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THEORIZING THE MULTIPLICITY OF DIGITAL PHENOMENA: THE ECOLOGY OF CONFIGURATIONS, CAUSAL RECIPES, AND GUIDELINES FOR APPLYING QCA[1]

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Faced with the challenge of multifaceted digital phenomena, researchers in IS and related fields have increasingly adopted qualitative comparative analysis (QCA). However, in the absence of explicit guidelines for how to use QCA for theory development, the popularity and proliferation of QCA possibly amplifies the risk of using QCA in an atheoretical manner, hindering theoretical advancement. In this paper, we offer a conceptual framework and prescriptive guidelines for applying QCA to develop causal recipes that account for complex digital phenomena marked by theoretical and configurational multiplicity. Causal recipes are formal statements explaining how causally relevant elements combine into configurations associated with outcomes of interest. We describe these causal recipes in terms of which causes matter (i.e., factorial logic) and how these causes combine into configurations (i.e., combinatorial logic) to produce target outcomes, and propose an ecology of configurations that elucidates the explanatory power of multiple configurations as well as their explanatory overlap. Further, we offer two illustrative empirical examples to demonstrate the usefulness of our framework and step-by-step guidelines for applying QCA to deductive theory testing as well as inductive theory development on phenomena marked by multiplicity.

Keywords: Theoretical multiplicity, configurational multiplicity, causal recipes, the ecology of configurations, qualitative comparative analysis (QCA)

Introduction

The need to better capture the multifaceted nature of business phenomena has recently been emphasized by researchers across a variety of business fields, including information systems (IS) (El Sawy et al. 2010; Yoo et al. 2010), marketing (e.g., Woodside 2013), management (e.g., Misangyi et al. 2017), and accounting (e.g., Bedford et al. 2016; Erkens and Van der Stede 2015). This issue appears to be especially relevant to the IS field, where the ubiquity of information and digital technologies along with their interdependencies with organizational and environmental elements have created a world characterized by multifaceted complexity (El Sawy et al. 2010; Orlikowski and Scott 2008; Yoo et al. 2012, 2010). As a result, IS researchers are confronted with the challenge

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of having to both theorize and empirically explain the multifaceted nature of digital phenomena; a nature that we argue is frequently marked by *theoretical multiplicity*—the applicability of multiple theoretical perspectives—as well as *configurational multiplicity*—the existence of multiple configurations of relevant factors for a given theoretical perspective.

We currently lack a conceptual framework that enables researchers to study theoretical multiplicity—how different theoretical perspectives may compete or complement each other in explaining such multifaceted phenomena. Further, to study configurational multiplicity, scholars in IS and related fields have increasingly adopted a configurational approach. In particular, qualitative comparative analysis (QCA), a set-analytic method (Ragin 2000, 2008) is becoming more widely used due to its ability to handle causal complexity (Fiss 2007, 2011; Misangyi et al. 2017). QCA was originally introduced to the IS literature as an innovative research approach for investigating complex digital phenomena (El Sawy et al. 2010; Fichman 2004), and a growing number of IS studies are using QCA as their main research approach (Dawson et al. 2016; Park et al. 2017; Park and Mithas 2020; Rivard and Lapointe 2012). While these studies have begun to establish QCA as an empirical approach to studying configurational multiplicity, they have largely been focused on its methodological aspects and have neglected how QCA might enable researchers to attend to theoretical multiplicity. Specifically, in the absence of conceptual framework and prescriptive guidelines for researchers in using QCA for theory development, applications of QCA can be atheoretical and often driven by the availability of data, resulting in potentially spurious findings and little theoretical advancement.

In this paper, we aim to address this challenge by suggesting a conceptual framework that goes beyond prior approaches in accounting for theoretical and configurational multiplicity in complex digital phenomena. Furthermore, we offer guidelines for applying our framework, enabling researchers to more effectively develop valid theoretical insights and avoid atheoretical QCA application. We provide two empirical illustrative examples to demonstrate the usefulness of our conceptual framework and guidelines for researchers to deploy QCA for deductive theory testing as well as inductive theory development.

Conceptual Framework for Theoretical and Configurational Multiplicity

Business environments are marked by the increasing ubiquity of information and digital technology and their tight interdependencies with organizational and environmental elements (Yoo 2010; Zammuto et al. 2007). Conceptually, IS scholars have referred to this phenomenon as digital ecodynamics (El Sawy et al. 2010) and entangled sociomateriality (Orlikowski and Scott 2008). In such a fused and messy digital world, there may frequently exist multiple logics for configuring information technologies and organizational resources for innovation (Yoo et al. 2012, 2010) and high performance (Brynjolfsson and McAfee 2014; El Sawy et al. 2010; Lucas et al. 2013). Likewise, a set of firms exhibiting diverse performance outcomes in either a positive or negative sense may not often be fully explained by a model based on a single theoretical perspective (Gioia and Pitre 1990). When a single theory can only capture part of the phenomenon, the divergent cases—while often of interest to both academics and practitioners—are frequently dismissed and not used to advance our understanding, even though they may merely indicate that while the focal theory cannot account for them, an alternative theory might. Accordingly, if digital phenomena are increasingly complex and multifaceted, it may be hazardous to rely on a single theoretical perspective with a relatively simple "the more, the better" linear model, which currently represents the dominant approach in IS research (Chen and Hirschheim 2004; Fichman 2004; Orlikowski and Baroudi 1991).

In response, some researchers have pointed to the value of diversity in styles of theorizing (Delbridge and Fiss 2013; Van Maanen 1995), calling for greater openness toward different theoretical approaches and styles to capture complex phenomena more completely. Particularly, the combinatorial nature of digital innovation suggests a configurational causal model based on "multiple conjunctural causation" (Misangyi et al. 2017; Ragin 1987)—that is, situations where multiple causes combine to bring about outcomes in complex and often equifinal ways. However, while there is evidently a need for more comprehensive studies combining multiple theoretical perspectives, we currently do not have a conceptual framework that would elucidate the relationship between different theoretical perspectives or how multiple configurations of factors may coexist within a single theoretical perspective.

Empirically, attention to the multifaceted complexity of business phenomena has been accompanied by the rise of a set-analytic approach and especially QCA, which is designed to capture multiple conjunctural causation (Ragin 1987, 2008; Fiss et al. 2013; Misangyi et al. 2017). Within the IS literature, QCA was introduced by Fichman (2004) and El Sawy et al. (2010) with the goal of investigating complex digital phenomena. Subsequently, a growing number of studies have employed QCA as their main research approach for both theory testing (Dawson et al. 2016) and theory building (Park et al. 2017). Table 1 provides a summary of selected studies from the IS and management literatures that use QCA.

Table 1. Selected Studies Adopting QCA

Paper*	Research Type	Main Arguments with Respect to QCA	Implication for Theory Building
Fichman (2004, JAIS)	Conceptual & methodological review and suggestion	QCA as a rigorous method for building and testing a holistic configuration theory in IT innovation research that goes beyond the dominant economic-rationalistic paradigm	Suggests QCA as a way to develop a holistic configuration theory of complex causality
Fiss (2007, AMR)	Methodological discussion & guidelines	QCA as a way to overcome the mismatch between theory and methods for organizational configurations	Compares QCA with other methods and explains the mechanism of QCA to investigate combinatorial causality
El Sawy et al. (2010, ISR)	Conceptual & research commentary	QCA-based configurational approach as an inquiry system for complex digital ecodynamics	Explains key aspects of configuration theories built on QCA that explain complex patterns, rendering them different from traditional variance and process theories
Fiss (2011, AMJ)	Conceptual & empirical meta-theory development	Fuzzy-set approach as a way to develop a novel theoretical perspective on causal core and periphery, and empirically applies it to investigating Miles & Snow typology.	Develops a meta-theory of typological reasoning based on concepts of causal core, periphery, and causal asymmetry
Rivard & Lapointe (2012, MISQ)	Empirical meta-analysis for theory development	QCA as a way to investigate complex patterns in the effects of IS implementers' responses to user resistance	Uses a QCA framework to show multiple configurations, resolve contradictions, and articulate patterns
Crilly et al. (2012, AMJ)	Empirical theoretic elaboration	QCA as a way to empirically investigate how firms facing identical pressures decouple their policy from practice in different ways and for different reasons	QCA enables the revelation of multiple equifinal configurations representing different ways of decoupling
Bell et al. (2014, AMJ)	Empirical theory testing	QCA as a way to explain how different combinations of monitoring and incentive-based governance mechanisms lead to the same level of investor valuation of firms	QCA as a way to investigate multiple mechanisms and boundary conditions for building a middle-range theory
Misangyi & Acharya (2014, AMJ)	Empirical theoretic elaboration	QCA for elaborating theory on how corporate governance mechanisms work together effectively	QCA as a way to reconcile inconsistency of extant research
Tan et al. (2016, MISQ)	Empirical theory testing	QCA for revealing combinations of four types of IS components failures that result in e-commerce service failure	QCA as a secondary method to complement the main analysis
Dawson et al. (2016, JMIS)	Empirical theory testing	QCA as a way to investigate IT governance configurations for IT department performance and state-level performance	QCA can show different configurations that produce high performance and low performance at different levels
Park et al. (2017, JAIS)	Empirical theory building	QCA to empirically build multiple configurations and find patterns with respect to the multifaceted role of IT in achieving agility	QCA as a way to retroductively build a middle-range theory that explains multiple pathways to organizational capabilities
Dwivedi et al. (2018, AMJ)	Empirical theory building	QCA as a way to account for the complex confluence of factors that explains multiple recipes for female CEO success	QCA as a way to retroductively build a middle-range theory that explains multiple pathways to organizational outcomes
Park & Mithas (2019, MISQ)	Empirical theory building	QCA as a way to link conjunctural, equifinal, asymmetrical causation to emergent, nonlinear relations in complexity theory	QCA as a way to retroductively build a middle-range theory for digital business strategy

*Articles ordered by publication date, selected from leading IS and management journals such as *MIS Quarterly* (MISQ), *Information Systems Research* (ISR), *Journal of the Association for Information Systems* (JAIS), *Journal of Management Information Systems* (JMIS), *Academy of Management Journal* (AMJ), and *Academy of Management Review* (AMR).

While these and other studies have begun to establish QCA as a research approach, they have so far not explicitly connected theoretical and configurational multiplicity. As a result, while a set-analytic approach has proved to be a powerful tool for mapping complex configurations, there remain challenges in linking these multiple configurations to respective theoretical perspectives. Specifically, the rote application of QCA's truth table algorithm to data can result in the identification of theoretically meaningless configurations, and the popularity and proliferation of QCA can amplify the risk of misuse if QCA is applied in an atheoretical way, as the "naïve use of QCA can lead to spurious results" (Vasey 2014, p. 110).

