represented as shown in Figure 2. The build-up of the concepts into five main categories was substantiated by both literature and empirical research (e.g. Shenhar and Dvir, 1996; Maylor, et al, 2008). This provided the basis for the claim that complexity of projects was sufficiently well understood to move forward – conceptually, it had reached saturation as no new concepts were being added.

[INSERT FIG 2 HERE]

Since 2011 – Understanding complexity *of* projects

Our own follow-up of this work included testing both the comprehensiveness and comprehensibility of the framework. As reported in Maylor et al. (2013), the 5-category model met the requirements for the first, but less so for the second. The solution was to include 'pace' into structural complexity. The rationale for this was that as we saw from our empirical work, 'pace' is a measure of relative resource intensity, and was consistent with other concepts in that dimension. The second was to combine 'uncertainty' and 'dynamics' into a dimension called 'emergent complexity'. The rationale for this was that they were linked in practice with an uncertainty at one point in time often leading to a dynamic situation at a later point in time. The three dimensions that have been demonstrated to be of value in nuancing the description of complexity *of* projects, and typical concepts within each dimension are shown in Table 1.

[INSERT TABLE 1 HERE]

The Complexity Assessment Tool (CAT) synthesised data from multiple industries into a straightforward method of evaluating the complexities of projects (Maylor et al., 2013). This has utility not only as a way of highlighting challenges and comparing projects, but also as a systematic method for projects participants to discuss issues that concern them, whether or not the impact can be quantified. Examples include challenges such as *"Success measures for the work can be defined in agreement with the client"*, *"Sufficient people with the right skills are available"*, "*The business case for the work is clear"* and *"Managers are experienced in this kind of work"* (Maylor et al., 2013, p. 48). If these are answered in the negative, they are not amenable to 'simple' solutions.

During the development of this work, it became clear that once complexities were identified and before moving to consider their responses to the complexities, managers on occasions took the opportunity to explore whether the complexity could be reduced. This was particularly evident in a major workshop we facilitated involving a customer and supplier in a major IT project that was experiencing poor performance. Following the identification of the complexities using the CAT, a conversation took place between senior managers on both sides where they discussed the particular difficulties. It was agreed that the project could get better results (beneficial for all concerned) by reducing some of those 'self-inflicted' complexities. By using the CAT to open up a structured dialogue (i.e. with neither side controlling the 'agenda'), problems affecting both organisations could be surfaced relatively freely, allowing practical solutions to be developed and discussed. The resulting simplification provided an indicator of the potential benefits of this being added as a stage in the consideration of complexity – making it actively managed.

In addition to our own work, a number of publications have continued to highlight the importance and challenge of complexity (e.g. Padalkar and Gopinath, 2016; Pinto and Winch, 2016) and give attention to complexity dimensions (e.g Bosch-Rekveldt et al., 2011; Vidal, Marle and Bocquet, 2011, 2013). Evidence from supply chains (de Leeuw, Grotenhuis, and van Goor, 2013; Gimenez, van der Vaart and van Donk, 2012; Hearnshaw and Wilson, 2013) is also instructive, as is the procurement of complex performance (Hartmann et al., 2014; Roehrich and Lewis, 2014; Spring, and Araujo, 2014).

More detailed investigations into specific contextual complexities have also been undertaken, including construction (Cheng, 2014; He et al., 2015; Taroun, 2014). The scale of the analysis of

complexities spans from the team to the organisation to multi-organisational systems. Ruuska et al. (2011) study the governance of major nuclear power plant projects, and Saunders (2015) considers organisational complexities from a high-reliability perspective as this aids our understanding of complex operations. The achievement of complex strategic objectives through portfolio management is also a theme (e.g. Koh and Crawford, 2012).

