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Developing dynamic organizational theories; three system dynamics based research strategies

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Abstract
There is an increasing attention for dynamic organizational theories. The *system dynamics* methodology, although originally developed for practical contributions, is increasingly used to develop dynamic theoretical contributions. However, these studies differ substantially in the research designs they apply. Some of these studies adopt a quantitative approach while others adopt a qualitative approach. Some of these studies focus on testing existing theories, while other studies focus on building theory or combine both theory testing and building. This variety hinders an effective understanding of the methodology. To increase clarity, this paper provides a systematic review of system dynamics based theoretical contributions in organizational theory between 1990 and 2016. By looking at differences and commonalities I show how various methodological decisions combine into three distinctive internally consistent system dynamics based research strategies for theoretical contributions. These results support making methodological decisions in future research designs when applying system dynamics to develop dynamic organizational theories.

Keywords Dynamic theory · Research design · Longitudinal research · Literature review · System dynamics

1 Introduction

A growing number of management scholars are developing dynamic theories, i.e. theories that explain how organizational phenomena change over time. Although longitudinal research is not nearly as popular as cross-sectional research, more and more scholars employ various research designs that allow including a time dimension (Bryman and Bell 2015). These designs focus attention on "how and why things emerge, develop, grow, or terminate over time" (Langley et al. 2013, p. 1). This is relevant because it complements

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cross-sectional research which shows *what* works, by identifying "*how* to produce the changes that the evidence suggests are desirable", thereby producing actionable knowledge (Langley et al. 2013, p. 4). While dynamic theories in themselves are far from new (Van de Ven and Huber 1990; Porter 1991), this trend is partly driven by the increasing availability of continuous streams of data (Luciano et al. 2018).

An increasing number of dynamic theories build on a methodology called 'system dynamics' (Forrester 1961, 1969). Despite the traditional focus of system dynamics on practical contributions, it is increasingly used to test and build theory (de Gooyert 2016). There is great variety in the ways that system dynamics has been applied to develop theoretical contributions, including both qualitative and quantitative research designs, and including designs focusing on testing theory, building theory, or both. This diversity in applications potentially hampers an effective understanding of the methodology as applied in organizational research. It is my aim in this study to resolve such confusion by advancing our understanding of the different ways there are to make system dynamics based theoretical contributions to management literature. I do so by showing how different methodological decisions combine into internally coherent research designs. To this end, I provide a systematic review of system dynamics based theoretical contributions in management theory between 1990 and 2016. As a result, this study helps smoothing the way for future system dynamics based theoretical contributions.

2 Background

System dynamics is a methodology that emerged out of servomechanisms engineering and has been applied to a wide range of complex systems consisting of both physical aspects as well as human behavior (Richardson 2001). It aims to understand the behavior of phenomena over time by mapping out the underlying causal relations. At the heart of the approach is the idea of circular causality or feedback loops: some causal mechanisms have the tendency to reinforce an initial action, while others have the tendency to oppose initial action (Sterman 2000). Explaining behavior of a system through the underlying feedback loops provides an endogenous explanation of a phenomena: it shows how behavior is the results of the structure of the system itself, not exogenous factors (Richardson 2001). By looking at the interaction between multiple factors the models often result in non-linear behavior: effects are rarely proportional to causes (Sterman 2000).

The traditional focus of system dynamics has been on providing practical contributions, i.e. explicitly aimed at achieving change; this focus is reflected in the main system dynamics textbooks (Ford 2009; Maani and Cavana 2007; Morecroft 2007; Sterman 2000; Richardson and Pugh 1981; Wolstenholme 1990). More recently, the methodology is increasingly applied with a focus on theoretical contributions to organizational theory, focused on expanding knowledge rather than achieving change. In dynamic theories the two often come together, as dynamic theories often work toward actionable knowledge through improving understanding of phenomena over time.