A key challenge of the configurational approach is thus determining which empirically identified configurations are theoretically meaningful. To avoid spurious configurations, it is essential to explain theoretically configurations identified in the empirical analysis, either in theory testing or theory building. In contrast, the mechanical application of QCA, resulting in configurations that cannot be justified by theoretical or substantive knowledge, is unhelpful and strongly discouraged (Greckhamer et al. 2018).

To help alleviate this situation, our current study suggests a conceptual framework that can accommodate and evaluate multiple configurations instantiating one or more theoretical perspectives. Furthermore, we provide prescriptive guidelines for applying QCA to develop theories on multiplicity.

A Conceptual Framework for Studying Multiplicity

To develop our framework, we draw on two different multiplicity notions, with causal recipes as the linking concept, as depicted in Figure 1. First, *theoretical multiplicity* refers to a situation where the phenomenon under consideration is best understood using more than one theoretical perspective, where each theoretical perspective determines what factors to consider, how they are related, and why these causalities exist. Second, *configurational multiplicity* refers to a situation where even within a particular theoretical perspective there may be different configurations of factors such that there is not one best way but in fact several effective ways to organize. Finally, *causal recipes* theoretically explain multiple configurations either *a priori* by a theory in a top-down deductive approach, or by an emergent theory in a bottom-up inductive approach, or in an abductive approach marked by "the dialogue of ideas and evidence" (Ragin 1987, p. 164), thus preventing a proliferation of QCA research with spurious configurations.

Within our framework, a configuration presents the empirical manifestation of theoretical arguments. Accordingly, multiple configurations with some minor variation based on different tradeoffs are typically associated with the same theoretical perspective. At the same time, a single configuration may also represent more than one theoretical perspective if it combines factors that reflect, for instance, two different theoretical perspectives. Thus, theories and configurations do not map onto each other in a simple fashion; a single theory may be reflected in multiple configurations and a single configuration may reflect more than one theory.

To further develop these arguments, consider now a set of scenarios of multiple configurations, some of which may indicate different theoretical perspectives while others may be grouped under the same theoretical perspective. In this regard, it is helpful to introduce the concept of explanatory overlap—that is, the degree to which different configurations account for the same or a different set of cases associated with the phenomenon. Figure 2 provides an overview of what might be called an *ecology of configurations*, which further explicates our framework of theoretical and configurational multiplicity.

The baseline for our discussion is a hypothetical (and, at least in IS research, often implausible) situation where the phenomenon under consideration is simple and accordingly may be sufficiently explained by a single configuration based on a single theoretical perspective. Given that in this situation there is no competing perspective, the issue of explanatory overlap between different configurations is moot; thus this baseline situation is not presented in Figure 2.

Now, let us relax that assumption and allow for a different situation where reality is not simple and may be accounted for by multiple configurations. In Figure 2, each circle or oval presents a single configuration, and single or multiple configurations may manifest either one or multiple theoretical perspectives. As the left column shows, the two configurations may be highly overlapping or distinct in their explanatory power. If overlap is high, the two configurations explain roughly the same set of cases and one may substitute for the other. Alternatively, if explanatory overlap is low, the two configurations explain different kinds of cases and are thus complementary in explaining more diverse cases.

Here, a given phenomenon may be accounted for by three, or *k* configurations, as shown in the middle and right columns of Figure 2. The top row of the figure thus indicates a situation akin to that in the parable of the blind men and the elephant, where each man describes a different part of the elephant's

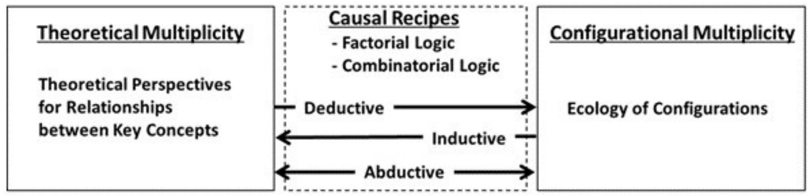


Figure 1. Conceptual Model: Causal Recipes as a Link between Theoretical Multiplicity and Configurational Multiplicity

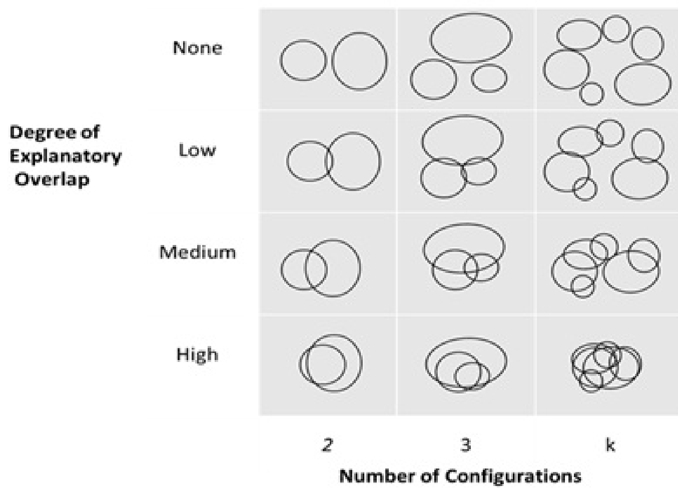


Figure 2. Ecology of Configurations

body, leading them to draw dissimilar conclusions about its true form, each partially correct yet incomplete regarding the full nature of the object under investigation. As Heisenberg noted, "we have to remember that what we observe is not nature herself, but nature exposed to our method of questioning" (1958, p. 34). The Venn diagrams in each cell thus provide an overview of significant diversity in the ecology of configurations that can explain the complex digital phenomenon from one or more theoretical perspectives, as we illustrate in our examples. Furthermore, in addition to the explanatory overlap between different configurations, Figure 2 illustrates their explanatory power represented by the size, with larger circles indicating greater explanatory power. Thus, explanatory power specifies the amount of variance, number of cases, or set of phenomena accounted for by different theoretical perspectives.[2]

[2]To be sure, high and low degrees of explanatory overlap between multiple configurations may also co-occur for a given phenomenon; for simplicity's sake we do not show this in Figure 2.

Causal Recipes for Explicating Multiplicity

The notion of a causal recipe emphasizes the intersection of different causes as opposed to their net effects (Ragin 2000, 2008), embracing a combinatorial reasoning that allows for equifinality of different configurations. However, this original notion does not yet conceptually address *which* causes matter and *how* they combine. Thus, in this study we define *causal recipes as formal statements explaining how the causally relevant elements combine into configurations in ways to produce a target outcome*.

Causal recipes are thus the theoretically or substantively identified expression of how an outcome is achieved. While not all empirically observed configurations may be theoretically meaningful and not all elements of a configuration may be required, causal recipes are the theoretical articulation of the logics inherent in these configurations, that is, the principles underlying how a configuration may achieve a target outcome. In this sense, causal recipes are the bridge that links theoretical and configurational multiplicity as depicted in Figure 1.

Expanding on previous work (Fiss 2011), we suggest that for each causal recipe there are two logics to consider: a *factorial logic* and a *combinatorial logic*. Within a given configuration of elements, the factorial logic describes *which* elements are important for the outcome of interest to occur and why, as well as which elements are causally not relevant and may be stripped away. For instance, using the analysis of a set of high-technology firms described by Fiss (2011), a particular configuration may point to the importance of formalization and centralization along with a low-cost strategy but may suggest that the rate of change of the environment lacks importance.

On the other hand, the combinatorial logic explains *how* the different elements of the configuration relate to one another to produce the outcome in an analytical way. The notion of multiple conjunctural causation suggests several key fundamental relations: complementarity, substitution, and suppression. Returning to the previous example, a theory may suggest positive complementarity between different elements such that executing a low-cost strategy may frequently require a formalized and centralized structure while also indicating a suppressive relationship between these elements and environmental uncertainty. Further, close analysis may indicate substitutive effects between structural complexity and the absence of a high rate of environmental change, such that both causes independently fulfill the requirements for achieving the outcome and if one is present the other may be absent.

In combination, factorial and combinatorial logics allow for a fine-grained examination of how the different elements matter and relate to each other, within a given theoretical perspective. To be sure, regardless of whether the research takes a theory-testing or theory-building approach, it is essential that both logics be grounded in theoretical or substantive knowledge.

How QCA Captures Theoretical and Configurational Multiplicity

As noted above, theoretical perspectives empirically manifest in configurations, with causal recipes as the articulation of the configuration's inherent logics. Accordingly, the identification of causal recipes and their two configuring logics connects directly to the ecology of configurations and a configurational approach. Here, we elaborate on how QCA can not only accommodate multiple configurations instantiating one or more theoretical perspectives in a way to allow the researcher to evaluate explanatory power and overlap between different configurations, but also enable the researcher to disentangle the factorial and combinatorial logics underlying the multiple configurations.[3]

QCA and the Ecology of Configurations

Ragin's (2008) truth table algorithm considers all characteristics of a case jointly (using the logical "AND" operation) and assigns the case to a specific configuration (or row of the truth table) in which the case has the highest membership, thus accommodating conjunctural causation. Furthermore, QCA treats a diverse population of cases having membership in multiple configurations, and the truth table algorithm uses the logical "OR" operation to allow the researcher to identify multiple configurations that may manifest multiple theoretical perspectives. Accordingly, QCA accommodates multiple different paths to the same outcome, a situation known as equifinality (Gresov and Drazin 1997).

In addition, there are several measures in QCA that allow the researcher to map configurations onto the ecology of configurations proposed here. First, the *consistency* measure allows the researcher to evaluate whether a given configuration is consistently associated with an outcome. Second, the *coverage* measure assesses the extent to which a configuration covers the cases of outcome. Coverage thus shows the empirical relevance and effectiveness of each configuration in bringing about the outcome—the higher the coverage, the more empirically relevant the configuration (Ragin 2008, p. 44), indicating explanatory power. Further, somewhat analogous to partitioning R^2 values in a regression, raw coverage can be partitioned into unique coverage to assess what proportion of the outcome is accounted for uniquely by a configuration and what proportion overlaps with other configurations; a higher unique coverage thus indicates lower explanatory overlap and unique paths to the outcome. As such, by considering these measures, QCA allows researchers to assess explanatory power of individual configurations as well as their explanatory overlap.

Explicating Factorial and Combinatorial Logics of Causal Recipes Using QCA

Across multiple configurations, each element may play a different role as part of a causal recipe for bringing about the

[3]We provide a detailed explanation of the nature and procedure of QCA for studying multiplicity in Appendix A.

outcome. The role of each element is not fixed but may change across multiple configurations depending on its interdependencies with other elements in the configurations (Fiss 2011; Ragin and Fiss 2008, 2017). Accordingly, an element may be essential for producing the outcome of interest in one configuration but may be irrelevant or even counterproductive in another configuration (Meyer et al. 1993).

