Developing Design Propositions through Research Synthesis

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Abstract

The field of organization and management studies has a significant and ever increasing published research base, often criticized as fragmented and of limited relevance for practice. A design science approach to management has argued that more room for the development of solution-oriented or prescriptive knowledge would increase its relevance. In this article we discuss prescriptive knowledge cast in the form of design propositions following the so-called 'CIMO-logic', extending previous applications of the design proposition notion. This logic involves a combination of a problematic Context, for which the design proposition suggests a certain Intervention type, to produce, through specified generative Mechanisms, the intended Outcome(s). We discuss how design-oriented research synthesis provides a vehicle for addressing fragmentation and increasing the chances of application. Moreover, we explore how the development of design propositions can result from synthesizing previously published research and illustrate this with the design of high-reliability organizations (HROs).

Keywords: design science research, design propositions, research synthesis, practitioner relevant knowledge, high-reliability organizations

The publication of organization and management research has grown exponentially in recent years, but this large resulting science base has been traditionally regarded as highly fragmented (see e.g. Pfeffer 1993; Koontz 1980; Van Maanen 1995; Whitley 1984a, 2000). Additionally, the relevance of this research for practice remains questionable (Daft and Lewin 1990; Hambrick 1994; Rynes et al. 2001; Tranfield and Starkey 1998), with some attributing this problem to poor communication (e.g. Hambrick 1994). Others (Van Aken 2004) ascribe the problem to the content being too descriptive, analytical and preoccupied with theoretical knowledge at the expense of interest in solving field problems, suggesting that normal science in organization and management has tended to focus on analysis and explanation, on problems and their causes. For example,

'It criticizes everyday accounts and practices… but does not seek to transform them except in the general sense of demonstrating their incorrectness.' (Whitley 1984b: 371)

Recently there has been a rising interest in the design science paradigm and its potential for increasing the relevance and application potential of the research base (Huff et al. 2006; Van Aken 2004; Romme 2003; Romme and Edenburg 2006; Bate 2007). Design science research intends to add to analy-

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sis and explanation, specifications for interventions to transform present practices and improve the effectiveness of organizations. It privileges prescriptive knowledge, i.e. knowledge linking interventions to outcomes, and grapples with the vexing question faced daily by managers of 'how should things be?' In this paper we will discuss prescriptive knowledge, cast in the form of design propositions (Romme 2003), extending this notion through the so-called 'CIMO-logic'.

Design propositions can result from empirical work in individual, original research projects, but these often offer only a single perspective on the typically fuzzy, ambiguous and complex issues in organization and management and often produce conflicting findings. A complementary approach is to formulate design propositions using the existing published research base. Systematic review (Tranfield et al. 2003) can provide a powerful method, but faces the challenge of synthesizing review results. This paper illustrates our approach with an exemplar drawn from the field of high-reliability organization (HRO) design.

Design Science Research

The paradigm of the design sciences was inspired by Simon (1996), in which he explores the fundamental differences between (natural) science and the 'sciences of the artificial'. Based on this idea, Van Aken (2004) refers to the distinction between *explanatory* sciences (Simon's natural sciences but also including disciplines such as sociology and economics) and *design sciences* (most of Simon's sciences of the artificial).

The mission of an explanatory science is a quest for truth by developing knowledge aimed at the classical triplet of description, explanation and prediction. Students are trained to become researchers, able to solve knowledge problems. Design sciences include medical science, engineering, law and according to Simon, also management. The mission of a design science is a quest for improving the human condition by developing knowledge to solve field problems, i.e. problematic situations in reality. Students are trained to become professionals, able to use their knowledge to design and implement solutions for field problems.

The distinction between knowledge for solving theoretical problems and knowledge for solving field problems is fundamental. For example, Aristotle (Lobkowicz 1967; Squires 1999: 110–117) made a distinction between:

- '*praxis*, acting upon one's situation to improve one's condition;
- *theoria*, explanatory knowledge for its own sake (the scientific ideal);
- *techne*, making artifacts.'

Explanatory sciences are interested in theoria, design sciences in praxis to solve *improvement problems* by acting upon existing entities (such as in medicine, but for Aristotle also in politics and war), as well as in techne to solve *construction problems* to realize new entities (such as in engineering). Both praxis and techne are important for organization and management studies for these fields address both improvement and construction problems. Therefore, design science research in management aims both to develop knowledge to design *interventions* to solve improvement problems and to design *systems* (coherent structures and processes) to solve construction problems.

The term 'paradigm', as used above, does not mean a closed set of basic beliefs about ontology, epistemology and methodology (Guba and Lincoln 2000), but rather Kuhn's (1962) broader interpretation of this concept as a combination of research questions asked, research methodologies accepted as appropriate to answer them, and the nature of resulting research products. Research on the basis of the paradigm of the design sciences is characterized by:

- research questions being driven by an interest in field problems;
- an emphasis on the production of prescriptive knowledge, linking it to interventions and systems to produce outcomes, providing the key to solving field problems;
- a justification of research products largely based on pragmatic validity (do the actions based on this knowledge produce the intended outcomes?).