System dynamics based studies developing dynamic theories differ greatly in the research designs they adopt. Some use existing theory as a starting point (Gary 2005; Repenning 2002; Sastry 1997), while others use observations of a yet unexplained phenomenon as a starting point (Oliva and Sterman 2001; Rudolph and Repenning 2002; Sterman et al. 1997). Some focus on mathematical simulations, while others adopt a purely qualitative design (Perlow et al. 2002; Repenning and Sterman 2002). Some studies test an existing theory (Sastry 1997), while others *build* theory (Perlow et al. 2002). The aim of this paper is to shed light on the different ways in which system dynamics is used to provide theoretical contributions to organizational theory. This is relevant as it aids scholars in explicitly and consciously making coherent decisions in their research design when applying the system dynamics methodology.

3 Method

3.1 Scope of literature review

This study applies a systematic literature review of system dynamics based theoretical contributions in management literature. To find theoretical contributions to management theory with considerable impact, I confined the search to top management journals: Academy of Management Review, Academy of Management Journal, Journal of Management, Management Science, Organization Science, Journal of Management Studies, Strategic Management Journal, and Administrative Science Quarterly. I used Google Scholar to find relevant articles. Articles in Management Science were collected directly through the publisher's website, because searching on 'Management Science' in Google Scholar returns hundreds of articles in other journals that include the words management and science. I searched for the exact phrase 'system dynamics' (not case sensitive) in any part of the article. The date range was specified as 1990–2016, and the search was performed on February 3, 2016. As a next step, I manually removed those articles that do not use system dynamics to provide a theoretical contribution, for example because they provide a literature review themselves, or because they focus on a methodological contribution rather than a theoretical contribution. Other articles were excluded for example because system dynamics only showed up in a biography of one of the authors, in the appendix, or in the references, or because system dynamics was only briefly mentioned. In addition to the search on Google Scholar, papers were searched in the same journals using version 2016a of the System Dynamics Bibliography (available at http://www.systemdynamics.org/bibliography/) and by looking into suggestions I received during the presentation of an earlier version of this study at the 2016 International Conference of the System Dynamics Society. This yielded four additional papers.

Searching on system dynamics in top management journals between 1990 and 2016 yielded 163 hits. After excluding all the hits that did not represent system dynamics based theoretical contributions to management theory, 34 articles remained. Table 1 below shows how those articles were distributed over the seven management journals.

3.2 Coding scheme

Each of the 34 articles selected for the review was coded for (1) whether it adopts a qualitative or a quantitative research design, (2) whether it focuses on theory building or theory testing, and (3) how it uses system dynamics to generate a theoretical contribution. The three dimensions are elaborated on below. All articles were independently coded by two researchers and differences were discussed until consensus on coding was achieved.

Table 1 Total number of system dynamics based theoretical contributions per major management journal

Journal	# Articles
OSc	9
MSc	7
SMJ	6
ASQ	5
AMJ	2
JoM	2
JoMS	2
AMR	1

3.2.1 Qualitative versus quantitative

Originally, system dynamics focused on computer simulation as a method to study the implications of a system's structure for its behavior (Forrester 1961). Over time, the ideas of feedback loops and endogenous explanations of behavior were also applied qualitatively, through mapping the structure of a system in causal loop or stock and flow diagrams (Wolstenholme 1999). System dynamics based theoretical contributions to organizational theory encompass both qualitative and quantitative research designs.

3.2.2 Theory building versus theory testing

Commonly a distinction is made between two types of theoretical contributions: theory *testing* and theory *building*. Studies testing theory typically "use theory to formulate hypotheses before testing those hypotheses with observations (Hempel 1966; Popper 1965)" (Colquitt and Zapata-Phelan 2007, p. 1282). Studies building theory "begin with observations that the authors use to generate theory through inductive reasoning (Chalmers 1999)", and they "typically conclude with a set of propositions that summarize the resulting theory" (Colquitt and Zapata-Phelan 2007, p. 1282). Of course, many studies combine elements of both theory testing and theory building, but the focus is often on one of these two types of theoretical contributions (Colquitt and Zapata-Phelan 2007). Although exceptions exist, quantitative studies are often used for theory testing, while "the prevailing wisdom has been that qualitative research is more useful for theory building than theory testing" (Sutton and Staw 1995, p. 382). As system dynamics is used both quantitatively with simulation models and qualitatively with causal loop or stock and flow diagrams, it is to be expected that system dynamics can be used for both theory testing and building. Davis et al. (2007), who discuss simulation modeling based theoretical contributions, argue that simulation studies are especially useful for the 'sweet spot' in between the two extremes (Davis et al. 2007, p. 480). They state that simulation modeling is helpful to elaborate rough, basic theories into logically precise and comprehensive theory, that then is enough developed to be examined empirically in further studies (Davis et al. 2007, p. 481).