QCA uses a form of counterfactual reasoning to generate three different types of solutions: a complex solution that only uses configurations with existing data, an intermediate solution that further uses "easy" counterfactuals (Ragin 2008), and a parsimonious solution that allows for the use of any logical remainder that would provide a simpler solution. By leveraging these different forms of evaluation, we can compare the intermediate and parsimonious solutions to identify "core" and "peripheral" elements (Fiss 2011) based on the strength of the evidence, thus aiding the researcher in identifying the factorial logic of causal recipes from configurations.

Finally, QCA enables researchers to detect and evaluate the combinatorial logic in terms of complementary, substitutive, or suppressive relationships by allowing comparison of the constellation of elements *across* different configurations. For instance, suppose the researcher identifies the following two configurations: A*B*C*E and A*B*C*~D (where A, B, C, D, E are elements, * indicates logical AND, and ~ indicates logical NOT). With both configurations exhibiting the outcome of interest, and in light of prior theoretical or substantive knowledge of the elements, the researcher might determine that three elements A, B, and C stand in a complementary relationship such that they need to be jointly present (i.e., A*B*C) to bring about the outcome, while elements E and ~D substitute for each other.

Applying QCA along with our conceptual framework allows researchers to develop more comprehensive theoretical accounts with greater explanatory coverage for phenomena characterized by multiplicity. Specifically, as aforementioned in Figure 1, there are three alternative approaches to developing causal recipes: deductive, inductive, and abductive reasoning. Mantere and Ketokivi summarize these as "we predict, confirm, and disconfirm through deduction, generalize through induction, and theorize through abduction" (2013, p. 72).[4]

Since the inherent characteristics of QCA are well aligned with abductive reasoning, many studies with QCA have adopted the abductive approach for their empirical analysis (Campbell et al. 2016; Dwivedi et al. 2018; Lee et al. 2019; Misangyi and Acharya 2014; Park et al. 2017; Rivard and Lapointe 2012). For instance, Lee et al. (2019) use an abductive approach to develop multiple archetypes of IT outsourcing strategy that produce both economic and strategic benefits. Based on the three main theories in the IT outsourcing literature, they first develop a theoretical framework that includes four relational variables in IT outsourcing projects and two contingency factors, and then empirically find configurations from which they develop three causal recipes, two reflecting a pure theoretical perspective and one hybrid reflecting two theoretical perspectives. Eventually, they suggest three archetypes of IT outsourcing strategy in the form of theoretical propositions integrating the previous fragmented and inconsistent knowledge in the IT outsourcing literature. Similarly, Campbell et al. (2016) develop a theoretical framework based on multiple theories that includes key variables to explain investor reactions to merger and acquisition (M&A) announcements. These authors then empirically explore the configurations that result in positive or negative market reactions to M&A. Based on their theoretical framework and multiple configurations, they suggest multiple theoretical propositions in the form of causal recipes. Further, Rivard and Lapointe (2012) engage in an iterative dialogue between data and theory involved in the adding or dropping of new constructs, the respecification of relationships, and the addition or subtraction of cases from the population in question and find configurations that resolve all conflicting cases.

With the abductive approach fairly well established, in the following we focus on deductive and inductive approaches.

[4]A deductive reasoning begins with an *a priori* claim that leads to specific prediction and validation. An inductive reasoning begins with repeated observations of specific conditions that lead to a general claim. Compared to these deductive and inductive approaches, an abductive reasoning approach is relatively less known, but it has been widely adopted by QCA studies. To briefly explain, an abductive (a.k.a. retroductive) approach is fundamentally based on a continuous dialogue and back-and-forth between theory and empirical data and evidence with the goal of developing a theory that can best explain the phenomenon in question. It requires researchers to interpret data in light of theory and keeps calling into question their theoretical conjecture (Alvesson and Kärreman 2007; Boje 2001; Mantere and Ketokivi 2013; Ragin 1994; Van Maanen et al. 2007). Specifically, with this approach, researchers select and define theoretical concepts and conjecture based upon existing theories most pertinent for the phenomenon in question, context specific knowledge, and past unmet expectations. Then, they devise a theoretical framework that includes the key variables and informs the collection of empirical data, but typically does not yet explain the specific causal recipes. Finally, researchers develop theoretical propositions or hypotheses about the main relationship, which can be further tested, developed and advanced by separate studies.

Guidelines for Applying QCA with Illustrative Examples

Drawing on the conceptual framework developed here, we now offer prescriptive guidelines along with illustrative examples for applying QCA to account for theoretical and configurational multiplicity both in the top-down deductive approach (in the first example) and the bottom-up inductive approach (in the second example).[5]

Deductive Approach Example: Multiplicity in the Governance of Software Firms

A top-down deductive approach largely follows the conventional approach for testing or extending extant theories and is most suitable for relatively well-known phenomena where there exist prior theories with relatively clear predictions. As we explained in Table 1, there are several studies that adopt a top-down theory-testing approach with QCA (Bell et al. 2014; Dawson et al. 2016; Fiss 2011; Frambach et al. 2016; Garcia-Castro and Francoeur 2016). However, these studies do not focus on theoretical multiplicity and thus do not explain how QCA enables researchers to explicitly deal with multiplicity, which we explain here.

When researchers attempt to establish theoretical multiplicity using a deductive approach, they predict the presence of causal recipes that reflect multiple theories and then empirically validate each causal recipe by identifying the existence of corresponding configurations. We illustrate these steps in detail with an example of theoretical and configurational multiplicity of governance mechanisms in the software industry.

Step 1: Hypothesize Causal Recipes

The first step to apply our framework with a deductive approach is to define key constructs based on theories that the study aims to validate and then hypothesize causal recipes in a way that reflects the theories. As an illustrative example, we develop propositions of causal recipes representing two distinct, seemingly opposing theoretical perspectives of corporate governance (i.e., agency theory and stewardship theory).

In digitized business, corporate governance issues such as IT governance (Dawson et al. 2016; Sambamurthy and Zmud 1999) and the role of the board of directors (Pan et al. 2018) have received much attention from IS researchers. A firm's board of directors functions as the firm's central governance mechanism and guardian of stakeholder interests (Bell et al. 2012). Importantly, the board of directors often decides on IT-related strategic issues such as IT budget, new IT investment, CIO appointment, IT outsourcing, and responding to new IT trends (e.g., moving business processes to cloud computing), to name a few.

In the governance literature, there is continuing debate on the appropriate board structure for firm performance (Dalton et al. 1998) and prior literature has primarily focused on explaining governance mechanisms with respect to board structure such as board composition with respect to the ratio of inside executive directors to outside non-executive directors on the board and CEO duality, indicating a situation where the CEO is simultaneously the board chair (Dalton et al. 1998; Filatotchev and Bishop 2002). In general, two streams of research have explained the multifaceted roles of these two governance mechanisms in achieving high firm performance. One stream of research, based on *agency theory*, has argued that higher level of board independence and vigilance achieved by strong outside directors results in better performance (Fama and Jensen 1983; Kor and Masangyi 2008). Specifically, a higher ratio of outside directors on a board represents a high level of board independence and enables more objective monitoring of management actions, keeping inside executive directors from pursuing their own interests at the expense of shareholders' interests (Arthurs et al. 2008; Fama and Jensen 1983; Jensen and Meckling 1976), which result in high performance and positive market response. In addition, because CEO duality presents an obvious conflict of interest that hinders the board from supervising the CEO effectively, CEO non-duality can complement the key mechanism of board composition in increasing board independence (Finkelstein and D'Aveni 1994; Krause et al. 2014). In the IS literature, Pan et al. (2018) show that software firms facing significant new entry threats are more likely to achieve high performance with high board independence.

In contrast, another stream of research built on *stewardship theory* argues that strong inside directors (i.e., chief executives, top managers) establish unity of command that enables firms to achieve high performance (Donaldson and Davis 1992; Kesner 1987; Walters et al. 2010). Specifically, CEO duality (i.e, CEO as the board chair) enables the firm to more easily establish a unity of command at the top for unambiguous agile decision-making and thus sends reassuring signals to stakeholders. Furthermore, insiders' specialized

[5]We do not intend to develop a novel theory with these examples but instead use them only for the purpose of illustrating our conceptual framework and guidelines. For the more prevalent abductive approach, we refer the reader to extant studies (Campbell et al. 2016; Lee et al. 2019), where our framework can be readily applied.

working knowledge and detailed information about the firm enable the board to make more informed, timely decisions (Baysinger et al. 1991), helping to adapt to rapid changes in high-velocity environments. Thus, according to stewardship theory, CEO duality combined with a higher ratio of insiders on the board can establish a unity of command to enhance firm performance and positive market response.

As such, the two distinct theoretical perspectives of corporate governance suggest opposing predictions of board structure for firm performance. Here, with a configurational approach, we propose context-specific causal recipes for configurations that can accommodate both theoretical perspectives simultaneously. To do so, we refer to extant studies that have emphasized the importance of industry maturity for a firm's governance strategy and performance (Covin and Slevin 1990; Filatotchev and Bishop 2002; Walters et al. 2010).

On one hand, in the growing software industry before the late 1990s, firms competed to create dominant standards for products and technologies and vied for installed bases of customers in the rapidly growing market of enterprise information systems such as enterprise resource planning systems and database management systems (e.g., Oracle, SAP, JD Edwards, PeopleSoft, Seibel, and Microsoft). To win the standard war, intensive R&D activities were essential for creating diverse, innovative software with speed and higher performance (Chellappa et al. 2010; Li et al. 2010). However, at the same time, intensive R&D activities imply a bias toward exploration-oriented strategic moves, which often result in uncertain and remote returns and thus poor firm performance in the short term (March 1991). According to the agency theory, in such contexts, greater board independence with a higher ratio of outsiders can help firms strike a healthy balance between investments for short- and long-term returns (Fama and Jensen 1983; Jensen and Meckling 1976). Furthermore, more outsiders help firms increase the chance to develop external networks with well-legitimized or high-status incumbents (Tuggle et al. 2010; Walters et al. 2010), which can eventually help them to get market legitimacy and survive competition.

On the other hand, the mature software industry in the 2000s was marked by the emergence of industry-wide standardized information systems (Chae et al. 2014; Wang 2010), which were also socially legitimized and taken for granted by consumers and stakeholders (Chellappa and Saraf 2010; DiMaggio and Powell 1983; Li et al. 2010; Podolny 1993). In that period, a few firms survived competition and dominated enterprise systems (e.g., Oracle, SAP) with such strategic advantages as large installed bases of customers and the related high switching costs that locked up their customers and secured their market shares (Chellappa et al. 2010; Li et al. 2010). Thus, greater certainty of the mature industry reduces the need for board monitoring, at least to some extent, and firms may need to move their focus onto achieving cost leadership with economies of scale typically achieved by large firm size. In such contexts, CEO duality enables firms to establish strong, unambiguous leadership that can overcome the complexity of large firm size and help to reinforce efficient organization and cost leadership (Finkelstein and D'Aveni 1994).