This type of research can be done in any discipline, but normally it is only considered as 'mainstream' research in a design science, i.e. in a discipline concerned with 'how' as well as 'what' questions (Becher 1989).

Design Propositions in Organization and Management

Prescriptive knowledge has a central role in design science research and follows the logic of Bunge's (1967) technological rule. Below, we develop this idea into the notion of design propositions following 'CIMO-logic' and discuss the ways in which such design propositions might be applied and developed.

The Logic of Prescription

Based on Bunge's technological rule, the logic of prescription is 'if you want to achieve outcome *O* in context *C*, then use intervention type *I*'. We prefer the term 'design proposition' to 'technological rule', as the latter term suggests — contrary to our intentions — a rather mechanistic, precise instruction. The key component of a design proposition is the intervention type *I*, to be used in solving the kind of problem in question. A design proposition can be seen as offering a general template for the creation of solutions for a particular class of field problems. For validation, design propositions have to be field-tested using pragmatic validity.

Pawson and Tilley (1997) add to the above argument by raising the issue of causality, i.e. by asking through which generative mechanism(s) the intervention produces the outcome in the given context. This addition results in design propositions following what we call the 'CIMO-logic'. This logic is constructed as follows: in this class of problematic Contexts, use this Intervention type to invoke these generative Mechanism(s), to deliver these Outcome(s). Table 1 gives more information on design propositions following CIMO-logic. A specific example of a design proposition following CIMO-logic might be:

> 'If you have a project assignment for a geographically distributed team (class of contexts), use a face-to-face kick-off meeting (intervention type) to create an effective team (intended outcome) through the creation of collective task insight and commitment (generative mechanisms).'

Design propositions created in this way therefore contain information on what to do, in which situations, to produce what effect and offer some understanding of why this happens.

Applying Design Propositions

The design proposition is not the complete solution for any given business problem, it is an input to the designing of the specific solution. Typically demand much professional knowledge and expertise, including knowledge of alternative design propositions with their CIMO-logic, along with the evidence from field-testing and intimate knowledge of the local situation and business domain in question.

The CIMO-logic constitutes only the logic of the design proposition, not its specific form. It is important in organization and management to resist taking a mechanistic view, such as might be involved in the prescription of a certain drug by a medical doctor to a patient, or the formula a civil engineer might use to calculate the maximum load of a bridge. In these fields, prescriptive knowledge is often expressed in directives such as 'if A then do B' (IO-logic). However, design propositions in organization and management studies are seldom reduced to algorithms and can take the form of an article, a report, a training manual or a whole book.

In the popular management literature, design propositions often follow simple IO-logic, not dwelling on the context dependency of the outcomes (perhaps because propositions are developed on the basis of the personal experience of the author in one specific context), or the mechanisms producing the outcomes. In application, design propositions based on CIMO-logic and taken from academic research often involve a comprehensive learning process rather than the straightforward execution of a simple rule. Written material can support the learning of practitioners by offering intellectual resources concerning alternative design propositions and their CIMO-logic, prior to the actual design of specific interventions. For example, the leader of the distributed team in the above example may read research on face-to-face kick-off meetings to understand how and through what mechanisms such a meeting can produce an effective team. Understanding that collective task insight is one possible mechanism will help him/her design the programme. Evidence from field-testing in various settings within the overall application domain can give further information from which to design the specific intervention and help predict outcomes in specific settings through case-based reasoning (see e.g. Watson 1997), in the same manner as lawyers predicting the outcomes of their cases on the basis of their knowledge of case-law.

Table 1.
CIMO-logic—the Components of Design Propositions

Component	Explanation
Context (C)	The surrounding (external and internal environment) factors and the nature of the human actors that influence behavioural change. They include features such as age, experience, competency, organizational politics and power, the nature of the technical system, organizational stability, uncertainty and system interdependencies. Interventions are always embedded in a social system and, as noted by Pawson and Tilley (1997), will be affected by at least four contextual layers: the individual, the interpersonal relationships, institutional setting and the wider infrastructural system.
Interventions (I)	The interventions managers have at their disposal to influence behaviour. For example, leadership style, planning and control systems, training, performance management. It is important to note that it is necessary to examine not just the nature of the intervention but also how it is implemented. Furthermore, interventions carry with them hypotheses, which may or may not be shared. For example, 'financial incentives will lead to higher worker motivation'.
Mechanisms (M)	The mechanism that in a certain context is triggered by the intervention. For instance, empowerment offers employees the means to contribute to some activity beyond their normal tasks or outside their normal sphere of interest, which then prompts participation and responsibility, offering the potential of long-term benefits to them and/or to their organization.
Outcome (O)	The outcome of the intervention in its various aspects, such as performance improvement, cost reduction or low error rates.