3.2.3 The use of system dynamics

Harrison et al. (2007) discussed how simulation modeling in general can help at arriving at theoretical contributions in management literature. They distinguish between three types of simulation models: system dynamics models, agent-based models, and cellular automata models (Harrison et al. 2007, pp. 1237–1238). Building on Axelrod (1997), they suggest that seven different uses of simulation models exist: *predictions* where empirical confirmation of relationships in simulation output provide indirect support for unobserved processes, *proof* where simulation output shows that the suggested relationships are able to produce certain types of behavior, *discovery* where the interaction of processes result in unexpected consequences, *explanation* where models result in behavior as in *proof* but with the addition that conditions under which the outcomes are produced are also illuminated, *critique* where simulation is used to asses preexisting explanations, *prescription* where simulations show more efficient ways of organizing, and *empirical guidance* where simulations help develop new empirical strategies for testing relationships that the simulation model uncovered (Harrison et al. 2007, pp. 1238–1240). While *prescription* and *empirical guidance* are relevant for research in the broader sense, they have little relevance when focusing on *theoretical contributions*, since prospection is about the implications of theory and empirical guidance is about the design of research that leads up to theory. The other uses however, *prediction, proof, discovery, explanation,* and *critique*, might resemble various ways of using system dynamics.

4 Results

Iteratively comparing commonalities and differences between the articles resulted in a typology of four main research strategies to use system dynamics for theoretical contributions in management literature. See for the final coding of all articles the electronic appendix.

1. *Grounded theory building* (7 articles). These articles start from large bodies of qualitative data. Iterating between theory and case data leads to the development of qualitative models (causal loop and/or stock and flow), and thereby to new theory.
2. *Conceptual virtual laboratory* (12 articles). These articles focus most heavily on a quantitative model and scenario runs/sensitivity analyses. The articles do not use empirical data, instead existing theories are formalized and/or combined to derive new insights.
3. *Phenomenon replicating explanation* (9 articles). These articles have some form of empirical data and use a quantitative simulation model to replicate a reference mode of behavior. In addition, what-if scenarios are ran to develop new insights that go beyond the empirical data from which the study started.
4. *Management flight simulator* (6 articles). These articles let subjects use a system dynamics based simulation model. Up front hypotheses are developed, embedded in existing theory. Statistical analyses are used to test these hypotheses. Because system dynamics is only used indirectly in this research strategy (as a stimulus for research subjects, rather than a method to develop theory by the researcher him/herself), this research strategy is

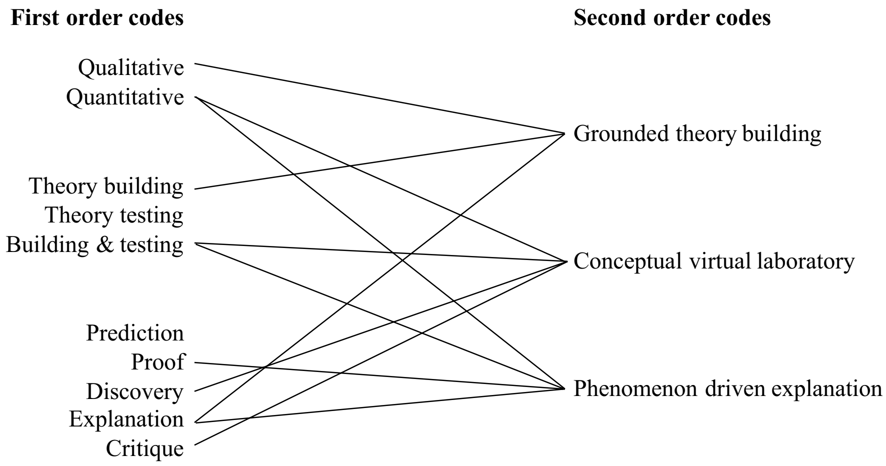

Fig. 1 Relation between first and second order code

not included in the discussion of system dynamics based research design for theoretical contributions below.