As such, by incorporating the context of industry maturity into our theorization, we can suggest the following propositions of causal recipes that define a governance structure evolving from board independence to a unity of command:

Proposition 1 (Agency Theory Perspective)*: Governance configurations for high board independence consisting of more outside directors on the board and CEO non-duality achieve high firm performance in emerging industries. In these configurations, board independence is a core mechanism while lower unity of command and industry environment are supporting mechanisms.*

Proposition 2 (Stewardship Theory Perspective)*: Governance configurations for high unity of command consisting of more inside directors and CEO duality achieve high firm performance in mature industries. In these configurations, unity of command is a core mechanism while lower board independence and industry environment are supporting mechanisms.*

It is useful to present hypothesized causal recipes in Boolean notation (Frambach et al. 2016; Ragin 1987), which in turn can be compared with empirically observed configurations in Step 3. The Boolean expression (T) of the two causal recipes in the above propositions is as follows:

$$\mathbf{B}*\sim C*\sim M + \sim B*\mathbf{C}*M \rightarrow P$$

where "+" indicates logical OR, "*" logical AND, "~" logical NOT, and the arrow is the logical implication sign. Letter P indicates high performance, B indicates board independence as implied by a high ratio of outsiders on the board (thus, ~B indicating a high ratio of insiders), C indicates CEO duality (thus, ~C indicating CEO non-duality), M indicates mature stage of the industry (thus, ~M for growing stage). Finally, bolded letters indicate core elements while regular letters indicate peripheral elements.[6]

[6]For the current illustrative example, we have theorized two conditions as core elements. However, identifying core versus peripheral elements may not always be theoretically justifiable and thus is not a necessary step for articulating causal recipes deductively.

Step 2: Empirical Analysis of Multiple Configurations Using QCA

Based on the conceptual development in step 1, the researcher collects the data and analyzes them using QCA to identify the configurations that consistently produce the outcome of interest. Then, the researcher maps those onto the ecology of configurations with explanatory overlap and explanatory power using consistency, raw coverage, and unique coverage.

Data and Methods: For this illustrative example, we use the data on firms that went public in the North America software industry (SIC 7372) from 1985 to 2007. This industry is well-known for high velocity where new products and technologies rapidly emerge (Chellappa et al. 2010; Li et al. 2010; Mendelson and Pillai 1988; Tanriverdi and Lee 2008) and thus where corporate governance is of great importance due to its critical role in IT-related strategic decisions and activities to adapt to fast changes (Pan et al. 2018).

Our board structure data come from SDC Platinum and financial data from Standard & Poor's COMPUSTAT. Due to the need for stock prices to calculate outcome variable Tobin's q, we selected firms that were included in both data sources, resulting in 225 firms that went public (i.e., firms in initial-public-offering (IPO) years). The following is a summary of key constructs:[7]

- *Firm performance:* Since the ultimate objective of boards of directors is to serve the best interests of shareholders (Vance 1978) and a public firm's stock value is one of the best measures for that, we set a firm's market performance measured by Tobin's q as the outcome variable (Tobin's q = (stock value + debt)/total assets) (Bharadwaj et al. 1999).

- *Board composition:* The ratio of the number of outsiders to the total number of board members in the year of IPO, which is a critical event for a firm's success.

- *CEO duality:* 1 if CEO is a chairperson, 0 otherwise.

- *Organization size:* Firm size is included because large firms are likely to get more market attention (Jensen 2004) and thus can affect Tobin's q. Size is defined as the ratio of annual firm revenue to annual industry average revenue at the end of the fiscal year.

- *Year 1999:* 1 if IPO year is 1999, 0 otherwise. We include this abnormal year to consider the dot-com bubble collapse reflected in the exceptionally high value of Tobin's q in 1999 as depicted in Figure C2 in the Appendix C.

- *Industry maturity:* 1 if IPO year is 1999 or after, 0 otherwise. In accordance with extant studies (Li et al. 2010; Ljungqvist and Wilhelm 2003), this period presents the mature stage of the industry subsequent to the dot-com bubble collapse. More details are explained in the Appendix C.

- *R&D intensity:* The ratio of R&D expenditure to sales. R&D budget is one of the main strategic decisions made by the board that reflects a firm's strategic position depending on industry maturity. This variable is also known to have a significant impact on Tobin's q (Bharadwaj et al. 1999; Jensen 2004).

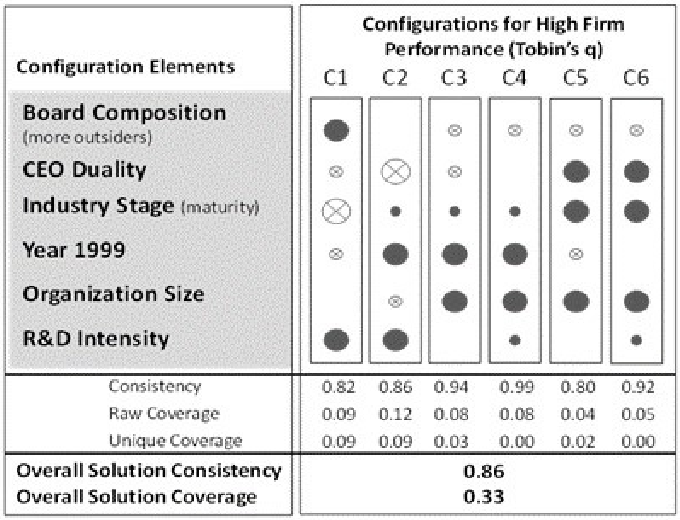
Then, we follow the standard QCA protocol for data analysis (Ragin 2008; Rihoux and Ragin 2009), explained in detail in the Appendix A.

Step 3: Mapping the Ecology of Configurations and Validating Hypothesized Causal Recipes

Now, we present QCA outcomes, map configurations onto the ecology of configurations, explicate multiple causal recipes in terms of factorial and combinatorial logics of configurations, and validate the hypothesized causal recipes by comparing them with the causal recipes obtained in the analysis.

We find six configurations of governance that consistently produce high firm performance; these are depicted in Figure 3 using the symbols by Ragin and Fiss (2008). We map these six configurations into an ecology of configurations using consistency, raw coverage, and unique coverage as depicted in Figure 3. As shown in the figure, C1 consists of a higher ratio of outside directors on the board as a core element and CEO non-duality as a peripheral element. On the other hand, C5 and C6 consist of a higher ratio of inside directors as a peripheral element and CEO duality as core, showing substitutive relations (i.e., more outsiders and CEO non-duality vs. more insiders and CEO duality). Furthermore, C1 is in the industry growth stage before 1999, and C5 in the mature industry stage, while C2, C3, and C4 apply in 1999. C6 may appear in the mature stage post-1999 as well in 1999 itself. In C1, R&D intensity plays a core role while in C5 and C6 firm size takes over the core role, showing substitutive relations. Based on these patterns, we can conclude that C1 empirically presents the causal recipe manifesting the agency theory perspective suggested in Proposition 1, while C5 and C6 support the causal recipe manifesting the stewardship theory perspective suggested in Proposition 2.

[7]While other variables such as brand value and marketing costs (Bharadwaj et al. 1999) may have some effect on Tobin's q, we restrict our analyses to the variables above to achieve simplicity for the purpose of illustration.



- Black circles indicate the presence of a condition; circles with "X" indicate its absence.
- Large circles indicate core conditions; small ones indicate peripheral conditions; blank spaces indicate "don't care."
- For Board Composition, black circle = more outsiders on the board; crossed-out circle = more insiders on the board.
- For Industry Stage, black circle = 2000s; crossed-out circle = before the year 2000.
- For Organization Size, black circle = large; crossed-out circle = small or medium business (SMB).

Figure 3. Governance Configurations for High Firm Performance

We complement the evaluation of recipes based on the ecology of configurations by using Boolean algebra to intersect the theorized recipes with the empirically identified recipes (Ragin 1987; Frambach et al. 2016). The Boolean statements for all empirically identified recipes (E') is as follows:

E' = **B***~C***~M***~Y***R** (C1) + **~C***M***Y**~S***R** (C2)
+ ~B*~C*M***Y*S** (C3) + ~B*M***Y*S***R (C4) +
~B***C*M***~Y***S** (C5) + ~B***C***M*S***R (C6)

where R indicates intensive R&D, Y indicates the Year 1999, and S indicates large firm size. Again, bolded letters indicate core elements. Now, recall that the original theoretical statement (T) was as follows:

T = **B***~C*~M + ~B***C***M

The result of intersecting the theoretical statement T with the empirically obtained one E' results in the following:

(T)(E') = **B***~C*~**M***~Y***R** + ~B***C***M***Y*S***R +
~B***C*M***~Y***S** + ~B***C***M*S***R

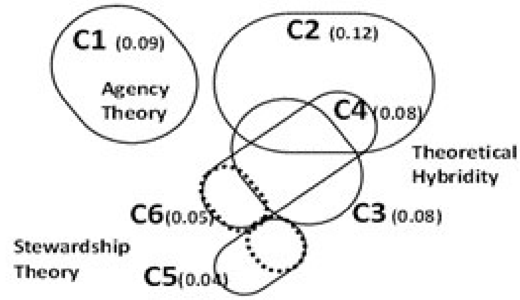
This intersection can be further simplified and factored to obtain

B*~C*~**M***~Y***R** + ~B***C*M*S***(~Y + R)

Both of these recipes are proper subsets of the hypothesized configurations, thus supporting both hypothesized causal recipes. Further, the resulting statement also confirms the hypothesized core status for board independence (**B**) and CEO duality (**C**).[8] Finally, although we did not theorize the core status of intensive R&D and large firm size, we implicitly emphasized the importance of these two elements in our theorization (i.e., intensive R&D to compete for standards in the growing stage and large firm size to achieve economies of scale in the mature stage of industry).

In addition to validating the proposed causal recipes, our conceptual framework enables researchers to develop further insights into the two theoretical perspectives. According to Figure 3 and Figure 4, there is moderate explanatory overlap between configurations representing the same theoretical perspective (e.g., C5 and C6) while there is no overlap between configurations presenting pure instances of the two theories, that is, no overlap between C1 (agency theory) and

[8]When an intersection of two or more recipes includes elements that differed on their core status in the original recipes, core status is ascribed to those elements in the intersected statement. However, this was not the case in the current example.



• The numbers in parentheses are the coverage of each configuration. C6 consists of the two dotted circles.

Figure 4. Ecology of Configurations Embodying Governance Multiplicity

C5, C6 (stewardship theory). This implies that the two theoretical perspectives actually complement each other more than they compete in explaining more diverse cases under different contexts. Furthermore, C1 has a coverage score of 0.09 while C5 and C6 together have a score of 0.07, meaning that the two theoretical perspectives have a similar explanatory power and thus both are almost equally present in the empirical configurations.

Finally, the Boolean expressions allow us to identify recipes that were not predicted, yet were empirically observed, namely configurations C2, C3, and C4. These configurations show a theoretical hybridity with mixed governance mechanisms, that is, more insiders on the board representing stewardship theory and CEO non-duality representing agency theory.