The Challenge of Research Synthesis in Management and Organization Studies

Other fields such as medicine have progressed by reviewing the knowledge stocked in their science base and synthesizing the findings. Our view is that such an excursion is worthy of consideration and is potentially beneficial for management and organization studies. However, given the hyper-diversity in both content and method, addressing synthesis through aggregation as in medical science is rarely possible. Consequently, synthesis poses a key challenge.

A number of methods have been developed that can cope with non-numerical data and diverse types of evidence (including that from qualitative research). In an extensive review, Dixon-Woods et al. (2006) highlight a key distinction between interpretive and integrative methods. Boaz et al. (2006) offer a comparison of five approaches all conducted in different fields using contrasting methodologies. Denyer and Tranfield (2006) argue that despite distinct epistemological and ontological differences between other academic fields and management and organization studies, the development of customized syntheses could provide an important and effective means of creating practical management knowledge.

Alternative Approaches to Research Synthesis

There are a number of significant and potentially useful approaches to synthesis. Below we discuss several, although we offer neither a comprehensive catalogue nor a representative sample of present practice.

Within many fields — medicine being the most obvious and probably the most advanced — the preferred approach to synthesis is statistical meta-analysis (Egger et al. 2001; Sutton et al. 2000). This involves the aggregation of a weighted average of the results of individual studies in order to calculate an overall effect size for an intervention. Meta-analysis can be an effective approach where there are suitable and comparable quantitative data available from several studies. In fields of research where there are variations in study design, the nature of evidence and study context, meta-analysis is problematic (Hammersley 2001). For example, in management and organization studies, researchers may seek to address managers' perspectives and experiences that are not concerned with effect sizes or variables with a defined outcome. Despite this, advocates of meta-analysis have argued that differences in study design and context can be accounted for through statistical techniques (Chalmers 2005).

Alternatively, some researchers promote the benefits of a traditional narrative approach (Hammersley 2001), a less formalized method for summarizing large quantities of information. Narrative synthesis has the benefit of being able to address a wide range of questions, not only those relating to the effectiveness of a particular intervention. Despite excellent examples of its application, it is criticized because of its potential bias and lack of both transparency and reproducibility.

Popay et al. (2006) have developed a method of narrative synthesis which involves four steps: developing a theoretical model of how the interventions work, why and for whom; developing a preliminary synthesis; exploring the relationships in the data; and assessing the robustness of the synthesized output. They identify a range of specific tools and techniques for achieving each step.

In contrast, meta-ethnography approaches synthesis through interpretation rather than analysis and aims to preserve the social and theoretical contexts in which substantive findings emerge (Noblit and Hare 1988: 5–6). Meta-ethnography involves open coding to identify emergent categories and then constant comparisons of the metaphors across studies. Advocates argue that these translations are unique forms of synthesis that preserve the interpretive qualities of the original data. A major weakness is that any interpretation is only one possible reading of the studies (Noblit and Hare 1988). Nevertheless, meta-ethnography is gaining ground (see e.g. Campbell et al. 2003).

The meta-narrative approach is new and novel. It helps explore large and heterogeneous literatures by identifying the unfolding 'storyline' of research (Greenhalgh et al. 2005). Drawing on Kuhn (1962), Greenhalgh et al. (2005) review the diffusion of innovations and map the historical development of concepts, theory and methods in each research tradition. While the approach can help build an understanding of a field, findings should be seen as 'illuminating the problem and raising areas to consider' rather than 'providing the definitive answers' (Greenhalgh et al. 2005).

Finally, Pawson (2002b) proposes realist synthesis for analysing the effectiveness of policy programmes through the development and testing of theoretical ideas on intervention–outcome relations. This overall objective mirrors the use of research synthesis for developing design propositions in management and organization studies. Pawson argues that the 'primary ambition of research synthesis is explanation building'. The purpose is to 'articulate underlying programme theories and then interrogate existing evidence to find out whether and where these theories are pertinent and productive' (Pawson 2006: 74).

While programmes are context-specific and not generalizable, intervention–outcome combinations are. For Pawson (2006) the starting point is a preliminary hypothesis. Specifically, key relationships between interventions and outcomes are mediated by generative mechanisms operating in a context-dependent manner. Accordingly, programme reviews aim at discovering context–mechanism–outcome combinations in order to know when, where and for whom to apply the programme, or elements of it.

Realist synthesis is not a synthesis of quantitative data (as in meta-analysis), nor a synthesis of narratives or interpretations (as in narrative synthesis or meta-ethnography). The realist's goal is to understand how interventions or systems work in various types of contexts. Studies are regarded as 'case studies, whose purpose is to test, revise and refine the preliminary theory' (Pawson 2006: 74).

