THE DYNAMICS OF OPPORTUNITY AND THREAT MANAGEMENT IN TURBULENT ENVIRONMENTS: THE ROLE OF INFORMATION TECHNOLOGIES

by

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A Dissertation Presented to the
FACULTY OF THE USC GRADUATE SCHOOL
UNIVERSITY OF SOUTHERN CALIFORNIA
In Partial Fulfillment of the
Requirements for the Degree
DOCTOR OF PHILOSOPHY
(BUSINESS ADMINISTRATION)

August 2011

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to my dissertation chair Omar El Sawy and the members of my dissertation committee – Peer Fiss, Ann Majchrzak, Daniel O'Leary, and Merril Silverstein – for their helpful guidance and kind support through the whole dissertation process.

I have been very grateful to my father and mother. Their love and unconditional sacrifice for me have encouraged me to accomplish the hard work of the doctoral program. I also thank my family, especially my brother, sisters, parents in law, and sister-in-law for their kind support.

Last, but most importantly, I would like to thank my wife SohYeun Lee and my daughter KyuRi Park. Without their love, support, and understanding throughout this process, I could not complete my degree. I owe my success to them and will share my happiness with them always.

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ABSTRACT

This study explains the role of information technologies in enabling organizations to successfully sense and manage opportunities and threats and achieve competitive advantage in turbulent environments. I use two approaches, a set-theoretic configurational theory approach and a variance theory approach, which are theoretically and methodologically different but complementary to each other for developing a more complete understanding of complex phenomena in *digital ecodynamics.* Digital ecodynamics is defined as fused dynamic interactions among IT, organizational agility and environmental turbulence.

Using a set-theoretic configurational theory approach, this study explores the holistic nature of digital ecodynamics in a way that describes how IT, organizational agility and environmental turbulence simultaneously and systemically combine to result in competitive performance. At the same time, this study develops a variance theory that explains how IT is "mechanically" related with organizational agility and environmental turbulence to result in competitive performance.

By comparing similarities and differences between multiple configurations that result in the same outcome, this study extracts several patterns that explain IT plays a core role in achieving a high level of agility and competitive performance, and can be either an enabler or an inhibitor for organizational agility depending on the context. The PLS results show that IT enables organizations to enhance agility and indirectly influences firm performance and innovation leadership through organizational agility. By

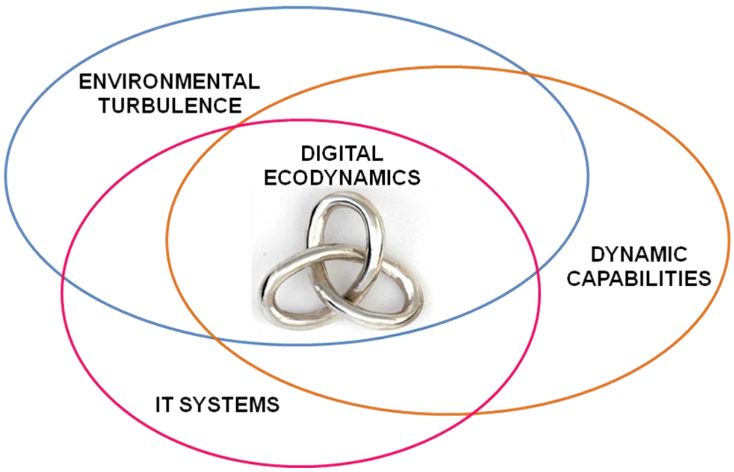
investigating the detailed relationships between three types of IT systems (i.e., business intelligence, communication & collaboration, and business process & resource management) and three types of agility (i.e. sensing, decision-making, and acting agility), this study shows that different types of IT systems play different roles in enabling different types of organizational agility. Lastly, this study shows a contingency effect of environmental turbulence: IT-enabled organizational agility is positively related with innovation leadership and firm performance only in hyperturbulent environments. In stable environments, a high level of IT capability should be absent to enhance firm performance. These insights developed from two theoretical approaches together better describe the multifaceted roles of information technologies in digital ecodynamics, and suggest that IT-enabled agility is one of the best ways to survive and thrive in hyperturbulent environments where competitive advantage cannot be sustained for a long time.