When taking an abductive approach, configurations that were observed but not theorized need to be treated with extreme caution. They may, however, serve as the basis of subsequent speculation, especially if they are aligned with prior theory or substantial knowledge, and may allow researchers to develop new causal recipes to complement and extend extant theories. In the current analysis, Year 1999 was included to consider the dot-com bubble collapse reflected in the exceptionally high value of Tobin's q in 1999. From a theory-testing perspective, C2, C3, and C4 should be ignored as they only emerged after the results were known. However, they may serve as input into subsequent research, especially if the focus of that research is to investigate the impact of environmental punctuation and jolt on organizational governance structure (Meyer et al. 2005). In doing so, a researcher may subsequently adopt an abductive approach with the goal of developing a theory for a punctuated equilibrium or expanding extant theories (Alvesson and Kärreman 2007; Boje 2001; Mantere and Ketokivi 2013; Ragin 1994).

Inductive Approach Example: Multiplicity in Enterprise Systems

A bottom-up inductive approach with QCA aims to build novel theory about a phenomenon for which it is difficult and perhaps impossible to *a priori* predict configurations. There are several studies that have adopted this approach with QCA (Crilly 2011; Crilly et al. 2012), but none of them have examined how QCA enables researchers to address multiplicity. Below, we use the example of multiplicity in enterprise systems to explain how to apply our conceptual framework with QCA in a way to induce theoretically meaningful causal recipes from empirically observed configurations.

Step 1: Understanding the a Phenomenon of Interest

An inductive approach to developing novel theory frequently begins with the observation of a new phenomenon and some conditions that lead to general claims. In the first step, the researcher aims to learn as much as possible about the new phenomenon and selects a set of constructs based on this substantive knowledge and the context of cases in question. Often, it is useful to adopt a meta-theory that entails some working assumptions about how different constructs might bring about multiple configurations. Using a meta-theory is different from a deductive approach in that a meta-theory does not predict a specific causal recipe as in the first example, but rather it helps researchers to interpret the empirically observed configurations to build theoretically meaningful causal recipes.[9]

[9] Examples of meta-theory include the exploration and exploitation meta-theory (March 1991), information processing view (Galbraith 1974), and technology affordance and constraint theory (TACT) (Majchrzak and Markus 2013), to name a few.

For our illustrative example, we focus on inductively developing theory regarding configurations of enterprise systems (ES). Organizations have extensively implemented ES such as enterprise resource planning (ERP) and supply chain management (SCM) systems that involve an enterprise-wide digital transformation (El Sawy et al. 2016; Goodhue et al. 2009; Lucas et al. 2013; Trinh et al. 2012). ES are designed to support business processes and organizational capabilities, but in practice we have frequently observed unexpected negative effects as well as the intended positive results. Industry surveys show a trend of continuing ES failures (Kimberling 2014) and the challenge businesses face in achieving the projected benefits from ES (du Preez 2012).

On the other hand, in IS research, we have observed an ongoing dispute about the role of ES, and especially how ES matters for organizational agility, that is, for sensing and responding to business events and environmental changes in a timely fashion. Several IS studies have conceptually argued for a positive or negative effect of ES on agility (Galliers 2006; Goodhue et al. 2009; Sambamurthy et al. 2003; Trinh et al. 2012), and there has been a dearth of studies that empirically examine the complex relationship between ES and agility, in particular, the role of ES in affording or constraining organizational agility.

We can expect that there are multiple ES configurations, but there is not sufficient theory to specify *a priori* what configurations may result in a high degree of organizational agility. In this example, by embracing a technology affordance and constraint theory (TACT) meta-theoretical view we empirically investigate multiple ES configurations and seek to discover causal recipes for organizational agility. Built on the relational ontology of socio-technical systems (Majchrzak and Markus 2013), TACT allows us to develop working assumptions such that technology affordances and constraints are neither pure technology features nor human or organizational attributes, but determined from the relation between technology and human/organization (Majchrzak and Markus 2013; Scott and Orlikowski 2014; Yoo et al. 2012). Accordingly, we expect that in multiple configurations ES can either enable or constrain agility depending on its interaction with other organizational elements. Prior knowledge and literature about ES and agility entail several other factors that are likely to affect organizational agility, leading us to include the following elements for illustration:[10]

[10]While there may be other elements, such as organizational structure and strategy type, the elements identified here would appear to be sufficient for the illustrative purpose that shows the validity and usefulness of our conceptual framework for studying multiplicity in information systems, our main objective here.

- *Enterprise system* (ES): ES is designed to provide a set of functionalities that help to integrate multiple business processes built on a central database that is accessible across the enterprise (Davenport 1998; Goodhue et al. 2009).

- *Organizational agility* (OA): OA is a firm's ability to sense and respond to environmental changes to quickly seize market opportunities. The sense-response process consists of strategic tasks for scanning important business events, interpreting and deciding the captured events regarding opportunities and threats, and acting such as reconfiguring resources or adjusting business processes (Park et al. 2017; Sambamurthy et al. 2003).

- *Top management team* (TMT) *energy:* It is the energy of top managers to steadfastly and energetically drive organizational changes to adapt to changing environments, driving energetic activities and commitment to organizational sense and response (Cooper et al. 2000; Hambrick et al. 1996).

- *Organizational size:* Size is well known to have a significant impact on organizational capabilities and performance. Size is defined here as either large or small-and-medium business (SMB) based on a government guideline reflecting multiple aspects of a firm, including number of employees, sales revenue, gross capital, and industry type.

- *Industry clockspeed:* Clockspeed is the speed with which a new product is introduced to the market; it is included as a context variable (Mendelson and Pillai 1998; Nadkarni and Narayanan 2007).

- *Environmental uncertainty* is related to the unpredictability in environmental change regarding product, technology and competitor (Davis et al. 2009).

Step 2: Empirical Analysis of Multiple Configurations Using QCA

Based on the selected constructs in step 1, the researcher then collects the data and analyzes them with the goal of identifying any configurations that are reliably associated with the outcome of interest. Here, we use a survey data set collected from senior managers from 83 firms that vary in size and industry. We follow the standard QCA protocol to investigate how these elements might combine into configurations sufficient for achieving high agility (Ragin 2008; Rihoux and Ragin 2009), which we explain in detail in Appendix A, along with a full description of all survey items and construct validity checks in Appendix B.

Step 3: Interpreting the Results and Building New Causal Recipes

In the third step, the researcher presents the empirically observed significant configurations and maps them onto the ecology of configurations, paying careful attention to explanatory overlap and power of individual configurations while also identifying similarities and differences across configurations. At this stage, the objective and focus of research built on a meta-theory may guide researchers in defining which configurations are theoretically meaningful and thus be further theorized, and which are not.

We find six configurations of high agility as shown in Figure 5 (i.e., C1~C6), which are then mapped onto the ecology of configurations with consistency and coverage measures as depicted in Figure 6. Overall, there is relatively low explanatory overlap, indicating that the configurations largely explain different kinds of cases and are thus more complementary than competing. Based on TACT, we identify three groups showing different ES roles: (C2, C5) configurations in which ES play an affording role; (C3, C6) in which ES play a constraining role; and (C1, C4) where ES do not matter for achieving agility. In C1 and C4, large firms with energetic TMT achieve agility regardless of ES. Thus, C1 and C4 are theoretically irrelevant to the research objective to build a theory that explains affordance and constraint mechanisms of ES in achieving agility and thus we exclude them for further theorization.

Next, the researcher theoretically explicates causal recipes regarding the role of the key elements and their relationships in terms of the factorial and combinatorial logics of the selected configurations.

Let us begin by evaluating the factorial and combinatorial logics in C2 and C5 from a TACT perspective. C2 and C5 are configurations for large firms and combine high ES capability and high TMT energy as core elements in either fast or slow environments, thus showing a complementary relation between TMT and ES capability. Unlike in fast environments (C2), in slow clockspeed industries (C5), the complementarity between TMT and ES works only in uncertain environments but not in certain environments. In a slowly and predictably changing environment, agility may not matter for large firms.

Second, C3 and C6 are configurations for smaller firms in which the constraining mechanism of ES applies. Both configurations indicate that high TMT energy is required, but a high level of ES capability should be absent for a smaller firm to achieve agility. Furthermore, both TMT and ES are peripheral, while size and environment uncertainty are core. These findings align well with the TACT perspective, indicating that the role of ES in achieving agility is neither predetermined nor fixed but emergent depending on how ES combine with other elements.

Now, let us consider further the theoretical implications of these findings. Organizational agility is typically conceptualized and operationalized with a series of strategic tasks involving sensing, decision-making and acting (Nazir and Pinsonneault 2012; Park et al. 2017). Thus, organizational agility implies organizational-level information processing that involves coordination and information sharing between managers across multiple departments to sense and respond to rapidly changing environments in a timely manner. In that process, both TMT and ES play an essential role (Daft and Weick 1984; Galbraith 1974). Top managers are in charge of the strategic tasks of organizational-level sense and response (Eisenhardt 1989; Hambrick et al. 1996). The role of TMT goes beyond simple support and opportunistic top management entrepreneurship and includes continuous proactivity and committed action in adapting to environments. Our findings from QCA and the result of an additional necessary condition test indicate that TMT energy is indeed necessary for high agility.

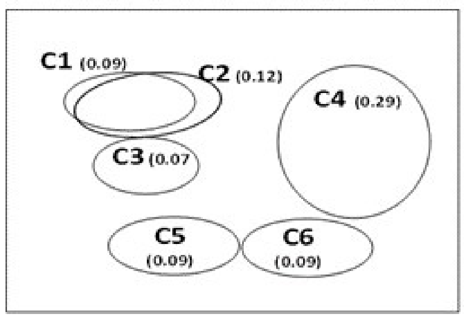
Further, enterprise systems are designed to support organizations to integrate data and applications across all business parts, to standardize business problems, and to support modularized structure (Trinh et al. 2012). Thus, ES allow seamless information flow and knowledge sharing across the enterprise, facilitating collaboration between top managers in different business units. In addition, ES-enabled tight integration and standardization helps TMT eliminate language barriers, in particular between IT executives and business executives, that can cause confusion and impede agility (Pinsonneault and Kraemer 2002; Preston and Karahanna 2009).