Realist synthesis can accommodate research evidence from a range of study types. Drawing on his earlier work on programme evaluation (Pawson and Tilley 1997), Pawson (2006) argues that the key to synthesizing research for the purpose of informing practice lies in developing an understanding of the underlying generative mechanisms (M). This gives a basic theory on why certain outcomes emerge. In policy programmes such mechanisms may explain how programme resources provided to subjects will change their reasoning and hence their behaviour (Pawson 2002b). Whether or not change actually takes place, or what kind of change ensues, is dependent on the nature of the context (C), which is comprised of the characteristics of the actors and the circumstances of the programme. The underlying mechanisms can be expected to generate a range of different outcomes (O) when implemented in a series of different contexts.

Therefore, the first task is to identify the underlying generative mechanism of the programme, asking why certain interventions are expected to produce the intended outcomes. Secondly, the programme theory is inspected in a range of contexts. For example, Pawson (2002b) inspects the value of 'incentives' as a policy instrument in six domains: health, safety, corrections, transport, housing and higher education. Each article is described and discussed in terms of its contribution to the emerging theory,

> '…. the reviewer's basic task is to sift through the mixed fortunes of a programme attempting to discover those contexts (C+) that have produced solid and successful outcomes (O) from those contexts (C) that induce failure (O−). The review process is then repeated across a number of additional studies featuring the same underlying mechanism, with the aim of gathering together the various permutations of success and failure. In realist jargon, the aim is to differentiate and accumulate evidence of positive and negative CMO configurations.' (Pawson 2002b: 345)

The results revise the model, explaining for whom, in what circumstances, in what respect and why, certain interventions produce preferred outcomes (Pawson 2002b). Understanding the nature of the relationship between contexts, mechanisms and outcomes is crucial. For example, 'naming and shaming' works well in many contexts, but when used in the non-payment of council tax in the

UK, it was found for certain communities to create 'heroes' rather than 'villains' (Pawson 2002a).

According to Pawson (2002b) realist synthesis produces 'mid range theory', lying 'between the minor but necessary working hypotheses that evolve in abundance during day-to-day research and the all-inclusive systematic efforts to develop a unified theory' (Merton 1968: 39).

Due to the fragmented and diverse nature of the field of management and organization studies, our approach outlined below selects and utilizes key aspects of several of the above approaches. It includes aspects of the four-step approach to narrative synthesis (Popay et al. 2006), the meta-ethnographic approach of coding emergent categories (Noblit and Hare 1988), the meta-narrative method of highlighting key research themes and schools of thought (Greenhalgh et al. 2005), and particularly the realist approach, incorporating the notions of context, mechanisms and outcomes (Pawson 2006).

An Example of Design-oriented Research Synthesis for High Reliability Organization (HRO)

A Voluminous and Fragmented Field

The literature on HROs provides an excellent exemplar to explore the overall approach and operational concerns raised in this paper because it is voluminous and fragmented with several distinct schools of thought. Many of the articles reveal the interventions (I) used, while others explain the underlying mechanisms (M), or describe context (C) in depth, or allude to outcomes (O).

For example, a discrete body of research on HROs emerged in the 1980s when the 'Berkeley group' became concerned with organizations that repeatedly perform activities with 'high hazard' technologies but experience very few errors and incidents (Roberts 1990; Rochlin 1993). Reliability from this perspective is regarded as a 'dynamic non-event' (Weick and Sutcliffe 2001: 69), which is not automatically attained, but has to be actively accomplished every day. HROs, according to the Berkeley group, are able to avoid, trap or mitigate failures through effective management and organizational design. The Berkeley group and its followers tend to adopt a micro-analytic perspective and investigate interactions and interrelations between individuals or groups.

In contrast, research on crisis management addresses the prediction and prevention of disasters and damage control (Meyer 1982) and a further strand of literature attempts to examine the organizational factors and processes that lead organizations to disaster (e.g. Shrivastava et al. 1988; Turner and Pidgeon 1997). Unlike the Berkeley group, this literature tends to adopt a macro-organizational perspective and addresses the social and organizational aspects of failure.

A further contribution, the theory of normal accidents, suggests that failures are inevitable and unavoidable in complex, high-risk and tightly coupled systems (Perrow 1994; Sagan 1993) and that accidents are 'normal', meaning that it is an inherent property of the system occasionally to experience failure. Sagan (1993) argues that redundancy and other safeguards can provide the impression of safety, but actually increase the vulnerability of the system. Normal accident theorists are generally critical of high reliability as are those emphasizing the human errors approach (Reason 2000) which suggests that people and systems are fallible. Authors highlight failures arising either from 'aberrant mental processes' or from 'upstream systemic factors'.