The findings from two approaches also practically contribute to managerial knowledge by showing how organizations transform to the IT-enabled agile organization with the most affordable costs and risks through multiple alternative paths. By comparing the causal structures of high performing configurations with those of low performing configurations, this study suggests the best transformational path to competitive performance. Then, the findings from a variance theory approach show the levels of key constructs for competitive agile organizations, guiding successful transformation.

CHAPTER 1: OPPORTUNITY AND THREAT MANAGEMENT IN DIGITAL ECODYNAMICS

D*igital ecodynamics,* "the holistic confluence among environmental turbulence, dynamic capabilities, and IT systems—and their fused dynamic interactions unfolding as an ecosystem [Figure 1-1]," create complex messy phenomena (El Sawy et al. 2010).

Figure 1-1: Digital Ecodynamics (Excerpt from El Sawy et al. 2010)[1]



Organizations with dynamic capability can introduce new products and services more frequently than before (Eisenhardt and Martin 2000; Teece et al. 1997). Information technologies are fused with business processes (El Sawy 2003) and play a more important role in achieving competitive advantage (Pavlou and El Sawy 2006, 2010; Sambamurthy et al. 2003) by providing new digital business platform (Shapiro and Varian 1998). Accordingly, business environments are changing increasing fast

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[1] Here, the *Gordian Knot* depicts the fusion quality of digital ecodynamics, showing no separations among its three elements but the wholeness of the fused interactions among the three elements.

(Bourgeois and Eisenhardt 1988; Fine 1998; Nadkarni and Narayanan 2007b) and more unpredictably (Davis et al. 2009; Mendelson and Pillai 1998, 1999). Turbulent and competitive environments become common in a broad range of industries, not only in high technology industries but also in non-high technology industries (D'Aveni 1994; Schumpeter 1939; Wiggins and Ruefli 2005).

Consequently, digital ecodynamics creates a number of critical issues for organizational survival; for example, it is blurring existing industry boundaries (Burgelman and Grove 2007), changing the rules of the game (Shapiro and Varian 1998), and creating new organizational forms and structures (Aron et al. 2007; Malhotra, Gosain, and El Sawy 2007; Wagner and Majchrzak 2007). Such messy complex changes create more amount of information than organizations can process in a timely manner, resulting in information overload (Galbraith 1974; March and Simon 1958). Further, market information is often not available or becomes obsolete quickly, and time windows for capturing opportunities and threats close too quickly (Bourgeois and Eisenhardt 1988). Thus, it becomes more difficult for organizations to sense and respond to market opportunities and threats in a timely manner (Brown and Eisenhardt 1997, 1998; Sambamurthy et al. 2003). The cost of mistakes in sensing and responding to market opportunities and threats can become enormous; for example, in 2001 Cisco lost $2B in supply chain management due to its failure in timely sensing and responding to market change (Kaihla 2002).

Thus, how to successfully manage opportunities and threats becomes a key issue for organizations to survive and thrive in digital ecodynamics (Alvarez and Barney 2004;

Eisenhardt and Martin 2000; Ireland 2007; Overby et al. 2006; Pavlou and El Sawy 2006; Sambamurthy et al. 2003). Since the fused dynamic interactions among IT systems, organizational dynamic capabilities and environmental turbulence are creating critical issues and more opportunities and threats, the understanding of the holistic and systemic features of digital ecodynamics becomes an essential part of developing a theory that explains the role of information technologies in organizational successful management of opportunities and threats in turbulent environments.

Although there are many studies that explain dyadic interactions between IT systems, organizational capabilities and environments in the strategic management literature and the IS strategy literature, such studies do not effectively capture the holistic and synergetic dynamics among the key elements of digital ecodynamics (El Sawy et al. 2010). We still need to develop an understanding of how these three elements simultaneously and systemically combine to result in competitive advantage.

Further, theories are needed which explain how and why information technologies enable organizations to develop organizational agility, which is defined as *organizational ability to successfully sense and respond to market opportunities and threats in a timely manner* (Overby et al. 2006; Sambamurthy et al. 2003). The IS literature has argued inconsistent roles of IT in enhancing organizational agility (El Sawy et al. 2010; Lu and Ramamurthy 2011); for example, IT as an enabler for organizational agility (c.f. Haeckel 1999; Pavlou and El Sawy 2006; Sambamurthy et al. 2003) and IT as an inhibitor (c.f. Galliers 2006; Retting 2007; van Oosterhout et al. 2006).