Thus, ES is supposed to facilitate effective organization-level sense and response by supporting TMT (Sambamurthy et al. 2003; Tallon and Pinsonneault 2011), but our findings show two opposing effects of ES depending on firm size such that a high level of ES affords large firms but constrains smaller firms from achieving agility. Accordingly, the role of ES and its relationship with other elements in achieving agility for large firms and small firms may have to be considered separately. As mentioned, organizational-level information processing for timely sense and response must involve collaboration between managers across multiple divisions. Large organizations have more complex organizational structure and interdependency in business activities between business units (Daft and Weick 1984; Harris and Katz 1991; Park et al. 2017). The functionalities of ES enable large organizations to overcome such structural complexity and interdependencies in business processes in achieving agility by providing man-

Configuration Elements	C1	C2	C3	C4	C5	C6
	Configurations for High Agility					
Enterprise Systems		●	⊗		●	⊗
TMT Energy	●	●	•	●	●	•
Industry Clockspeed						
Less than 2 years	•	•	•	⊗	⊗	⊗
Between 2 and 5 years	⊗	⊗	⨂	•	⊗	⨂
Over 5 years	⨂	⨂	⊗	⨂	•	•
Environment Uncertainty	•		⨂		•	⨂
Organization Size	●	●	⨂	●	•	⨂
Consistency	0.88	0.95	0.92	0.82	0.93	0.93
Raw Coverage	0.09	0.12	0.07	0.29	0.09	0.09
Unique Coverage	0.01	0.04	0.07	0.29	0.09	0.09
Overall Solution Consistency	**0.87**					
Overall Solution Coverage	**0.68**					

- Black circles indicate the presence of a condition; circles with "X" indicate its absence.
- Large circles indicate core conditions; small ones indicate peripheral conditions; blank spaces indicate "don't care."
- For Organization Size, black circle = large; crossed-out circle = small or medium business (SMB)

Figure 5. Enterprise Systems Configurations for High Organization Agility



- A number in parentheses is the coverage for each configuration.
- (C1, C2, C3) in fast, C4 in moderate, (C5, C6) in slow clockspeed industry. (C1, C2, C4, C5) for large firms and (C3, C6) for SMB firms.

Figure 6. Ecology of Configurations Embodying Enterprise Systems Multiplicity

agers with the dependencies between business processes and enterprise-wide consistent information in real-time (Pavlou and El Sawy 2006), which in turn enables organizations to effectively redesign or add a new process to make strategic moves quickly. Thus, ES functionalities may be more helpful for large organizations.

On the other hand, small organizations lack such a complex structure and thus may not need a high level of ES capability because a simple structure enables them to easily share information in real-time for timely collaboration between departments. Rather, the complexity that enterprise systems can bring to the small organizations may itself be a significant challenge to overcome, particularly if change is expected in a timely manner (Goodhue et al. 2009; Trinh et al. 2012).

Based on the theoretical insights derived from applying a TACT perspective to our findings, we now present sample propositions that set forth causal recipes reflecting ES mechanisms as follows:

***Proposition 1**. For large firms, high TMT energy afforded by high ES capability is sufficient for achieving agility in uncertain environments, whether fast or slow.*

***Proposition 2**. For small firms, only high TMT energy without high ES capability is sufficient for achieving agility in certain environments, whether fast or slow.*

Our propositions come with some caveats. As is typical for an inductive theory-building approach, our propositions are provisional and preliminary. While supported by the current data and a meta-theory, these suggested causal recipes can be further validated by subsequent research, for instance either by following a theory-testing approach as outlined above for another sample of firms or with an abductive approach for another cycle of dialogue that connects back to the cases to evaluate and advance their explanatory power and insight.

Implications for IS Research

When information and digital technologies are fused with organizational elements in complex and messy ways, developing a comprehensive understanding of their dynamics requires multiple theoretical perspectives. Here, we have argued that current theorizing and empirical investigation are often not well matched with the configurational complexity of such multifaceted phenomena. While QCA provides an alternative in such situations and has for that reason been increasingly adopted in IS and business research, it has at times been applied atheoretically, thus increasing the risk of providing findings that may have little theoretical validity. In response, we have aimed to offer guidance for researchers who are interested in applying QCA in their research but may not be aware how it can be utilized in a theoretically rigorous manner, and particularly for situations of theoretical and configurational multiplicity.

Specifically, in the current article we offer a conceptual framework and prescriptive guidelines for developing theories on multiplicity. We emphasized the importance of developing causal recipes so that researchers can theoretically explain multiple configurations. Our conceptual framework shows how multiple theoretical perspectives may simultaneously manifest in multiple configurations, speaking to situations where the researcher faces both complementarities and inconsistencies among multiple theories. Furthermore, our prescriptive guidelines allow researchers to apply QCA in both a deductive approach for testing theoretical multiplicity with multiple configurations or in an inductive approach for theoretically interpreting multiple configurations to develop new causal recipes. The two empirical examples illustrated our conceptual framework through a step-by-step application, thus demonstrating its usefulness in guiding researchers for deploying QCA in IS research and beyond. On the other hand, our conceptual framework and guidelines also can be useful for reviewers to decide whether the manuscript they review applies QCA in a theoretically rigorous way and avoids merely describing empirically observed configurations. Thus, we hope the current work can prevent the proliferation of atheoretical applications of QCA with potentially spurious configurations.

Finally, we want to call for further conceptual and empirical research that can extend our conceptual framework and guidelines, particularly in using the approaches for small- and large-N studies (Greckhamer et al. 2013). With small-N situations typically involving between 12 and 50 cases, the researcher's understanding of the cases tends to be close and rich enough so that substantive knowledge of each case will assure the validity of findings, with strong predictive theory providing additional assurance if applicable. Accordingly, in small-N situations all three approaches will typically result in valid insights.

The situation is somewhat more challenging when dealing with large-N situations of hundreds or thousands of cases (Ragin and Fiss 2017). Here, familiarity with the individual cases is usually not feasible, although rich information of a few exemplary cases may be used to validate causal recipes that have been identified during the analysis. Accordingly, prior theories are a key mechanism to assure the validity of recipes as illustrated by our first example involving a deductive theory-testing approach. However, when a prior theoretical knowledge is not available and an inductive approach is selected, validity of findings becomes harder to assure. The correct, transparent application of the truth table algorithm may offer some partial protection here, but may nevertheless result in the identification of spurious configurations. Thus, the causal recipes developed with this approach may need to be further validated with other succeeding studies, as described in our second example involving inductive theory building. Furthermore, the use of holdout samples may allow the combination of inductive or abductive approach with subsequent theory testing that can provide a further way to validate causal recipes.

In sum, looking across small- and large-N situations, three research designs emerge. First, small-N situations with any of the deductive, inductive, and abductive approaches will usually result in acceptable validity of the findings based on substantive case knowledge. Second, in large-N situations employing a theory-testing approach, validity is still acceptable in the presence of clear predictions based on theory. Finally, in large-N situations using an inductive approach, researchers face the most significant challenges in assuring validity and generalizability of causal recipes, and subsequent validation of recipes with additional studies with a deductive or abductive approach will be particularly important.

Concluding Comments

In information systems and related fields, dominant theorizing approaches have struggled to effectively handle the messy multifaceted nature of evolving digital phenomena. In recent years, QCA has emerged as a powerful tool for application in complex contexts due to its ability to uncover multiple configurations and account for complex interdependencies between elements in producing an outcome of interest. However, the popularity and proliferation of QCA increases the risk of misusing the technique and producing spurious configurations without theoretical advancement. We hope that our conceptual framework for multiplicity along with its prescriptive guidelines for applying QCA will improve the validity of theoretical inferences and contribute to a healthy and more diverse ecosystem of theorization approaches and matching rigorous research methodologies in IS research and beyond.

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Appendix A

QCA Nature and Procedure for Explaining Multiplicity

QCA was originally developed in the field of comparative sociology and political science with the goal of extending cross-case comparative analysis so it would more easily allow researchers to study configurational phenomena (Ragin 1987). As originally envisioned, QCA presents a "middle path" between the qualitative and quantitative approach (Ragin 1987, 2000). QCA is not based on correlations and thus statistical tendencies but instead is based on set-theory and set-subset relationships between membership in antecedents, and membership in an outcome of interest, using Boolean algebra and algorithms along with counterfactual analysis. In QCA, element, factor, attribute and causal condition represent the same meaning and thus can be used interchangeably (Rihoux and Ragin 2009).

Capturing an Ecology of Configurations with QCA

Specific to our task at hand, QCA allows researchers to focus on the combinations of factors that lead to outcomes of interest, shifting attention from "net effects" toward multiple conjunctural causation. It is this focus—on how causes combine rather than compete to explain outcomes—that sets QCA apart from traditional correlation-based quantitative methods; this ability is based on the truth table algorithm. That is, QCA does not disaggregate a case into separate independent characteristics that can be examined while holding the other characteristics constant (i.e., net effect), but instead the truth table algorithm of QCA considers all characteristics of a case jointly with the logical "AND" fuzzy-set operation and assigns the case to a specific configuration in which the case has the highest membership.

Furthermore, QCA treats attributes of cases as potentially having membership in multiple configurations. Unlike the linear model's focus on the mean, QCA's focus on membership-exceeding thresholds for both conditions and outcomes does not suppress or discard any cases; thus it is particularly attractive as a research method for understanding multiple theoretical perspectives embedded in a diverse population of cases. The truth table algorithm uses the logical "OR" operation to allow the researcher to identify multiple, equifinal configurations associated with the same outcome. Specifically, by providing insight into different configurations of factors, the algorithm maps the various configurations—both theoretically possible and empirically observed—within an *n*-dimensional possibility space (Soda and Furnari 2012), that is, the ecology of configurations and uses Boolean algebra and counterfactual analysis (Ragin 2008) to extract simplified configurations that are associated with the outcome. Such multiple configurations, while having different structures, may lead to the same outcome, a situation known as equifinality (Gresov and Drazin 1997).

In QCA, several measures that map configurations onto the ecology of configurations are available to the researcher. First, the truth table algorithm in QCA uses a measure of "consistency" to evaluate whether a given configuration is consistently associated with an outcome. With the set-analytic consistency, QCA strips away those combinations not dependably related to the outcomes, helping to identify configurations that consistently produce the outcome.

The second measure is set-analytic "coverage." While organizations can achieve the same outcome with different configurations, meaning different paths (i.e., equifinality), individual paths differ in their empirical importance and effectiveness. Raw coverage indicates the extent to which each configuration covers the cases of outcome (i.e., the proportion of cases that have membership in its respective path to the outcome). Raw coverage shows an empirical relevance and effectiveness of the solution for the outcome—the higher the coverage, the more empirically relevant the configuration (Ragin 2008, p. 44), indicating explanatory power. Further, while raw coverage indicates the overall importance of a configuration, unique coverage explains the part of a configuration that does not overlap with others in explaining cases exhibiting the outcome. Thus, lower unique coverage indicates greater explanatory overlap with other configurations, implying a situation of overdetermination. On the other hand, higher unique coverage means lower explanatory overlap and indicates different and unique paths to the outcome. By considering these two measures, QCA allows the researcher to evaluate the importance of different configurations and the relationship between them in the ecology of configurations.