Within each of these domains there are contributions from various disciplines including management and organization studies, sociology, psychology, political science and engineering. The field is also methodologically pluralistic, with qualitative, quantitative and theoretical contributions and a voluminous 'grey' literature, for example health and safety reports.

The Method of Synthesis

We took as our key task in undertaking design-oriented synthesis to develop ideas on interventions and systems that offered the possibility of producing failure-free operations and to help further understanding of the generative mechanisms involved.

The first phase of the synthesis aimed at developing an initial theory that might account for HRO successes and failures. In total, 23 HRO studies were selected, principally the seminal papers of the Berkeley group, as well as important contributions from Turner, Perrow, Sagan and Reason. A preliminary review of this core literature was used to build an embryonic conceptual model of HRO operations. The nascent theory outlined how to perform high-hazard operations avoiding high-impact failures by applying the following sequence:

– Detection: 'clues' (anomalies, errors, mistakes and incidents), even those that are subtle are noticed, identified, investigated, examined and verified.
– Communication: information on the current 'health' of the system, including anomalies, errors, mistakes and incidents are disclosed and disseminated to appropriate actors.
– Sense making: appropriate actors conceptualize the situation and evaluate potential options.
– Action: interventions are made to the social and/or technical system.
– Response: in which change follows action. People or physical processes behave differently; failure is trapped, avoided or mitigated.

However, many things can obstruct this pattern. A negative conjecture can be developed into a preliminary model of failure:

– Detection: 'clues' go unnoticed and/or are misidentified or misinterpreted.
– Communication: information is not distributed or is distorted, clues are masked and suspicion is not conveyed to appropriate actors.
– Sense making: appropriate actors are unaware of the problem or misinterpret the nature and/or significance of the threat.

– Action: zero or inappropriate interventions are made to the social and/or the technical system.

– Response: no change follows inaction or inappropriate intervention; failure persists and/or propagates; system failure may ensue.

The next phase of the synthesis involved testing, revising and refining the preliminary theory. Supplementary literature searches were conducted using keywords and databases, and a snowballing technique (pursuing references of references) was employed. This search strategy is particularly important for locating complex sources of evidence (Greenhalgh and Peacock 2005) for it explores interesting leads and identifies associated literatures such as books, conference papers and selected internet documents.

The selection of articles chosen was based on the criterion 'fit for purpose'. This criterion has been developed by Boaz and Ashby (2003), who suggest that it helps in avoiding the technocratic preoccupation with elegant research designs. Pawson (2002b) concurs, suggesting that the researcher simply asks whether or not the literature retrieved adds anything new to understanding the phenomenon.

Next, the information sources are regarded as cases which are examined for elements of context (c), interventions or design elements (i), generative mechanisms (m) and outcomes (o). The objective is to modify incrementally the nascent theory in view of factors derived from new sources of information and examples of the phenomenon. Space limitations mean that a comprehensive synthesis of the HRO design literature cannot be presented in this paper although we have sustained the focus on (c), (i), (m) and (o) in order to demonstrate the logic of the design propositions and their relationship to existing studies. A comprehensive synthesis of the literature is available upon request from the authors.

Developing an Understanding of Context

One of the key features of context extracted from the literature is the high *social and political pressure* on HROs not to fail (Roberts et al. 1994a). Any failure of hazardous technologies is perceived by operators and the public to have such potentially grave consequences as to warrant its absolute avoidance. Sociopolitical pressure has a direct effect. For example, the nuclear power industry is well aware that public perception influences regulation, and in turn regulation influences industry policies that translate into behaviours (Grabowski and Roberts 1997: 154). The disasters literature also highlights the negative impact of social and political pressure. Vaughan (1996) reports that NASA was under heavy political pressure and in danger of having its budget cut at the time of the ill-fated *Challenger* launch.

The literature reflects the original emphasis of studies of organizations operating in 'high hazard' environments such as nuclear aircraft carriers and nuclear reactors (Roberts 1990), nuclear submarines (Bierly and Spender 1995) and an elite armoured brigade (Zohar and Luria 2003). Recent literature has tentatively linked HRO concepts to medical settings addressing medical errors and enhancing patient safety (Gaba 2000).

A further key feature of the context is *interactive complexity* (Roberts 1990; Zohar and Luria 2003). Roberts (1990) identifies two key contextual factors: complexity and tight coupling. Complexity includes the 'potential for unexpected outcomes', 'complex technologies', 'the potential for systems serving incompatible functions to interact', 'indirect information sources', and 'baffling interactions'. Tight coupling includes 'time-dependent processes', 'invariant sequences of operations', 'the only way to reach the goal', and 'little slack'.

Schulman (1993) argues that HROs can be analysed along two dimensions, behavioural (types of interventions needed) and analytical (types of information needed). He distinguishes decomposable systems, such as air traffic control, where parts of the system can be closed off in case of potential failure, from holistic or tightly coupled systems, such as nuclear power plants, where operational complexity cannot be decomposed and failures can propagate quickly throughout the entire system.