To develop a more complete understanding of complex phenomena in digital ecodynamics and the role of IT in transformation to agile organizations, this study uses two approaches that are theoretically and methodologically different but complementary to each other: a set-theoretic configurational theory approach and a variance theory approach.

On one hand, using a set-theoretic configurational theory approach, this study explores the holistic nature of digital ecodynamics in a way that explain explains how and IT, organizational agility and environmental turbulence simultaneously and systemically combine to result in high performance and innovation leadership. The fuzzy set qualitative comparative analysis (fsQCA) identifies multiple configurations of IT, organizational agility, and environmental turbulence that result in high performance and innovation leadership. By comparing similarities and differences between the configurations, this study extracts several patterns and suggests propositions that describe the dynamic and complex interactions of the key elements in a holistic way and the multifaceted roles of information technologies in creating competitive firm performance at the system level.

On the other hand, based on a variance theory approach this dissertation investigates "mechanical" and universal relationships between IT, organizational agility, innovation leadership and firm performance and the contingency effect of environmental turbulence on the relationships. This study also delves into the detailed relationships between IT systems and organizational agility.

In the remainder of this chapter, I will review the IS strategy and strategic management literature on IT-enabled organizational agility in turbulent business environments and develop research questions. Then, I will explain two theoretical perspectives that this study uses. Lastly, the key findings and contributions of this dissertation will be explained.

1.1 Holistic Systemic Features of Digital Ecodynamics

Studies on digital ecodynamics need to investigate its holistic features that can be captured only at the system level (Ackoff 1994; El Sawy et al. 2010). Focusing on some parts of a system or missing some important parts may hinder us from understanding the holistic features. For example, existing environmental studies based on contingency theory have been criticized by their reductionism (Schoonhoven 1981; Van de Ven and Drazin 1985). That is, if we decompose a system into independent parts and aggregate the findings from each part and dyadic relationships, we may not fully understand the whole. The sum of parts may not explain phenomena occurring only at the system level. By understanding the roles of parts only at the system level, we can capture the essential properties of the whole system (Ackoff 1994). Digital ecodynamics as fused dynamic interactions among IT systems, organizational agility and environmental turbulence is often creating non-linear, discontinuous, and punctuational change (El Sawy et al. 2010; Meyer et al. 2005), which can be more effectively captured from a holistic perspective and at the system level.

1.1.1 The Missing Role of IT in the Strategic Management Literature

Information technologies play an important role in changing business processes, environments and organizational capabilities. IT drives environmental change, such as digital convergences of industries, firms and products (Fransman 2000) and the rules of the game in industries by providing new digital platforms (Shapiro and Varian 1998). At the same time, IT enables organizations to develop agility and flexibility for successfully coping with turbulent environments. For example, IT increases information processing capabilities to manage information overload caused by high environmental velocity and bounded rationality (Bensaou and Venkatraman 1995; Mendelson and Pillai 1998). IT also helps organizations collectively sense and adapt to environmental change through knowledge exchange among supply chain members (Malhotra et al. 2007), sustain competitive advantage by enhancing dynamic capabilities for new innovations (Pavlou and El Sawy 2006; Sambamurthy et al. 2003), and achieve high performance through information sharing (Rai et al. 2006). IT drives change in business processes, for example, changing a governance mechanism for outsourcing (Aron et al. 2007) and the way of communicating between key stakeholders (Wagner and Majchrzak 2007).

While IT plays such important roles in business processes, environmental change, and organizational capabilities, the strategic management literature largely ignores IT. For example, only 2.8% of the research articles published in the leading management journals explored the role of IT (Orlikowski 2009; Zammuto et al. 2007)[2]. Especially,

[2] The journals included in the survey were Academy of Management Journal, Academy of Management Review, Administrative Science Quarterly, and Organization Science.

studies on organizational sensing and managing environmental change generally do not consider the role of IT, but mostly focus on non-IT aspects, such as top management team diversity, social networks, and resource-dependency. Further, although strategic management studies suggest fit as a major research framework to study the dynamics of environments and organizations (Zajac, Kraatz, and Bresser 2000, Naman and Slevin 1993; Venkatraman 1989), they do not include IT as one of the major factors of the configuration. The omission of IT in fit or configurational theories can be a mistake because, as explained earlier, IT is an important factor that determines organizational capabilities to manage issues caused by digital ecodynamics (El Sawy et al. 2010; Malhotra et al. 2007; Mendelson and Pillai 1998; Pavlou and El Sawy 2006, 2010; Sambamurthy et al. 2003).