Our review also revealed the plurality of approaches that continues to be taken to the subject of complexity. For instance, Johnson (2013) argues that technical complexity and novelty were major factors driving the emergence of project management as a profession in the 20th century. The importance of studying complexity has been reinforced as it is specifically identified as a major impediment to project success. Thamhain (2013) looks at the challenges of managing risks in complex projects, and Haji-Kazemi et al. (2015) highlight the difficulty of spotting and responding to 'early warnings' of difficulties. Using the above dimensions, these are both considered as *emergent complexities*.

On the assessment of complexity, Williams et al. (2012) argue that as complexity increases, it becomes harder to assess objectively what constitutes that complexity, and 'gut feeling' becomes increasingly important. Whilst not condoning the tautology in the argument, it does suggest that a subjective assessment may be more useful for more complex projects, consistent with the approach taken in this paper.

There are no concepts in these studies that were not already identified in the 2011 systematic review nor do the papers explicitly claim such.

Responses to complexities

In considering complexity and response, Koppenjan et al. (2011) show that there is a tension in large engineering projects between the desired focus on planning and control (the intended response to structural complexities), and the ambition to remain flexible given the complexity and uncertainty of the work (how to respond to emergence). They find that in practice managers strive to accommodate both. Liu and Leitner (2012) similarly find that managers respond to complexities by being *ambidextrous* in their practices – using strategies of both exploitation (applying known or planned responses to dealing with structural and socio-political complexities) and exploration (responding to emergent complexities) (see also Turner et al., 2014; Turner, Maylor and Swart, 2015).

Kapsali (2013) also notes a move against the 'engineering' approach to project management (deconstruction, planning and control responses) and argues for the value of systems thinking in this context. Similarly, Staadt (2012) discusses the challenge of socio-political complexities in projects and supports the use of a Soft Systems Methodology (SSM) for sensemaking in this context. The benefit of SSM is also supported by Frank et al. (2011).

Chang et al. (2013) identify that the Integrated Master Schedule (IMS) in major, complex, project undertakings can be used to communicate and negotiate project realities and aid in creating a shared understanding of the work among stakeholders. An IMS can therefore be framed as a response to complexities. The important role of stakeholder communications is also highlighted in other studies (Beringer, Jonas and Gemünden, 2012; Müller, Glückler and Aubry, 2013). Park and Lee (2014) investigate knowledge-sharing, dependence and trust in IT projects, and write that project complexity can actually encourage project participants to share knowledge with each other, which can aid the overall performance. The role of trust and knowledge-sharing is also investigated by

Wiewiora et al. (2014), and Chiocchio et al. (2011) look at the effects of team trust, conflict, and collaboration on project performance. Lehtiranta (2011) additionally emphasises the complexity (as well as the benefits) of social interactions in construction projects, taking a relational risk perspective on the subject. Brady and Davies (2014) use two major UK construction case studies to focus on structural and dynamic complexity (but not socio-political complexity) and some of the responses to each.

Although the literature is valuable and varied, it is evident that project complexity is far from being 'solved'. There is, though, guidance for performance improvement. Clarke (2012) argues that shared team leadership will be more effective than vertical leadership in more complex projects. Choo (2014) finds a U-shaped effect of problem definition time on project duration. Too little time spent defining the work can lead to a longer project duration, but too much time expenditure can lead to diminishing returns (a tension well described by Merrow, 2011). This initial judgement is important for complex project work. Flexibility in contracting under conditions of complexity can also be valuable (Kujala, Nystén-Haarala and Nuottila, 2015), and again this can be expressed as a response to an emergent complexity.

Chronéer & Bergquist (2012) find that in process industries, the complexities of the work mean that project managers need both production and product-related competence to be effective in integrating the different facets of the undertaking. Similarly, this consideration of competences can be viewed as a response to the complexities inherent in the work and can point to an attempt to match people to the requirements of the tasks. This is a theme to which we return later in this paper.

The literature did demonstrate considerable opportunity for further work, but the most powerful question to carry forward was: *could complexity be beneficially managed and could this be systematised?* The resulting series of workshops that we now describe was designed with this objective.