An interesting strand of research has suggested that HRO ideas and concepts are transferable to 'ordinary', low-hazard environments (Zohar and Luria 2003: 855). For example, there is now considerable literature applying the basic notions and concepts of HRO design in schools (Stringfield et al. 2001), software firms (Vogus and Welbourne 2003) and railways (Busby 2006).

This brief inspection of 'context' has identified three general contextual variables that affect reliability: *social and political pressures*, the *extent of the hazard* and the importance of *interactive complexity.*

Developing an Understanding of Interventions and Mechanisms

One of the key mechanisms identified in the literature is *attention*. Reliability is influenced by what people 'pay attention to, how they process it, and how they struggle to maintain continuing alertness' (Weick and Sutcliffe 2001: 19). According to HRO theorists, attention is enhanced through *mindfulness*. Weick and Sutcliffe (2001) identify five processes that contribute to creating and sustaining mindfulness: reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, under-specification of structures, and preoccupation with failure. Perrow (1994: 23), however, argues that 'the warning sign of an incomprehensible and unimaginable event cannot be seen because it cannot be believed'. This is supported by Simons and Chabris' (1999) theory of 'inattentional blindness' which explains how sighted actors become 'blind' to objects in the visual field.

Reliable operations require appropriate actors to conceptualize problems and evaluate potential options. Achieving this requires iteration between what is known and what is expected, and is achieved though a process of *sense making* (Weick 1993). Turner and Pidgeon (1997), in studying disasters, noted the discrepancies between assumptions and actuality. Sense making can be affected adversely when false assumptions are allowed to exist for an extended period of time, a 'disaster incubation period' (Turner and Pidgeon 1997). Other factors distorting sense making include the 'fallacy of centrality' (Westrum 1982) and 'groupthink' (Janis 1972). The former purports to account partly for the accidental shootdown of two helicopters in Iraq along with practical drift – the slow, steady uncoupling of local practice from written procedure (Snook, 2000), while the latter is referred to by Vaughan (1996) as the 'normalization of deviance' in the Challenger disaster.

While effective HRO design needs to invoke the generative mechanisms of attention, mindfulness and sense making, a key issue is the design of communication structures. Weick (1987) emphasizes the need for accurate, sufficient, unambiguous and properly understood communication of rich, real-time information about the health of the system and any anomalies or incidents. Roberts et al. (1994a) report that aircraft carriers have 20 communication devices to connect critical parts of the ship. However, the communication of information on the current 'health' of the system may be impacted where junior organization members are involved. Weick and Sutcliffe (2001: 74) note that:

'With every problem, someone somewhere sees it coming. But those people tend to be low rank, invisible, unauthorized, reluctant to speak up.'

The literature also highlights another generating mechanism triggered by the sharing of information, namely the *heedful interrelating* of actions. While trust, respect and honesty are reported important ingredients in heedfulness (Weick and Roberts 1993: 361), contrary suppositions can be found in the literature in the theories of 'social loafing' (Karau and Williams 1993), and 'diffusion of responsibility' (Latané and Darley 1970).

High-reliability organization designs have a high degree of *specialization*, with staff having relatively fixed and defined organizational roles (Weick 1996). This ensures that:

'specific individuals are assigned to particular areas such that all essential duties are performed and no critical information is overlooked or lost.' (Eisenhardt 1993: 131)

Weick (1996) argues that individuals can be capable of changing their roles very quickly, but when threatened by disaster people may not have access to an appropriate role (see his analysis of the Mann Gulch disaster: Weick 1993).

A key design issue is the juxtaposition of *decentralization and centralization* which, unlike in other organizations, appears to coexist well in HROs (see e.g. Rochlin 1993) although actors often do not perceive the dualities they successfully manage (Rochlin 1993). HROs are malleable authority structures, flexing between a formal routine structure, a competency-based high-tempo structure and a hierarchical emergency structure. The generative mechanisms at work here are well summarized by Eisenhardt:

'Centralization provides coordinating values and permits the best use of experience in the organization. Thus it is reliable. It is also fast as it provides a way to move beyond a conflict deadlock. On the other hand, decentralization allows sensing of action where problems occur. Thus it is likely to lead to faster response because hierarchy is circumvented.' (1993: 133)

The literature reveals another significant dichotomy between *adherence to rules and standard operating procedures* and *improvisation.* Tightly coupled HRO regimes are based on the former. Under threat, individuals tend to adopt behaviours acquired in the past (Weick 1987). Thus, HROs emphasize the importance of training which should encompass procedures and drills, diagnosis and corrective action. But there are limits to formal training in error identification which necessitate knowledge of where the threat resides. Roberts et al. (1994b) argue that extreme accountability may bind a decision maker to an organizationally approved rule, despite the knowledge that another choice would be preferable. Weick (1993) argues that people need to use the resources of the moment and surface their concealed tacit knowledge to formulate improvised solutions to threatening problems. Weick (1993) suggests that the foreman of a firefighting crew survived because he invented a new solution to an unanticipated problem by creating new knowledge unknown by him until then.