One of the main goals of this study is to find out the role of IT in enhancing organizational agility to cope with turbulent environments.

1.1.2 The Assumption of Stable Equilibrium Environments

As Emery and Trist argued in their seminal paper (1965), environments may never be in an equilibrium state where no activities occur, but environments are always in a state of flux, constantly changing with frequent punctuational discontinuities (Bogner and Barr 2000; Brown and Eisenhardt 1998; Morgan 1986; Meyer, Gaba, and Colwell 2005). Perpetuated environmental change challenges existing theories in organizations and IT that were built on the premise of environmental equilibrium or incremental and stable environmental change. For example, instead of conventional sensemaking, only continual adaptive sensemaking can deal with perpetuated hyper-turbulent environments (Bogner and Barr 2000). Based on their four studies executed over 25 years, Meyer, Gaba, and Colwell (2005) explain that existing theories are not valid in environments far from equilibrium and that existing research methods assuming linear relationships do not work in such environments. They argue that in a turbulent environment, "truly groundbreaking studies will be informed by more nuanced temporal theorizing about cycles, pacing, and event sequences."

The IS strategy literature argues that the fit between IT strategy and business strategy (Henderson and Venkatraman 1993; Oh and Pinsonneault 2007) enhance firm performance. Such theories can explain well how IT helps organizations enhance performance in a stable environment. However, if environments change radically, competitive advantages created by the fit of intra-organizational factors disappear quickly (Brown and Eisenhardt 1997; Eisenhardt and Martin 2000; Sambamurthy et al. 2003). Thus, by taking external environmental factors into their research models, IS studies can develop better theories that explain the role of IT in enhancing firm performance in constantly changing environments. Some IS studies argue the contingency effect of environmental turbulence on the relationship between IT-enabled agility and firm performance. For example, Overby et al. (2006) theoretically argue that IT-enabled organizational agility in stable environments may be unnecessary and costly. Pavlou and El Sawy (2006) empirically demonstrate the significant moderating role of environmental turbulence on the relationship between IT-enabled dynamic capability and competitive advantage. One of the goals of this study is to advance our understanding of the contingency effect by empirically investigating whether IT-enabled agility enhance competitive advantage both in turbulent and stable environments.

In sum, the strategic management literature largely ignores IT in its research model, and at the same time the IS strategy literature largely ignores environments, although some recent studies consider all the three factors (DeSarbo et al. 2005; Pavlou and El Sawy 2006, 2010). However, the literature is largely seeking dyadic relationships instead of exploring the holistic systemic dynamics among IT systems, organizational agility and environmental turbulence (El Sawy et al. 2010). This study will consider all these elements simultaneously in a way that explains how they systemically combine to result in competitive performance.

1.2 The Role of IT in Developing Organizational Agility

Information technologies, as explained earlier, have great impacts on businesses in many different ways. The impact of IT on firm performance has been a key issue in the IS literature (Barua et al. 1995; Kettinger et al. 1994; Wheeler 2002). While some studies argued that IT does not matter (Carr 2003), since the mid 90s, many studies demonstrated the positive impact of IT on firm performance at the industry level (Bharadwaj et al. 1999; Brynjolfsson and Hitt 1993; Kohli and Devaraj 2003).

As such, the IS literature has demonstrated that IT increases firm performance at the industry level, but it still needs a better understanding of how individual organizations achieve different performance using information technologies. The IS literature has developed theories in group-level IT systems implementation and its impact on teams' flexibility, agility and performance. However, the literature lacks an understanding of how information technologies, such as business intelligence systems and enterprise systems, enable organization-level transformation to agile enterprises that can successfully sense and respond to market opportunities and threats in a timely manner and achieve competitive advantage in turbulent environments (Davenport 2006; Eckerson 2004; Wixom and Watson 2010).