Analyzing the Factorial and Combinatorial Logic of Configurations

We now explain in more detail how to use QCA to evaluate causal recipes regarding the factorial and combinatorial logics. Across equifinal configurations, each configurational element may play a different role as part of a holistic, causal "recipe" for the outcome, meaning that the role of each element is not fixed but may change across multiple configurations depending on its interdependencies with other elements in the configurations (Fiss 2011). An element may be essential for producing the outcome of interest in one configuration but may be irrelevant or even counterproductive in another configuration.

Recall that factorial logic refers to the importance of particular configurational elements ("What elements matter?") while combinatorial logic refers to the relationship between different configurational elements ("How are these elements connected?"). QCA employs counterfactual analysis to extract three different types of solutions: complex, intermediate, and parsimonious. A complex solution does not employ counterfactuals; an intermediate solution employs only "easy" counterfactuals that can be substantiated by theoretical logic or substantive knowledge; and a parsimonious solution employs both "easy" and "difficult" counterfactuals, that is, a solution that employs any possible counterfactual. Comparisons between the intermediate and parsimonious solutions can further aid the researcher in identifying the factorial logic of a configuration. Specifically, elements that are part of both the intermediate and parsimonious solutions are viewed as "core," having a stronger causal relationship with the outcome of interest, while elements that are only part of the intermediate solution are viewed as "peripheral" (Fiss 2011). Thus, QCA allows the researcher to evaluate the factorial logic of a configuration by identifying (1) which candidate elements are stripped away to identify the different configurations; (2) how important each configuration is regarding the outcome; and (3) how important a particular element of a configuration is for the outcome of interest (core vs. peripheral). Thus, unlike cluster analysis, for example, QCA allows the researcher to examine the role of individual elements as core/peripheral, present/absent, and "don't care" conditions and their relationships as complementary, substitutive, or suppressive.

Furthermore, these characteristics of QCA make it unique and different from traditional correlation-based methods in explaining multiplicity. Even though, in some cases, the QCA result can be similar to that of a linear model with moderators or the idea of complementarities in a linear model, particularly in the case of configurational multiplicity from a single theoretical perspective, such a possibility alone does not make these two approaches the same. A linear model with moderators still estimates net effects of individual variables with a focus on the change in net effects under the influence of moderators, and the complementarity in a linear model assumes that the complements are individually manipulable and easier to comprehend in dealing with two or three complements (Venkatraman 1989). However, QCA fundamentally begins with an explicit recognition and anticipation of multiple distinctive and theoretically discernible configurations of multiple variables that manifest holistic, conjunctural causation (Misangyi et al. 2017).

The Procedure of QCA

The following key steps are built on the extant QCA literature (Ragin 2008; Rihoux and Ragin 2009).

Step 1: Articulating the Research Topic

First, the researcher articulates a research topic and phenomenon. Either theoretical or statistical sampling may be used here to construct the relevant population of cases, with theoretical sampling being more appropriate for small-N situations while either theoretical, statistical, or various forms of non-probability sampling (e.g., snowball sampling) may be used for medium to large-N analysis (Greckhamer et al. 2013). Note that due to its non-parametric nature, QCA is not meant to infer population characteristics from a sample of observations, but is intended to help the researcher study the configurational diversity found in a given set of observations. Causal conditions should be selected either based on extant theories most relevant to the phenomenon under investigation in deductive and abductive approaches or based on substantive knowledge of the cases and phenomenon in an inductive approach. In deductive and abductive approaches, theories provide an analytic frame with which researchers can devise the right questions to better explore the phenomena (Ragin 2008).

Step 2: Calibrating Set Membership

The calibration process transforms antecedent and outcome variables by assigning set membership in a qualitative state (e.g., the set of firms exhibiting a high level of performance). In fuzzy-set QCA (fsQCA), membership values may take on any value between 0 and 1, where near 1 means a high membership in the set of, for example, high performance and near 0 means a full non-membership in the set. Further details on the calibration process, including the direct and indirect method of calibration, are readily available from various sources (Ragin 2008).

For example, in the second illustrative example in this study, for enterprise systems we examine TMT energy, environmental uncertainty, and organizational agility, and we calibrate the average of the survey items' scores of each variable into fuzzy membership using Ragin's (2008) direct method of calibration. These items are measured using seven-point Likert scales. We set 6 as the threshold for full membership and 2 as the threshold for full non-membership, with a value of 4 as the crossover point of maximum ambiguity (Ragin 2000). Table A1 shows an example of interval scale values and the corresponding set membership scores after calibration for the conditions and the outcome.

Further, to simplify the analysis, we defined firm size as a crisp set and assigned each case as either large (1) or small/medium (SMB) (0). For industry clockspeed, we categorized cases into three separate crisp-sets: those with less than two years as fast clockspeed, those with clockspeed between two and five years as at the crossover point, and those with clockspeed over five years as not fast clockspeed.

Table A1. Example of Calibration

	Interval Scale Values				Set Membership Scores			
OrgID	Enterprise Systems	Environmental Uncertainty	TMT Energy	Organization Agility	Enterprise Systems	Environmental Uncertainty	TMT Energy	Organization Agility
Org1	5.22	5.67	5.00	4.33	0.86	0.92	0.82	0.62
Org2	2.46	4.33	4.13	3.08	0.09	0.62	0.55	0.2
Org3	3.75	3.33	4.13	3.72	0.41	0.27	0.55	0.4

For the first illustrative example, in Table A2, we summarize the details of the calibration process for variables with (75, 50, 25) percentiles for three anchors: full membership, crossover point, and full non-membership.

Table A2. Measurement and Calibration for the Illustrative Example 1

		Calibration Anchors		
Variable	Measurement	Full Membership	Crossover	Full Non-membership
Firm performance	Tobin's q	5.70	3.08	1.53
Board composition	The ratio of the number of outsiders to the total number of board members in the IPO year	0.75	0.5	0.25
Organization size	The ratio of annual firm revenue to annual industry average revenue at the end of fiscal year	0.29	0.17	0.10
R&D intensity	The ratio of R&D expenditure to sales	0.33	0.20	0.15
CEO duality	1 if CEO is a chairperson, 0 otherwise.	No need to calibrate		
Year 1999	1 if IPO year is 1999, 0 otherwise.	No need to calibrate		
Industry maturity	1 if IPO year is in 2000s, 0 otherwise.	No need to calibrate		

Step 3: Building Configurations with Truth Table Analysis

After calibration, analysis proceeds using Ragin's truth table algorithm (Ragin 2008; Schneider and Wagemann 2012). The calibrated data set with fuzzy-set membership scores shown in Tables A1 and A2 is then used for building a truth table and set operations for minimization in the next steps of fsQCA. After completing calibration each case is allocated to its corresponding row of the truth table. A truth table is a list of all logically possible combinations of causal conditions, and explicitly shows the relationships between individual combinations and the outcome of interest. In the truth table, each condition has either 1 or 0. Thus, with k causal conditions, a truth table has 2^k rows, and each row as a combination of causal conditions corresponds to a corner in the k dimensional vector space created from the k causal conditions, representing an extreme, ideal configuration. For example, with three causal conditions, the truth table will have eight rows, and each row corresponds to one of the eight corners of a three-dimensional vector space (in this case, a cube). Using Boolean algebra and the set membership scores of conditions, the fuzzy truth table algorithm of fsQCA calculates the set memberships of each case in all the combinations. There is only one combination for which a case can have a membership score greater than 0.5, and the truth table algorithm allocates the case to that combination.

Table A3 is the truth table of our second example and Table A4 is the truth-table for the first illustrative example. In Table A3, each row is a combination of the causal conditions for high firm performance. In the truth table, the "Number" column shows the frequency of cases allocated to each combination. Consistency is a measure that indicates how consistently the combination produces the outcome, more specifically, the degree to which membership in the combination is a consistent subset of membership in the outcome (Ragin 2008, p. 133). In fsQCA, there are two kinds of consistency: raw consistency, which is calculated analogously to crisp-set consistency but in addition gives credit for "near misses" and penalties for large inconsistencies, and PRI (proportional reduction in inconsistency) consistency, an alternate measure of consistency that additionally eliminates the influence of cases that have simultaneous membership in both the outcome and its complement (i.e., y and ~y). In our example we rely on both raw and PRI consistency. Since our example has 83 cases, a large-number case study, we set the minimum acceptable frequency of cases at two, thus including only rows with at least two empirical instances. Next, for rows (i.e., combinations of conditions) that satisfy this frequency threshold we set the lowest acceptable raw consistency cutoff at 0.90, significantly greater than the 0.75 minimum recommended by Ragin (2008), meaning that only combinations with a raw consistency of at least 0.90. We also set the cutoff for PRI consistency at 0.75, which is relatively high. Thus, the rows satisfying these consistency cutoffs are considered as reliably resulting in high performance. In Table A3, the Agility column has a value 1 for the combinations with raw consistency higher than 0.90 and PRI consistency higher than 0.75, otherwise 0.

Table A3. Truth Table for High Agility

Org. Size	Less Than 2	2 to 5	Over 5	ES	TMT Energy	Uncertainty	Number	Ability	Raw Consistency	PRI Consistency
1	1	0	0	1	1	0	3	1	1.00	1.00
1	0	1	0	1	1	0	5	1	0.97	0.92
1	0	1	0	1	1	1	6	1	0.97	0.93
1	0	1	0	0	1	1	2	1	0.96	0.87
1	0	1	0	0	1	0	2	1	0.96	0.86
1	1	0	0	0	1	1	3	1	0.94	.082
0	0	0	1	0	1	0	2	1	0.93	0.77
1	1	0	0	1	1	1	3	1	0.93	0.85
1	0	0	1	1	1	1	3	1	0.93	0.81
0	1	0	0	0	1	0	3	1	0.92	0.79
1	0	1	0	1	0	0	2	0	0.91	0.50
1	0	0	1	0	1	0	5	0	0.85	0.56
1	0	1	0	0	0	0	2	0	0.85	0.42
0	1	0	0	0	1	1	4	0	0.81	0.58
0	0	1	0	0	1	0	2	0	0.80	0.24
0	0	1	0	0	0	1	2	0	0.74	0.11

With the truth table assembled, we next apply the truth table algorithm to reduce the numerous combinations into a smaller set of configurations based on the QM algorithm and counterfactual analysis. For instance, consider a situation where the combinations A*B (read "A and B") as well as ~A*B (read "not-A and B") are both associated with the outcome of interest. In such situations, A may be present or absent and the outcome still occurs, and thus A can be dropped retaining only element B. This kind of logical reduction results in a simplified set of configurations that lead to the outcome of interest.

Further, in contrast to empty cells in cross-tabulation, empty rows in a truth table known as limited diversity do not present a problem per se for the algorithm and the minimization result is valid for the observed cases. Once the analysis has exhausted the existing configurations, QCA employs counterfactual analysis that uses what are known as logical remainders—truth table rows that are not populated by cases in our dataset. Counterfactual analysis allows us to distinguish between "easy" and "difficult" counterfactuals, where "easy" counterfactuals deal with an empirically unobserved combination by adding a condition known to produce the outcome to a combination, while "difficult" counterfactuals deal with an empirically unobserved combination by removing a condition from a combination displaying the outcome on the assumption that the condition is redundant and thus the resulting combination still produces the outcome. (For details on this process, see Ragin 2008.) The analysis compares both situations by deriving three kinds of solutions: a complex one using no counterfactuals, an intermediate one using only "easy" counterfactuals, and a parsimonious one using both "easy" and "difficult" counterfactuals.