Redundancy or slack has also been identified by HRO theorists as a key design element. HROs build reserve capacity into the system to enable them to cope with unexpected circumstances, including backup functions and the overlapping of tasks. Slack can enable organizations to innovate and learn, permitting experimentation with new strategies and projects that might not be approved in more resource-constrained environments. Nohria and Gulati (1996) hypothesize an inverse U-shaped relationship between slack and innovation: too little impedes experimentation and too much leads to complacency and the pursuit of bad projects.

The importance of *learning* in hazardous systems suggests that reliable systems are smart systems (Weick and Roberts 1993). Busenberg (2000), drawing on Popper and Lipshitz (1998), argues that these organizations have learning processes in their cultures, allowing them 'to systematically collect, analyze, store, disseminate, and use information' (Popper and Lipshitz 1998: 170).

In most organizations, errors are tolerated because they enable decision makers to learn through a process of detection and correction, the cost of errors not being as great as the value of information gained from experiential learning (Roberts et al. 1994b: 614). However, since trial-and-error learning is not available to those operating safety-critical systems (Weick 1987), they are required to operate 'trials without error' (La Porte and Consolini 1998: 20) by analysing near-misses and carrying out simulations.

This concise examination of the literature has identified several generative mechanisms: *attention, mindfulness, sense making* and the *heedful interrelating* of *actions*; and several design interventions that can trigger such mechanisms, namely *specialization, decentralization/ centralization, adherence to rules/improvisation, creating redundancy*, and *introducing learning mechanisms*.

Developing an Understanding of Outcomes

On the one hand the literature reveals *high-impact failures* such as the Challenger disaster, Bhopal and Chernobyl, and on other hand identifies organizations that evade failure for extended periods of time. For example, the Pacific Gas and Electric Inc.'s nuclear power plant was chosen by the Berkeley group as the best facility in the USA in 1989. Its electrical distribution grid was 99.96% reliable in terms of outages over the period of the study. The Federal Aviation Authority air traffic control system suffered no mid-air collision between aircraft under their positive control in the 1980s (Roberts 1990). Roberts (1990: 147) presents data on safety aboard US Navy carriers, including the fact that the last major deck fire attributable to anything other than doing battle occurred in 1969.

The literature also reveals data on *error rates*. For example, the *error rate* for US Navy aircraft dropped from over 50 fatalities per 100,000 hours of flight time in 1949 to 2.97 fatalities per 100,000 in 1988. Likewise, in studying an elite armoured brigade, Zohar and Luria (2003) found injury rates per 100 soldiers reached 0.14, lower than the army average for all ground forces. Similarly Roberts et al. (1994a: 147) report that in 1980 the US Navy had as few as 1.89 class A (involving a fatality or property damage to aircraft exceeding one million dollars) accidents for every 100,000 flight hours.

This succinct assessment of outcomes reveals two key variables: *high-impact failure* and *error rates*.

HRO Design Propositions

Searching the research base of a discipline from the perspective of a given field problem usually results in identifying whole sets of variables (C), (I), (M) and (O). These deal with both overall design principles as well as more detailed variables, giving the set a multilevel and possibly nested structure. But a special characteristic of design propositions lies in their combinational nature. That was what we found in the field of HRO design, offering not precise instructions to practitioners, but providing an opportunity to configure the CIMO-logic as a result of the rich evidence. For example, one tentative HRO design proposition runs as follows:

In contexts characterized by social and political pressure, interactive complexity and high hazard, in order to avoid high-impact failure and reduce error rates,

> I^1 Maintain a state of attention and alertness by creating new categories, exploring multiple perspectives and focusing on process; be concerned about the unexpected;
>
> I^2 Continuously communicate rich, real-time information about the health of the system and any anomalies or incidents; this should be accurate, sufficient, unambiguous and properly understood; be aware that juniors are unlikely to speak up;
>
> I^3 Foster heedful interrelating by engendering loyalty, commitment and camaraderie in the group; promote support, trust and cooperation as key values; make people accountable and do not diffuse responsibility to others: in an HRO 'the buck stops everywhere';
>
> I^4 Encourage specialization and ensure role clarity; help individuals understand the roles of others; allow people to 'try on' various other roles in safe environments;
>
> I^5 Be sensitive to the possible interactive complexity of the system;
>
> in holistic systems reinforce adherence to rules and standard operating procedures; centralize during high tempo or emergency situations; be aware of the dangers of mechanistic routinization and practical drift;
>
> in decomposable systems decentralize decision making to those with competence and experience especially during high tempo and emergency situations; ensure that core values are socialized before people are allowed independence;