Some IS studies on organizational dynamic capability argued that the impact of IT capability on firm performance is realized through organizational dynamic capability. Sambamurthy et al. (2003) suggest that IT as an enabler for organizational agility indirectly increases firm performance through agility. Pavlou and El Sawy (2006) demonstrated IT as an enabler for dynamic capability indirectly influences competitive advantage through dynamic capability in the new product development context.

On the other hand, some IS studies suggest an opposing role of IT as an inhibitor for organizational agility (Galliers 2006; Retting 2007; van Oosterhout et al. 2006). IT can hinder organizations from moving fast and changing flexibly due to its fixed artifacts and inflexibility in legacy systems (El Sawy et al. 2010; Lu and Ramamurthy 2011). Further, in stable environments IT-enabled agility can be costly because in slowly and predictably changing environments organizations do not need to rapidly sense and respond to change (Overby et al. 2006) and there are many alternative ways to achieve competitive advantage (Davis et al. 2009; Fine 1998).

The IS literature calls for rigorous empirical studies that investigate the argued inconsistent roles of information technologies (Lu and Ramamurthy 2011). The current understanding of IT and agility largely relies on conceptual or case studies and consulting company reports. Further, the IS literature largely lacks theoretically developed constructs and rigorously tested measures for organizational agility and information technologies. The IS literature also needs an empirical investigation of the contingency effect of environments on the relationships between IT, organizational agility, and firm performance. Pavlou and El Sawy (2006) found that the relationships between IT, dynamic capability, and competitive advantage are positively significant regardless different levels of environmental turbulence. However, in stable environment, organizations may not need to rapidly move away from a competitive position but instead enjoy the benefits provided by the combination of rare and valuable resources (Barney 1991; Wade and Hulland 2004). Thus, the environmental turbulence can have a contingency effect on the relationship between IT-enabled agility and firm performance. This dissertation empirically investigates the role of IT as an enabler and an inhibitor for agility and firm performance from both a configurational theory and a variance theory perspective. This study also investigates the contingency effect of environments.

Last but not least, according to the task-technology fit theory, some types of IT systems better support some types of tasks (Zigurs and Buckland 1998). There is a paucity of an understanding of the fit between IT systems and agility in the context of event management tasks. So, this study defines three types of IT systems and three types of agility corresponding to individual types of event management tasks, and then explores the role of each type of IT systems in enhancing agility, and delves into the detailed relationships between types of IT systems and types of agility.

1.3 Multidimensional Environmental Construct

Studies that treat environmental turbulence as a thin unidimensional variable or assume stable environments may not help develop a deep understanding of phenomena in complex, non-linear, and punctuational environments (Meyer et al. 2005). Environments become increasingly turbulent (Bogner and Barr 2000; Brown and Eisenhardt 1998; Wiggins and Ruefli 2005; Nadkarni and Narayanan 2007b), and have multiple dimensions each of which has unique characteristics (Davis et al. 2009; McCarthy et al. 2010). Thus, studies that do not include environments in their research model or misuse structurally inappropriate environmental constructs are likely to develop ambiguous or wrong theories. Appendix A shows a typology of environments that summarizes existing constructs of business environments in a way that helps conceptualize environments with multiple dimensions relevant to the context of a study. This dissertation argues that environmental change generates critical business issues and more frequently create opportunities and threats that organizations need to sense and manage in order to achieve competitive advantage. Therefore, in Appendix A, this study chooses the *velocity* as the most appropriate construct for environmental change. Environmental velocity has two dimensions – the speed of change and the direction (unpredictability) of change (McCarthy et al. 2010), which will be explained in more detail in the conceptual development chapter.

1.4 Research Questions

Based on the explained literature gaps and research motivation, this dissertation intends to answer the following research questions:

- How do information technologies, organizational agility, and environmental turbulence simultaneously and systemically combine to result in competitive performance?
- What is the role of information technologies in enhancing organizational agility to successfully sense and respond to market opportunities and threats and achieve competitive performance?
- How and why do the relationships between information technologies and organizational agility and performance change depending on different levels of environmental turbulence?