Figure 1 below shows how the first order codes relate to the research strategies summarized above (again, management flight simulators left out).

The full list of the 34 articles is shown in Table 2 below including their research strategy. Articles were categorized as '1' if the study has a qualitative system dynamics model, as '2' in case of a quantitative model without empirical data and '3' for a quantitative model with empirical data, and as '4' if the study describes flight simulator experiments. The titles of the respective articles can be found in the references.

4.1 Research strategy 1: grounded theory building

Grounded theory building is a research strategy where large bodies of data are collected, and theory is built by iteratively reflecting between existing theory and the collected data. This procedure is described in Burchill and Fine (1997) as the 'Inductive System Diagram methodology'. Although later articles have not adopted this name, their description closely fits the procedure as followed by later 'grounded theory building' articles. From Burchill and Fine (1997, p. 469):

> Inductive System Diagrams combine aspects of Grounded Theory methods (Glaser and Strauss 1967; Glaser 1978; Strauss 1987) and System Dynamics (Goodman 1974; Randers 1980). Grounded theory approaches are used to develop variables which have significant explanatory power and are intimately tied to the data. The cause and effect relationships among these variables are then shown using causal-loop diagramming techniques from the field of system dynamics (Forrester 1958, 1961). This combination of grounded theory and causal-loop diagramming allows researchers to generate and communicate substantive theories intimately tied to the data which can be evaluated against the criteria of: verifiable data, explicit inferences and disconfirmable predictions.

Table 2 System dynamics based theoretical contributions in major management journals in the period 1990–2016

	Authors	Journal	Year	Strategy
1	Paich and Sterman	MSc	1993	4
2	Sengupta and Abdel-Hamid	MSc	1993	4
3	Burchill and Fine	MSc	1997	1
4	Lomi, Larsen, and Ginsberg	JoM	1997	2
5	Sastry	ASQ	1997	2
6	Sterman, Repenning, and Kofman	MSc	1997	3
7	Moxnes	MSc	1998	4
8	Sterman and Wittenberg	OSc	1999	2
9	Oliva and Sterman	MSc	2001	3
10	Crossland and Smith	SMJ	2002	3
11	Nickerson and Zenger	OSc	2002	3
12	Perlow, Okhuysen, and Repenning	AMJ	2002	1
13	Repenning	OSc	2002	2
14	Repenning and Sterman	ASQ	2002	1
15	Rudolph and Repenning	ASQ	2002	3
16	Black, Carlile, and Repenning	ASQ	2004	3
17	Romme	OSc	2004	2
18	Gary	SMJ	2005	2
19	Vancouver, Tamanini, and Yoder	JoM	2010	2
20	Duintjer Tebbens and Thompson	MSc	2009	2
21	Rudolph, Morrison, and Carroll	AMR	2009	3
22	Azoulay, Repenning, and Zuckerman	ASQ	2010	1
23	Kunc and Morecroft	SMJ	2010	4
24	Lomi, Larsen, and Wezel	OSc	2010	2
25	Gary and Wood	SMJ	2011	4
26	Walrave, Van Oorschot, and Romme	JoMS	2011	3
27	Gary, Wood, and Pillinger	SMJ	2012	4
28	Goh, Love, Brown, and Spickett	JoMS	2012	1
29	Rahmandad	OSc	2012	2
30	Van Oorschot, Akkermans, Sengupta, and Van Wassenhove	AMJ	2013	1
31	Anderson and Lewis	OSc	2014	2
32	Etzion	OSc	2014	2
33	Martinez-Moyano, McCaffrey, and Oliva	OSc	2014	1
34	Rahmandad and Repenning	SMJ	2016	3

In the same article, the following aspects are mentioned as strengths of this approach (Burchill and Fine 1997, p. 471):

> The strengths of the inductive system diagram method are: (1) its clarity and conciseness in representing and structuring the proposed theory and its dynamics, (2) its flexibility to be continually updated to reflect the accumulated body of knowledge and field data, and 3) its rigor attributable to a focus on verifiable data, explicit inferences, and testable predictions, all of which provide a high level of transparency and

> auditability, easing the process of evaluating the validity of both the proposed theory and the theory generation process.