3. Methods: workshop approach

Workshops were designed to draw participants through the phases of complexity management. The first stage was to understand particular complexities, followed by a session on how these might be reduced, and a discussion of responses. Three pilot workshops were carried out in early 2012 to test the format and whether these could be made of interest both for research purposes and for the participants. The pilots were developed with project managers from a major global IT services organisation, a large global defence supplier and senior representatives from a large UK government department. It was therefore a collaborative development that needed to generate both a high quality and impactful conversation about project complexity for the participants, as well as useful data that would contribute to answering our research question. Feedback from the workshops was evaluated and right from the pilot stage was very positive. Data were analysed immediately following each workshop and likewise showed that the data obtained were contributing to answering the research question.

Following these pilots, the workshop format was stabilised into the nine points given below. 43 workshops were conducted by the authors with 1143 people participating over the period July 2012 to July 2015. Workshops took place as part of executive masters programmes, in-company events and open-invitation executive education programmes. These were predominantly held in UK, also Australia (six workshops), USA (one workshop), Denmark (one workshop) and Italy (one workshop); two workshops were held in UK with exclusively South African participants. Participants were drawn

from a wide range of industrial contexts and both the public and private sectors and all were involved in managing projects in some form, either as project managers, Project Management Office or Project Support staff, as well as leaders involved in sponsoring projects.

During the workshops, participants would work in groups of 5-10 ($\bar{x}$ = 7.8). The following approach was used:

1. Introduce the nature and challenge of complexity (variable length depending on time available).
2. Participants issued with 'Post-It' notes, and asked to individually write for five minutes, 'what in your experience makes projects complex to manage?' Each item written on a single Post-It.
3. Introduce classification system – the three dimensions of structural, socio-political and emergent complexity.
4. Engage in facilitated classification using these dimensions. Most elements that were not immediately placed (for instance 'new technology' was regularly not immediately placed) could be assisted by checking 'what makes this element complex or difficult to manage?'
5. De-brief what each group had found and review use of the classification.
6. Each group then asked to select six complexities (two from each dimension) to work on, and then consider whether each of these could be (a) removed, (b) reduced, or would the manager (c) have to 'run with it.' We called these remaining, unresolved, issues 'residual complexities'. Where removal or reduction was identified, this had to be accompanied with a brief statement of 'how' that removal or reduction would be achieved.
7. De-brief with each group reporting out how many of their six complexities could be removed or reduced. Numeric data recorded.
8. Groups return to their discussions to categorise whether their plans could be achieved at the project level (within the immediate defined responsibilities of the project managers), the organisational level (outside the immediate defined responsibilities of the project manager) or both. Report out and numeric data (number at project and organisational levels) recorded again.
9. Plenary discussion of the responses to the residual complexities.

4. Results

Examples of complexities identified in workshops are shown in Table 2.

[INSERT TABLE 2 HERE]

In addition, by carrying out the first phase of the complexity management process, 'understand', we noted two qualitative observations. There was a high degree of similarity between the number (not severity) of the structural and socio-political aspects of complexity. In contrast, there were markedly fewer identified emergent complexities in the experience of participants. It was not possible to distinguish whether this reflected the incidence of complexities or their level of recognition, but would be an area for further research.

The second qualitative observation was that the majority of people were readily able to carry out the classification. Once explained, it was found to be highly intuitive to work with and provided a more nuanced conversation that moved beyond 'complex vs complicated'.

The first quantitative observation came with the second phase of complexity management: 'reduce'. 145 groups identified six complexities each (870 in total). We were more than a little surprised that of these, participants decided that 713 (82%) could be removed completely or reduced. We had expected that some could be reduced, but nowhere near this number.

The second quantitative observation was from the final part of the workshop, where groups were asked to consider at what level the complexity reduction action would have to take place. 58% of the complexities could be reduced or removed by actions at the project level. Examples of this included:

- carry out more detailed planning to reduce a structural complexity,
- engage stakeholders earlier and more systematically to reduce a socio-political complexity,
- use a more flexible structure to reduce an emergent complexity.