1.5 Theoretical Perspectives – Variance and Configurational Theory

To develop a more complete understanding of the holistic features of digital ecodynamics and the role of information technologies in enhancing organizational agility, this study uses two approaches, a variance theory and a set-theoretic configurational theory approach, that are theoretically and methodologically different but complementary to each other (El Sawy et al. 2010; Fiss 2007; Ragin and Amoroso 2011). A set-theoretic configurational theory approach is used for exploring diverse holistic features of digital ecodynamics in a way that describes how IT, organizational agility and environmental turbulence simultaneously and systemically combine to produce competitive firm performance. At the same time, based on a variance theory approach this dissertation investigates mechanical, sequential relationships between IT, organizational agility, environmental turbulence, and firm performance with the aim to advance IS theories of IT-enabled agile organizations.

Figure 1-2: Two Approaches: Variance and Configurational Theory

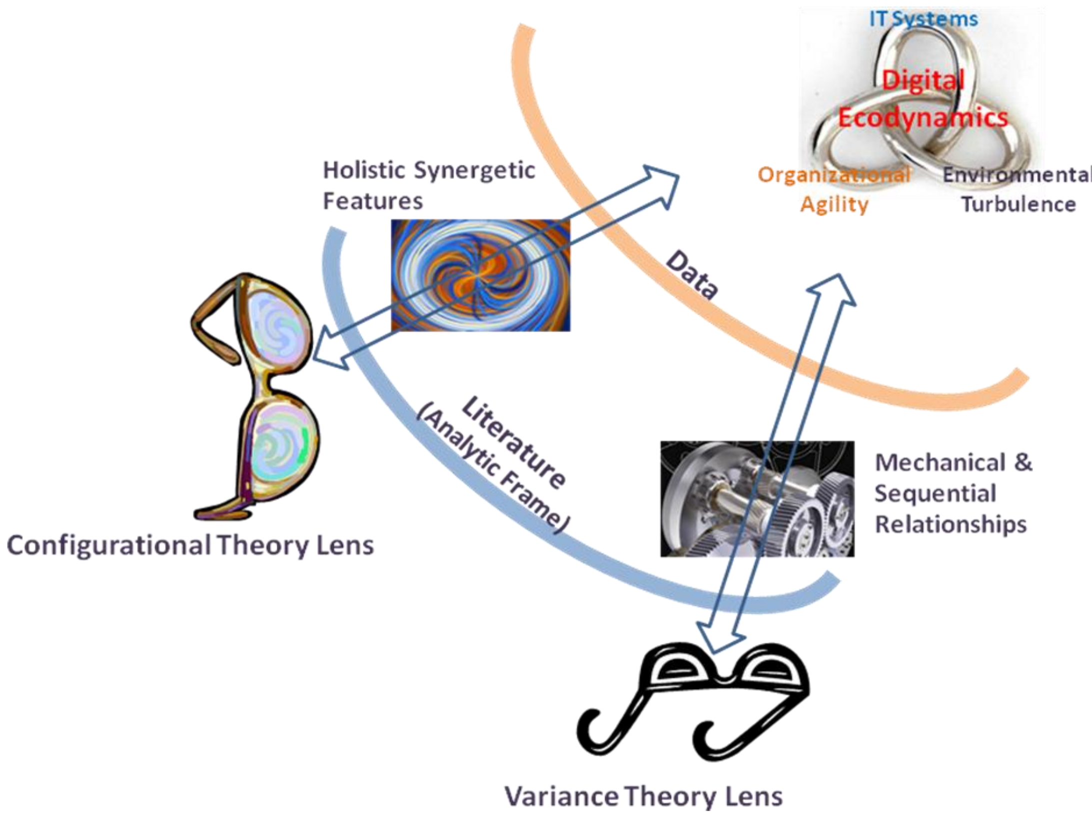


Figure 1-2 briefly depicts such thoughts about these two theoretical lenses and their different purposes. It includes the literature and data layer. The literature provides an analytic frame that is a detailed outline of a theory about phenomena and constitutes ways of seeing phenomena. On the other hand, by synthesizing data, a researcher can make an image of phenomena, which enables a researcher to test and refine a proposed theory or build a new theory (Ragin and Amoroso 2011).