Grounded theory building articles use system dynamics qualitatively rather than quantitatively, for example using ethnography (Perlow et al. 2002), fieldwork (Azoulay et al. 2010) or a case study (Van Oorschot and Akkermans 2013). That is, a theoretical contribution is made using causal loop diagrams or stock and flow diagrams without using formulas and data to calculate and compare simulation runs.

4.2 Research strategy 2: conceptual virtual laboratory

The research strategy 'conceptual virtual laboratory' most closely resembles the research strategy as proposed by Davis et al. (2007): existing 'simple' theories are used as a starting point and the implications of combining theories are 'discovered' through extensive scenario analysis/sensitivity analyses. For example, Nickerson and Zenger (2002, p. 548) state: "Our theory […] follows directly from very basic assumptions in organization theory". Repenning (2002, p. 110) describes the approach as follows:

> [In] this paper I take an approach quite different from those present in the existing literature. I do not report new data, demonstrate the existence of a new variable, or test the strength of a specific linkage between two variables. Instead, the principal contribution of my effort is to derive new insights from established variables and relationships. […] I use the development and analysis of a simulation model to characterize the range of organizational outcomes that these processes generate. The end result is an internally consistent theory that, while firmly grounded in previous work, reaches a new level of specificity concerning the determinants of implementation success and failure.

As such, conceptual virtual laboratories are employed to 'generate theory from theory' (Rudolph and Repenning 2002, p. 3):

> Unlike many formal models in the social science literature, ours was not deduced from general principles but, using the methods of grounded theory, was induced from theories and data from a range of domains. While commonly used to build theory from raw data using qualitative analysis, the grounded theory approach is not limited to this activity. Strauss and Corbin (1994) advocated the development of formal (or general) theories grounded in previously generated domain-specific (what they call substantive) analyses. They reminded the reader that Glaser and Strauss (1967) not only urged the use of grounded theory in conjunction with quantitative (not just qualitative) analysis but also recommended its use to generate theory from theory.

Rather than looking at the implications of causal relationships that had not been considered yet, these studies discover new implications of causal relationships that were already known. For example, Lomi et al. (1997) use an existing model to "examine the boundaries between regions of stable and unstable behavior that can be found on a policy-making space" (Lomi et al. 1997, p. 568).

Some of the conceptual virtual laboratory studies explicitly use the computer model to critique the theories they used as a starting point. Trough formalizing the existing theory, these studies reveal internal inconsistencies. Sastry (1997) for example starts with stating: "a simulation model that formalizes the conventional theory of punctuated organizational change highlights a problem: under a wide range of conditions, organizations appear to fail following reorientation" (Sastry 1997, p. 237). Similarly, Vancouver et al. (2010) state: "we use modeling to see whether the uncertainty reduction hypothesis, which underlies much of the socialization literature […] is viable" (and even go as far as saying that "better theory means dynamic computational theory, Vancouver et al. 2010, p. 2). These latter studies present themselves as theory testing rather than theory building, as for example described by Sterman and Wittenberg (1999, p. 338):

> [W]e seek to demonstrate that it is both desirable and possible to portray in a formal model the causal hypotheses embodied in written theories of scientific endeavor and test whether they can generate the dynamics as those authors see them. The process of formalizing such hypotheses helps to identify inconsistencies, implicit assumptions, glosses, and errors in the mental simulations authors necessarily perform to infer the dynamics of science from their theories of its structure.

Repenning makes a similar remark (2002, p. 110):

> Human ability to reliably infer the behavior of even low-order dynamic systems is exceedingly limited. While the typical experimental study focuses on the ability of managers to control a dynamic process (e.g., Diehl and Sterman 1995; Brehmer 1992; Sterman 1989), the observation applies equally well to researchers trying to infer the dynamic consequences of their theories.

4.3 Research strategy 3: phenomenon driven explanation

The third research strategy uses system dynamics to show how a set of causal relationships can be responsible for a specific phenomenon. A typical starting point in these articles is something like: 'current theories fail to explain the observed phenomenon'. Repenning and Sterman (2002) for example observe that organizational theories do not explain why useful innovations often go unused: "existing theory offers little to explain why", and "the structures, processes, and feedbacks that influence whether an organization learns or stagnates, whether a promising improvement program is adopted or rejected, remain largely unknown" (Repenning and Sterman 2002, p 266).