52% (because of overlap these add up to >100%) could be removed or reduced by actions at the organisational level. For instance:

- giving increased advance warning of project requirements to allow projects to progress at a more suitable pace.
- grouping project stakeholders into a suitable governance structure to allow their voices to be gathered (e.g. a project board) rather than leaving the project team to deal with a disparate group of individuals.
- allowing financial flexibility in budgets to accommodate variations and changes that either speed up or slow down a project.

As the figures above demonstrate, some complexities required actions at both the project *and* organisational levels to reduce.

4.1 Responses

We now turn to the original challenge – understanding the contingency of response. Specifically, we wanted to explore whether by recognising the complexity, could the response to the complexity be the subject of deliberate choice? In order to explore this, we investigated process at the project level. The question being asked at this stage is, '*What can managers do in response to the complexities they have identified?'*

Our descriptions of the responses started with consideration of the nature of each of the dimensions of complexity.

4.1.1. Structural complexity responses

Structural complexity is characterised by scale, interdependency and pace. Project Management has a plethora of tools and techniques accumulated over many years for the purposes of dealing with these challenges (see e.g. Meredith and Mantel, 2012). The tools applied included Work Breakdown Structure and Critical Path Analysis. These assisted in making sense of a task, by breaking it down and being able to model the impact of interdependencies and resource intensity. Earned Value was frequently mentioned for monitoring progress against a plan. Benefits realisation was used on an ongoing basis to demonstrate value against the original business case for the project. These are enshrined in the bodies of knowledge (e.g. PMI, 2013; APM, 2012) and can be framed as 'planning and control' responses to structural complexities. For instance, the current PMI BoK Guide (PMI, 2013) outlines ten process areas (including initiating, planning, executing, monitoring and controlling, and closing a project) which cover the 'traditional' but limited responses (Kapsali, 2013)

to structural complexities. Similarly, Section 3 of the APM BoK (APM, 2012) gives an overview of the key areas project managers should be covering. Further responses are encapsulated into Systems Engineering (e.g. Jackson, 2003; www.incose.org), but also the use of a more diverse toolset (Remington and Pollack, 2007).

Planning and control responses are not the exclusive responses to structural complexities, but this is the set of responses that have the most natural 'fit' with this set of complexities. Workshop participants noted the use of *traditional PM tools*; a typical comment being, *'…we have mandated processes that deal with this stuff.'*

4.1.2 Socio-political complexity responses

When considering the elements of socio-political complexity, people, power, politics, agendas and conflicts, the responses set out in the BoKs were perhaps less useful. Communications and stakeholder management (PMI BoK Guide, 2013) could be considered here, but the approach is based on the same 'planning and control' rationale. In contrast, the APM BoK (APM, 2012), Section 2.1 highlights the interpersonal skills of communication, conflict management, delegation, influencing, leadership, negotiation and teamwork. Our initial evaluation of workshop data showed that practitioners often employed relational means rather than processes to respond to these complexities. For instance, where there is a conflict between members of a team, an approach that seeks to build relationships with both of those people would be appropriate (consistent with the findings of Park and Lee, 2014). They could resort to formal process, but only as a last resort.

4.1.3 Emergent complexity responses

Emergent complexities provided more of a challenge. The conventional response to uncertainty was noted by participants to be through risk management – characterised above as a 'planning and control' response. Change, the other key constituent of this dimension, can similarly be accommodated through the use of change management processes. However, the discussions noted that the planning and control response is both a constraint and an enabler for responding to emergent complexities. There is an identifiable tension between having to follow a process and a manager having the flexibility to respond in the best way they see fit at the time, whatever the process says. This has been illustrated through the growing use of the practices of agile project management (Highsmith, 2007; Dyba and Dingsoyr, 2008).