Based on a flexible analytic frame a configurational theory approach is well suited for capturing holistic, systemic features of digital ecodynamics (El Sawy et al. 2010; Fiss 2007; Ragin and Amoroso 2011). A configurational theory approach treats a set of elements (i.e. a configuration) as a single predictor, and the structure of configurations can change, meaning individual configurations can have different elements playing different roles in producing an outcome. It focuses on finding the effect of a configuration on the outcome and finding patterns among elements of a configuration and/or patterns across configurations (El Sawy et al. 2010; Fiss 2007). The role of each element is presented as either core or peripheral and either present or absent, thus showing how individual elements play different roles in enabling a system to produce an outcome of interest. As such, rather than seeking the net effect of each variable on outcome variable, it seeks holistic patterns that show how elements systemically combine to produce an outcome, showing complementary and synergetic effects among elements (Ragin 2008). Thus, it can effectively explore how a system or configuration can shift from one state to another state by changing its structure, meaning that it can capture the features of nonlinear change, jolt and disequilibrium. More details of a configurational theory approach will be explained in Chapter 4.

On the other hand, using a fixed analytical frame, a variance theory is well suited for building a universal generalizable theory (El Sawy et al. 2010; Markus and Robey 1988). Existing theories on phenomena enable a researcher to find the most likely causal structure between variables. This approach assumes that the structure of relationships is invariant over time and usually linear and additive. A variation of a dependent variable is explained by levels of independent variables, and independent variables are necessary and sufficient conditions for a dependent variable (Markus and Robey 1988; Sabherwal and Robey 1995). It focuses on finding the net effect of each independent variable on a dependent variable, thus showing which predictors explain more variation in an outcome variable (Fiss 2007).

Table 1-1 summarizes and compares the main characteristics of the two approaches.

Table 1-1: Characteristics of Variance and Configurational Theory Approach

Variance Theory	Configurational Theory
• Good at predicting levels of outcomes from levels of predictors	• Good at describing holistic, systemic features
• Invariant structure of the relationships (a fixed analytic frame)	• Variant structures of combinations of elements (flexible analytic frame)
• Net, independent effect of predictors on outcome	• Complementary, synergetic effects of elements to produce an outcome
• Necessary & sufficient independent variables	• Necessary & sufficient conditions
• Usually linear and additive structure	• Nonlinear and discontinuous structure
• Effective in testing and refining a theory, and making more universal generalizable theory	• Effective for exploring diversity of new phenomena and building a new theory

In sum, the two research approaches together can develop a more complete understanding of the holistic nature of digital ecodynamics and the role of IT in transformation to agile organizations, with theoretically and methodologically different characteristics but complementary to each other.

1.6 Summary of Key Findings and Contributions

This dissertation contributes to IS strategy for digital ecodynamics by developing a better understanding of the holistic nature of digital ecodynamics and the multifaceted roles of information technologies in agile organizations using both a set-theoretic configurational theory approach and a variance theory approach.

The findings from a configurational theory approach capture diverse holistic features that describe synergetic and complementary interactions among IT systems, organizational agility and environmental turbulence that can be captured only at the system level, therefore overcoming the reductionism issue (Fiss 2007; Ragin 2008). This dissertation opens the black box of digital ecodynamics, and describes how the elements of a configuration intermingle with each other and how individual elements play different roles as either core or peripheral and as either present or absent in enabling a configuration to achieve high performance and innovation leadership. This rich combinatorial expression of the systemic interactions of IT, agility, and environmental turbulence enables the complex diversity of digital ecodynamics to be presented in a meaningful way to show equifinal paths to the same outcome and the multifaceted roles of information technologies.

Equifinal paths to the same outcome means that there are multiple configurations that result in the same outcome, such as a high level of agility, innovation leadership and high performance. This is a unique feature that can be explained by a configurational theory approach. By comparing similarities and differences between multiple configurations, this study found several patterns that explain how IT, organizational agility and environmental turbulence systemically combine to produce the outcomes of interest. For example, there are two groups of configurations that achieve high performance: IT-enabled vs. non-IT-enabled. In turbulent environments, IT plays a core role in achieving high performance, and in stable environments non-IT-enabled configurations can achieve high performance.