With a phenomenon as starting point, the 'phenomenon driven explanation' articles develop a simulation model as a 'dynamic hypothesis', a potential explanation of the phenomenon by proposing the structure, in terms of causal relations, that drives the behavior. While conceptual virtual laboratories may rely on earlier theories instead of empirical data, phenomenon driven explanations often gather empirical data to have a 'reference mode of behavior'. If the developed computer model is able to simulate this reference mode of behavior, this is seen as an important step of validating the dynamic hypothesis. The procedure is explained by Sterman et al. (1997, p. 504) as follows:

> Our approach involved three steps. First we constructed a detailed history of TQM at Analog Devices using interview, archival, and statistical data (§2). We then generated hypotheses about the decision processes and feedback structures that created that history. Third, we developed a formal simulation model to test these hypotheses and explore policies (§§3 and 4).

Some articles using the 'conceptual virtual laboratory' strategy or the 'phenomenon driven explanation' strategy mention that for them the purpose of simulation lies in the 'synthesis' of different lines of theory. Surprisingly, 'synthesis' is absent in the list of seven purposes of simulation models as proposed by Harrison et al. (2007). A typical starting point in these articles is something like: ‘a phenomenon is complex, therefore, synthesis of several existing theories is needed to understand the process behind the complex phenomenon’. Crossland and Smith (2002) for example combine theories on demand queues and theories on information cascades to “evaluate the probable related effects that may occur” (Crossland and Smith 2002, p. 417). Some articles use two hitherto separate literature streams rather than specific theories to synthesize existing knowledge. Rahmandad and Repenning (2016) for example build on learning curve literature and organization failure literature: “by connecting the two disparate literatures, an explicit theory of capability erosion offers the possibility of new explanatory mechanisms to understand firm heterogeneity and an enhanced understanding of organizational demise” (Rahmandad and Repenning 2016, p. 652).

5 Discussion

Between 1990 and 2016, 34 articles have provided system dynamics based theoretical contributions in top management journals. These studies make very different methodological decisions. Some adopt a qualitative approach, while other adopt a quantitative approach (Wolstenholme 1999). Some focus on building theory, while others focus on testing theory, and yet others combine the two (Colquitt and Zapata-Phelan 2007). They use the system dynamics methodology for different ends, varying from proof, discovery, and explanation, to critique (Harrison et al. 2007). By showing this diversity, my review painted a very different picture of the system dynamics methodology compared to the traditional system dynamics textbooks that present a single sequence of steps to be followed when using system dynamics (Ford 2009; Maani and Cavana 2007; Morecroft 2007; Sterman 2000; Richardson and Pugh 1981; Wolstenholme 1990). Moreover, the diversity does not align with the idea as expressed by Davis et al. (2007) that there is a single established procedure for using simulation to arrive at a theoretical contribution.

The different methodological decisions that can be made when designing research should be aligned in order to achieve *methodological fit*, i.e. “internal consistency among elements of a research project” (Edmondson and McManus 2007, p. 1155). Some combinations of decisions are more logical than others. Qualitative research is more appropriate when few existing theories are available on an organizational phenomenon, because it allows to go into depth and provide the nuance that is necessary when conceptualizing new variables and construing new theories (Colquitt and Zapata-Phelan 2007). When knowledge has been accumulating and theories on an organizational phenomenon are more mature, it is more appropriate to test theories by formalizing combinations of existing theories as building blocks (Davis et al. 2007). Comparing the methodological decisions made by the articles in this review revealed three internally consistent research strategies for system dynamics based theoretical contributions: ‘grounded theory building’, ‘conceptual virtual laboratory’, and ‘phenomenon driven explanations’.

Grounded theory building uses qualitative research to develop new theory, using causal loop or stock and flow diagrams that are common in system dynamics to explain organizational phenomena. Compared to qualitative studies that do not use system dynamics in any way, these studies add clarity and conciseness by using diagrams that are particularly suitable for showing the implications of circular causality, or feedback loops, for how phenomena develop over time (Burchill and Fine 1997, p. 471). System dynamics as such helps appreciating the mutual causality that emerges when phenomena are studied over time (Perlow et al. 2002, p. 932). In addition, using such diagrams helps integrating various strands of theory by showing their interrelatedness (Martinez-Moyano et al. 2014, p. 333). Limitations to such studies are the limited generalizability that comes with focusing on one or just a few cases (Repenning and Sterman 2002), and the necessity of testing the developed propositions in additional studies (Azoulay et al. 2010, p. 500), as typical for explorative qualitative research.