In addition, the workshops demonstrated that there was a whole response group that did not appear to have been given much attention in project management. We noted previously that flexibility in contracting conditions was a recognised response to emergent complexity (Kujala et al., 2015). However, many of the responses went beyond exploiting such flexibility and took the form of *entrepreneurial* actions. For instance, a manager in a large transport infrastructure project used an approach in which he would 'walk the route' with contractors once a week. Any changes or amendment would be agreed during the walk, rather than as formal contract variations. This applied whether the request for changes was at the behest of the client or the contractor. The project was a notable success with contract closure occurring days after works completion, rather than months as was custom and practice in the industry. This entrepreneurial action was in direct contrast to the standard process – a definite 'explore' rather than 'exploit' response (Liu and Leitner, 2012; Turner et al, 2014).

Our initial conceptualisation was that a response structure could be developed based on the type of complexity. For structural complexities, a 'planning and control' approach is prudent – as promoted in the BoKs and much of the literature within the field. For socio-political complexities, a

‘relationship-development’ approach is suitable, and for emergent complexities retaining flexibility appears to be the most beneficial. However, in reviewing the workshop data, the managers’ responses did not always accord with this categorisation. From this we hypothesised a 3x3 matrix (Table 3) between complexity dimension and the nature of the response. The actions on the diagonal might thus be the most ‘expected’ responses, but off-diagonal responses could also be implemented and be valuable. Table 3 contains the modal responses identified from the workshop data.

[INSERT TABLE 3 HERE]

5. Discussion: from linear to recursive relationships

It became apparent during our analysis of the findings that the initial conceptualisation of complexity and response as a linear system was no longer adequate. It doesn’t dismiss what has been said so far, but does place a constraint on any work that follows. Our initial assumption was that the perceived complexity would influence the response, and that was sufficient. For instance, the application of an Integrated Master Schedule (Chang et al, 2013) as a response to a structural complexity. Two problems emerge here. Firstly, the use of an IMS is an ongoing activity rather than a single event in time. Whilst it may have the effect of reducing the managerial challenge over time, it is by no means instantaneous. Secondly, it also introduces another artefact (the MS) that needs to be fed with data, maintained, reported on and possibly another team member to run it. This may not realise the anticipated complexity reduction, particularly if it is associated with a complex reporting or data structure, increased oversight or a ‘challenging individual’ is brought in to run it.

One specific example of this from our workshops was the introduction by a global IT service provider, of a new IMS system. Major projects were required to provide inputs to the system. This was intended to reduce the complexities for the organisation of seeing the resource requirements across many projects. However, the new system was incompatible with existing planning software, and would not take more than three levels of work breakdown structure. The result was that for all practical purposes, the firm now had two parallel systems for determining master schedules, and consequently greatly increased complexity for project staff.

When considering other responses from Table 3, all of these could have similar potential impacts – either increasing or decreasing the perceived complexity of that aspect, or possibly moving the complexity elsewhere. Adding the ‘solution’ to the problem may make the system more complex in a manner unforeseeable at the time.

The relationship between complexity and response then is recursive and we propose conceptualising it as a *duality* – where the response is simultaneously enabled and constrained by the perceived complexity and vice versa (see Figure 3). A duality is an appropriate conception as opposed to a *dualism* – there is not complexity *or* response – both are ongoing, co-exist and interact. The nature of such interactions in dualities have provided rich research fields for Social Practice scholars (from Giddens (1984) to more recently Feldman and Pentland (2003)). The concept of response is expanded to include ‘actions not taken’. This may echo the findings of Kutsch and Hall (2009) in risk management where legitimate responses to risk included delay, denial and avoidance of the risk stimulus.

[INSERT FIG 3 HERE]

The immediate advantage of this conceptualisation is the number of avenues for investigation that it opens up. For instance, in considering the behaviour of managers, is there a concept of 'balance' between perceived complexity and potential actions? How are the consequences of the potential responses assessed? How do managers decide if a potential action is worthwhile – by minimising overall complexity? Do managers 'trade' complexities, replacing one that they cannot respond well to, with one that they can, by invoking particular responses? Do managers consciously respond to minimising overall complexity? What are the relative temporal effects at play? For instance, how quickly does a response provide some 'complexity relief'?