This process of counterfactual analysis is also explained by Soda and Furnari (2012). For instance, as these authors note, the conservative strategy of assuming that all logical remainders will produce a positive outcome "is formally implemented in most fsQCA software" (Soda and Furnari 2012, p. 290), and results in the parsimonious solution. On the other hand, the strategy of assuming all logical remainders will produce a negative outcome results in the complex solution, while retaining only theoretically or logically plausible remainders results in the intermediate solution.

Table A4. Truth-Table for the Illustrative Example 1

CEO Duality	Industry Maturity	Organization Size	R&D Intensity	Board Composition	Year 1999	Number	Tobin's q	Raw Consistency	PRI Consistency
0	1	1	1	0	1	6	1	0.99	0.98
1	1	1	1	0	1	2	1	0.98	0.98
0	1	0	1	1	1	2	1	0.95	0.94
0	1	1	0	0	1	4	1	0.89	0.88
0	1	0	1	0	1	12	1	0.88	0.86
0	0	1	1	1	0	2	1	0.88	0.76
1	1	1	1	0	0	2	1	0.84	0.70
1	1	1	0	0	0	2	1	0.81	0.65
0	0	0	1	1	0	5	1	0.78	0.64
1	0	0	0	0	0	8	0	0.73	0.54
1	0	1	0	1	0	3	0	0.71	0.48
0	1	0	0	0	1	4	0	0.70	0.67
0	0	1	0	1	0	5	0	0.68	0.45
1	0	1	1	0	0	8	0	0.68	0.49
1	1	0	1	0	1	6	0	0.61	0.58
1	1	0	0	0	0	5	0	0.59	0.38
0	0	1	1	0	0	11	0	0.58	0.40
0	0	1	0	0	0	35	0	0.55	0.43
1	0	1	0	0	0	12	0	0.54	0.27
0	0	0	1	0	0	13	0	0.52	0.36
0	0	0	0	0	0	8	0	0.50	0.30
0	1	1	0	0	0	4	0	0.49	0.35
1	0	0	1	0	0	7	0	0.48	0.26
0	1	1	1	0	0	2	0	0.45	0.28
1	1	0	1	0	0	4	0	0.35	0.10
0	1	0	1	1	0	2	0	0.30	0.06
0	1	0	1	0	0	16	0	0.28	0.17
0	1	0	0	0	0	6	0	0.26	0.10

Notes: Frequency cutoff = 2; raw consistency cutoff = 0.78; PRI consistency cutoff = 0.68.

Step 4: Construing Causal Recipes from Theoretic Perspectives

As a last step the resulting configurations are mapped to the ecology of configurations and also are interpreted with respect to factorial and combinatorial logic in multiple conjunctural causation from the adopted multiple theoretical perspectives in deductive and abductive approaches and a meta-theory perspective in an inductive approach. To achieve this, the role of individual elements needs to be interpreted in terms of core/peripheral and present/absent, and the measures of raw and unique coverage obtained during the truth table analysis should be used.

Appendix B

Measurement Items and Construct Validation Check for the Illustrative Example 2

Constructs	Measures
Organizational Agility (1 = strongly disagree, 4 = neutral, 7 = strongly agree). ***Our firm:***	
Sensing	• Is slow to detect changes in our customers' preferences on products. • Is slow to detect changes in our competitors' moves (e.g., new promotions, products, and prices). • Is slow to detect changes in technologies.
Decision-making	• Analyzes important events about customer/competitor/technology without delay. • Finds opportunities and threats from changes in customer/competitor/technology in a timely manner. • Makes an action plan to meet customers' needs without delay. • Makes an action plan to react to competitors' strategic moves without delay. • Makes an action plan on how to use new technology without delay.
Acting	• Can reconfigure our resources in a timely manner. • Can modify/restructure processes in a timely manner. • Can adopt new technologies in a timely manner. • Can introduce new products in a timely manner. • Can change price quickly. • Can change strategic partnerships in a timely manner. • Can address our customers' changing needs and complaints without delay.
Enterprise Systems (1 = Almost Never, 7 = Always, 4 = About half the time)	
ES—the level of organizational ES capabilities	*Information systems in our organization:* • visually present business processes. • support the design and creation of new business processes. • support streamlining and scheduling processes. • automate business processes. • provide information about what human and other resources are needed for business processes. • provide real-time information about resource availability.
TMT Energy TMT	(7-point Likert scale: 1 = lowest, 7 = highest, 4 = neutral) • Our top management team is energetic. • Our top management team drives dynamic change.
Environmental Uncertainty	Uncertainty: 1 = Very Unpredictable, 7 = Very Predictable, 4 = Moderate) • The direction of change in our customers' product preferences is… • The direction of change in competitors' moves is… • The direction of change in the technology in our industry is…
Industry Clockspeed	Our principal product's life cycle is: • Less than 2 years, between 2 and 5 years, over 5 years

We defined organizational agility as a second-order construct consisting of three first-order constructs: sensing, decision-making, and acting agility. The weights of individual paths from the first-order constructs to organizational agility are calculated using a principal components factor analysis. Composite reliabilities are greater than 0.90 for all constructs, indicating sufficient internal consistency (Nunnally 1978). All Cronbach alpha values were greater than 0.7, which is evidence of reliability (Bagozzi and Edwards 1998; Fornell and Larcker 1981). The AVE for individual constructs is greater than its correlations with other constructs, and it is greater than 0.5. Further, all standardized-item loadings resulting from a factor analysis are greater than 0.75 and loaded on their corresponding factor. So, our constructs satisfy discriminant and convergent validity (Gefen et al. 2000).

Appendix C

The Software Industry Analysis for the Illustrative Example 1

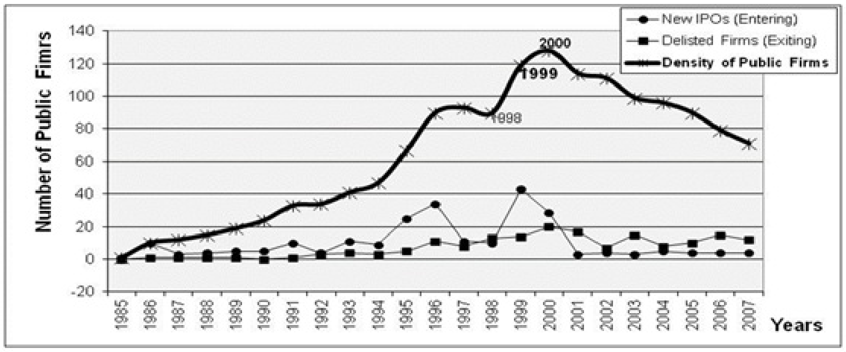

Figure C1. Entry, Exit, and Density of Public Firms

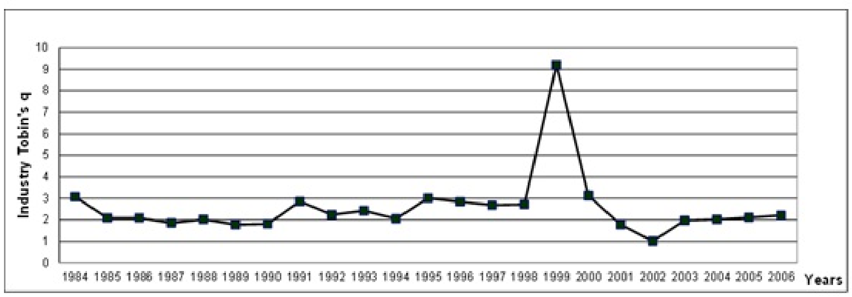

Figure C2. Industry Average Tobin's q

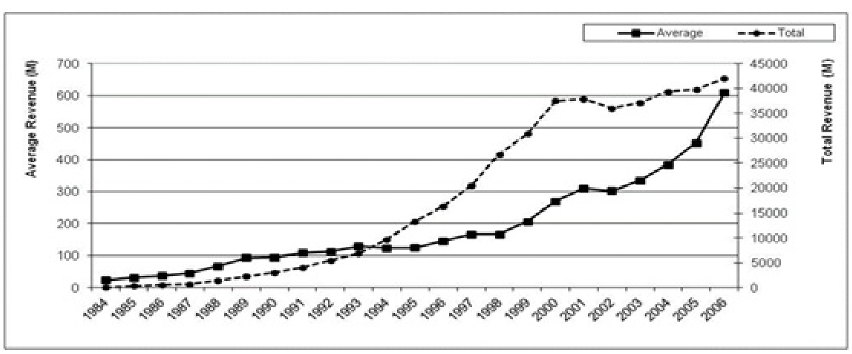

Figure C3. Revenue Trend

As an industry is growing, it acquires more legitimacy, which helps organizations in the industry get resources more easily (Baum and Oliver 1991; DiMaggio and Powell 1983). Thus, as an industry becomes mature, the industry density defined as the total number of firms in the industry increases (Hannan et al. 1995). However, at some point, the founding rate decreases and the mortality rate increases as the density increases, because the power of competition surpasses that of legitimacy. Thus, an industry can be considered growing when the legitimacy effect surpasses the competition effect and the density is still increasing; otherwise, the industry is considered rather mature. Thus, in the current study, the industry maturity is defined based on the dynamics between competition and legitimacy over the changing industry density (Argyres and Bigelow 2007; Hannan et al.1995; Utterback and Abernathy 1975), while Tobin's q and industry revenue can further complement its instrumentation.

Figure C1 depicts the density of the software industry from 1985 to 2007. The density of public firms in this industry increased by the year 1999 when the power of competition started surpassing that of legitimacy. Further, in Figure C2, the value of Tobin's q in the year 1999 was exceptionally high, which implicates the existence of an IT bubble in the industry. This figure is consistent with the literature on the dot-com bubble that places it around the year 1999 or 2000 (Li et al. 2010; Ljungqvist and Wilhelm 2003). In the year 1999, in accordance with an unusually high value of Tobin's q, the market had high uncertain expectations for the IT industry's growth, resulting in unusually great market entries. However, the real market growth measured by industry total revenue was not exceptionally high (Figure C3). Actually, the performance did not meet the high market expectation, leaving investors disappointed, which was followed by a tumble of stock prices and Tobin's q in the next year. The density of the software industry started radically decreasing after the year 2000. However, the total revenue of the industry stabilized after 1999 and did not decrease, so the average revenue of each firm increased rapidly, meaning that the surviving firms enjoyed the mature market. Accordingly, we define the period before 1999 as the growth stage and the period since 1999 as the mature stage of the software industry.