Conceptual virtual laboratories use quantitative research to test and develop theory, using sensitivity analyses to discover the relative importance of variables for producing certain modes of dynamic behavior, or the unexpected consequences of combinations of simple processes (Harrison et al. 2007). The virtual laboratory is used to carry out 'simulation experiments' (Rahmandad 2012, p. 150), which allows to consider all kinds of conditions that would be difficult to observe in practice (Lomi et al. 2010, p. 133). Specific expectations about which conditions are likely to produce interesting results are not necessary as the additional costs of running more experiments across large parameter spaces are low. System dynamics then allows to explore the implications of combining existing theories for the behavior of the system (Gary 2005, p. 645). In addition, translating existing theories into mathematical relationships in formal models supports testing the internal consistency of these theories (Sastry 1997, p. 237). A limitation of these studies is that formalizing theories requires simplifications, leaving out much of the details that the model departs from (Sastry 1997, p. 267), and requires assumptions that may need further scrutiny by additional studies (Lomi et al. 2010, p. 146).

Phenomenon driven explanations also use quantitative research to test and develop theory but focus on explaining observed behavior rather than discovering unexpected behavior under experimental conditions. Thus, where conceptual virtual laboratories typically have little expectations to guide the analysis and explicitly aim to *discover* surprising results, phenomenon driven explanations are guided by very concrete expectations about the behavior that the simulation model should be able to produce and aim to *explain* that behavior. Where conceptual virtual laboratories may fully rely on earlier research, phenomenon driven explanations gather empirical data to test their dynamic theory. It is a 'history-friendly approach' in that it "serves to map the evolution of a specific empirical case against the developmental predictions drawn from a model" (Walrave et al. 2011, p. 1732). Compared to qualitative approaches, developing a formalized model provides a tool that helps providing a "bridge between thick description and broader theoretical generalizations" (Black et al. 2004, p. 605). Because phenomenon driven explanations rely on empirical data from one or just a few cases the same limitation on generalizability holds as with grounded theory building (Rahmandad and Repenning 2016, p. 668). In addition, by focusing on certain aspects of phenomena and not others, the same limitation of necessary simplifications holds as with conceptual virtual laboratories (Rudolph and Repenning 2002, p. 24).

Theoretical contributions increase our understanding of phenomena, and therefore come with implications for earlier explanations of that same phenomenon (Davis 1971). Existing knowledge may be rendered obsolete. The origin of these new insights that contradict existing theories is very different for the three research strategies. Grounded theory building creates new knowledge by iteratively contrasting thick descriptions of field data with existing literature as is common for inductive studies (Burchill and Fine 1997, p. 468). The origin of new insights can be traced back to the gathered data, with earlier theories guiding the analysis of that data. Conceptual virtual laboratories run large numbers of experiments to investigate the sensitivity of organizational phenomena for certain variables, not necessarily based on a priori expectations about the importance of those variables. By running what-if scenarios across large parameters the strength of the causal relations is discovered, providing new insights. The origin of new insights then lies in the simulation runs that resulted from the model. Phenomena driven explanations provide new insights by showing how an alternative dynamic hypothesis is better able to produce observed behavior than existing theories, by confronting it with empirical data. In this case, new insights emerge from the *interaction* of existing theories that together proof to be able to produce observed behavior.

6 Conclusion

Management scholars increasingly aim to develop dynamic theories, explaining how organizational phenomena develop over time. This study described three internally consistent research designs that use system dynamics to develop dynamic theoretical contributions: grounded theory building, conceptual virtual laboratories, and phenomenon driven explanations. These research strategies help to appreciate the implications of circular causality, non-linearity, and delays that become relevant when phenomena are studied over longer periods of time. The current study aids the development of dynamic organizational theories by providing more clarity on how system dynamics is used to arrive at theoretical contributions.

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