In applying this thinking, we may also be converging on the work of complexity science, where Kaufmann's ideas from evolutionary biology showed that co-existing systems co-evolve. Whilst the timescales at most project levels are rather different from evolution, the consideration of complexity and response as co-evolving clearly has more resonance now than with a linear model.

Lastly, what is the relationship between complexity and risk? Would complexities be like risks, and be subject to the same behaviours of 'delay, deny, avoid' (Kutsch and Hall, 2009) as suggested above? Should un-resolved complexities also provide an input to the risk management process (as some organisations currently do)?

6. Conclusions

We began with a challenge to "*understand what makes projects complex to manage and to provide a common understanding of the 'lived experience' of managing in a project context."* We have addressed this from an OM perspective by studying the managerial actions undertaken as part of the transformation processes of an operations system – in this case, projects. As a result, we have synthesised and tested a comprehensive and comprehensible framework, based on both literature and empirical study. The purpose of this is to "*provide both academics and practitioners with a shared language to name and make sense of …how to both shape and respond to this complexity."* Our second step was not originally intended as we were focusing on response, but complexity reduction appears to be a feasible as an intervening step. The third step in addressing the challenge then comes in that response. We have noted that by describing the complexity, sense can be made of the range of potential responses. This provides some additional insight. For instance, in a general criticism of standard approaches (notably where PMI BoK Guide is criticised, but also PRINCE2), the framework shows that these approaches have application in responding to structural complexities, are less useful in responding to socio-political complexities, and may even be in conflict with certain responses to emergent complexities. It may also help with matching people with the task and with planning their personal development.

The theoretical contributions of this work are twofold. Firstly, the development of the complexity response framework allows researchers a theoretically and empirically grounded framework for analysing OM practices in the context of projects. Secondly, we have shown that the notion of complexity response as a linear system of cause and effect is an inadequate conceptualisation. Our development of the model (Fig. 3) is a powerful way of viewing complexity and response and the reciprocal nature of this relationship offers a rich vein for future research.

6.1 Areas for further research

Four areas would benefit from further research and development.

Firstly, the understand – reduce – respond approach does not yet have comprehensive empirical data on whether it is effective (i.e. improves project performance) as part of regular project work.

Many anecdotal accounts demonstrate this, but collation of empirical data would be helpful in both building evidence for it as well as contributing to nuancing the approach. In addition, the workshops did not distinguish which complexities were the most commonly chosen as reduceable and which not. Further work could evaluate this process with a view to determining for instance, whether these were the most beneficial candidates for attention or the easiest to reduce.

Secondly, the responses to emergent complexities appear to be the biggest gap between the OM and PM literature and the practices seen thus far. Specifically, the area of entrepreneurial practices as a response to emergence is a promising line of enquiry. This could usefully supplement the existing work that has been reported to focus on the *explore* element of ambidexterity.

Thirdly, the notion of matching the work and the worker is appealing. Using the complexity framework to describe the task could enable a better fit with the person being chosen for the leadership role. There are multiple frameworks available for assessing the role preferences of individuals (e.g. Primary Colours of Pendleton and Furnham, 2012; PMI's Talent Triangle, PMI 2014), and the impact of match and mis-match between these and the project complexities could be assessed. How the 'worker' can be developed by focusing on their ability to respond to was previously reported (Maylor et al, 2013) and demonstrated that managers found socio-political complexities the most difficult to deal with yet their training was predominantly in responses to structural complexities. This may also have pedagogical implications.

Lastly, exploring the recursive nature of complexity and response appears to open up many possibilities. For instance, the construction of a plan to respond to a structural complexity, should indeed reduce the perceived complexity, but as was suggested with IMS, may in itself lead to other complexities. The behaviours associated with this choice of response should be fascinating to explore, and whether for instance, managers actively choose a level of complexity they are willing to tolerate.

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