I^6 Provide an environment for appropriate actors to create order, make retrospective sense of what occurs and evaluate potential options; be aware that sense making can be affected by groupthink, the fallacy of centrality and the normalization of deviance;

I^7 Build redundancy into the system to enable it to cope with unexpected circumstances; be aware that too little slack impedes experimentation and too much leads to complacency and the pursuit of bad projects;

I^8 Systematically collect, analyse, store, disseminate and use information relevant to the performance of the system; create and share a set of values that supports the learning process; study events that could have resulted in failure and carry out 'trials without error' frequently.

When one finds such sets of interventions, it is important to acknowledge that the elements of organizational design are interdependent and configurational. To achieve an outcome in a given setting it is not possible to do simply I^1. Managers need to adopt $I^1 + I^2 + I^3 + I^n$… In other words, the design proposition is comprised of a combination of interventions (I^1…I^n) that invoke particular generative mechanisms (M^1…M^n) to produce a particular outcome (O) in a specific context (C). Not understanding the CIMO-logic and dynamics between combinations can have catastrophic effects. For example, encouraging individual acts of heroism, effective in decomposable systems, could lead in tight coupling to unpredictable behaviour and potential catastrophe.

Discussion and Conclusion

This article began by identifying two key and enduring challenges facing the field of management and organization studies, namely, its fragmented nature and the challenge of applicability of findings to policy and practice. First, fragmentation of the field has proved an enduring feature, posing an intriguing problem that is well documented. For example Whitley (1984a; 2000) characterizes the field as 'a fragmented adhocracy'. He suggests that:

> 'this sort of scientific field is characterized by a high degree of task uncertainty and a low degree of co-ordination of research procedures and strategies between researchers and research sites. Research in these fields is rather personal, idiosyncratic and open to varied interpretations.' (Whitley 1984a: 341)

This fragmentation refers both to groups of researchers and to types of knowledge products (Koontz 1980; Whitley 1984a, 2000; Pfeffer 1993). The defining characteristic of fragmentation is the lack of interaction between researchers and research groups resulting in limited use of knowledge products (Tranfield and Starkey 1998), sometimes justified on the grounds of incommensurable underlying paradigms (see e.g. Jackson and Carter 1991).

Fragmentation is seen by some as a weakness. Tranfield and Starkey (1998) quote Gouldner's (1971) comment (of sociology) that 'a fragmented field is a weak field'. Pfeffer (1993) suggests as a solution that some elites should impose their theoretical views and priorities on the field, thus closing the ranks and having more impact externally (see e.g. Canella and Paetzold 1994 and Van Maanen 1995 for a strong opposition to this solution).

Organizations are fuzzy, ambiguous, complex socially constructed systems that cannot be well understood from a single perspective. If understanding, both of problems and solutions, is to guide actions to improve organizational performance, the diversity and richness produced by fragmentation has to be viewed and harnessed as a strength rather than seen as a weakness, using this diversity to create synergies.

The central challenge of research syntheses in management and organization studies lies in locating and integrating information sources from many subfields, often each using idiosyncratic methods. It is to this critical issue that this article speaks, offering design-oriented research synthesis as an appropriate mechanism and vehicle to help overcome challenges and capitalize upon difference and diversity.

Second, while the production of management and organizational research has increased rapidly over recent years, creating an extensive knowledge base that has the potential to inform the design of interventions or systems for improving performance, there have been few clear signs that published materials have noticeably impacted practice. The growing recognition within organizations of the need to exploit knowledge assets requires methodologies for systematically integrating research evidence and developing and capitalizing its application potential.

Tranfield et al. (2003) published a conceptual design for a methodology for evidence-informed management, initially modelled on but significantly transformed from, medical science. Pfeffer and Sutton (2006) published similar ideas and in the same year Rousseau (2006) used her presidential address to the American Academy of Management to discuss this subject. In many social science fields such as education, social policy and criminal justice, guidance for policy and practice already results from reviews and syntheses of the science base (Petticrew 2001). This article has shown how transferable lessons can be identified from existing studies to support an evidence-informed approach to practice. In particular, we propose design-oriented research synthesis as an appropriate methodology for developing field-tested design propositions, following CIMO-logic.

A quest for truth results in competing knowledge claims and thus in fragmentation. A quest for improving the human condition welcomes anything that contributes to solving field problems and thus cherishes diversity. Design-oriented research synthesis uses the entire, diverse knowledge base on a given class of field problems to produce deep understanding of interventions that, in given contexts, produce intended outcomes by invoking certain generative mechanisms. Developing this rich solution-oriented knowledge contributes both to increased understanding and the practical relevance of our field.

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