The findings from a configuration analysis explain the multifaceted roles of IT as either an enabler or an inhibitor for organizational agility. The patterns extracted from the comparison of configurations show that different types of IT systems can be either an enabler or an inhibitor in the same configuration. Further, the same type of IT systems can be either an enabler or an inhibitor over different configurations. As such, this study provides a rich understanding of the multifaceted roles of IT.

On the other hand, the findings from a variance theory approach provide empirical evidence for IT as an enabler for organizational agility. The findings also demonstrate that information technologies indirectly influence innovation leadership and firm performance through organizational agility. Further, the findings show that different IT systems play different roles in developing different types of agility. Business intelligence systems enhance both acting and sensing agility, while communication and collaboration systems are especially effective in enhancing sensing agility. Interestingly, PLS results show that business process and resource management systems do not have a significant relationship with organizational agility. However, the configurational analysis results show that business process and resource management systems play a peripheral role in enhancing agility. Thus, the findings from the two approaches explain that business process and resource management systems do not directly and significantly influence agility, but they still play a complementary role in enhancing agility, for example, by feeding raw data to business intelligence systems. This example demonstrates how the two different approaches complement to each other and develop a more complete understanding of the complex dynamics of IT-enabled agile organizations in turbulent environments.

Further, this dissertation investigates the contingency effect of environmental turbulence. Using fuzzy set memberships I define three groups of cases that are different in their levels of environmental turbulence, and then with PLS analysis, I demonstrate that IT-enabled organizational agility can enhance innovation leadership and firm performance only in hyper-turbulent environments. In stable environments, all relationships become insignificant. The findings from a configurational analysis complement this finding by showing that in stable environments IT should be absent for a configuration to result in high performance. There could be multiple alternative ways to increase performance in such slowly and predictably changing environments (Davis et al. 2009; Fine 1998). Therefore, too much investment in IT to achieve agility could be costly (Overby et al. 2006). This is another example that shows how the two approaches together develop a better understanding of complex phenomena in digital ecodynamics.

This dissertation contributes to methodologies for IT-enabled agility studies by developing constructs and measures for organizational agility and IT systems. It suggests an open-system event management model by synthesizing existing environmental sensemaking and responding models. Based on this theoretical model, this study defines constructs for organizational agility and IT capability, and empirically tests their validity.

This dissertation also practically contribute to managerial knowledge by showing how organizations transform to the IT-enabled agile organization with the most affordable costs and risks through multiple alternative paths.

1.7 Dissertation Overview

This dissertation consists of six chapters. Chapter 2 develops a conceptual framework of open-system event management, with which I further develop theoretical constructs for organizational agility and IT capability. Chapter 3 describes the research methodologies, including measurement development, data collection and validity test. Chapter 4 describes patterns and propositions found from a set-theoretic configurational theory approach, which explain the holistic nature of digital ecodynamics. Chapter 5 explains a variance theory that investigates the relationships describing the role of IT in enhancing organizational agility, innovation leadership and firm performance. Chapter 6 summarizes and discusses the key findings and insights of this dissertation, their theoretical and practical implications, and limitations and suggestions for future research.

CHAPTER 2: CONCEPTUAL DEVELOPMENT

Organizational sensemaking and responding to opportunities and threats in turbulent environments are so complex and multifaceted that studies on this topic cut across multiple disciplines including information systems, strategic management, entrepreneurship, and marketing (Ardichvili et al. 2003; Jaworski and Kohli 1993; Sambamurthy et al. 2003; Weick 1999). By synthesizing environment sensemaking and responding models, I suggest an open-system event management model, which explains how organizations sense critical environmental events, make a decision for defining opportunities and threats embedded in the captured events, and make competitive actions by introducing new innovations to the market. Based on this model, I develop theoretical constructs of three types of agility and three types of IT systems in a way that each construct can capture unique aspect of organizational agility and IT capability related to event management tasks. Further, I define organizational agility and IT capability as a second-order formative construct consisting of their three first-order constructs. Further, I define environmental turbulence as a second-order construct using the concept of velocity that has two dimensions: speed and direction of change. Lastly, I conceptualize top management team (TMT) energy as one of important factors for research in IT-enabled agile organization in digital ecodynamics.

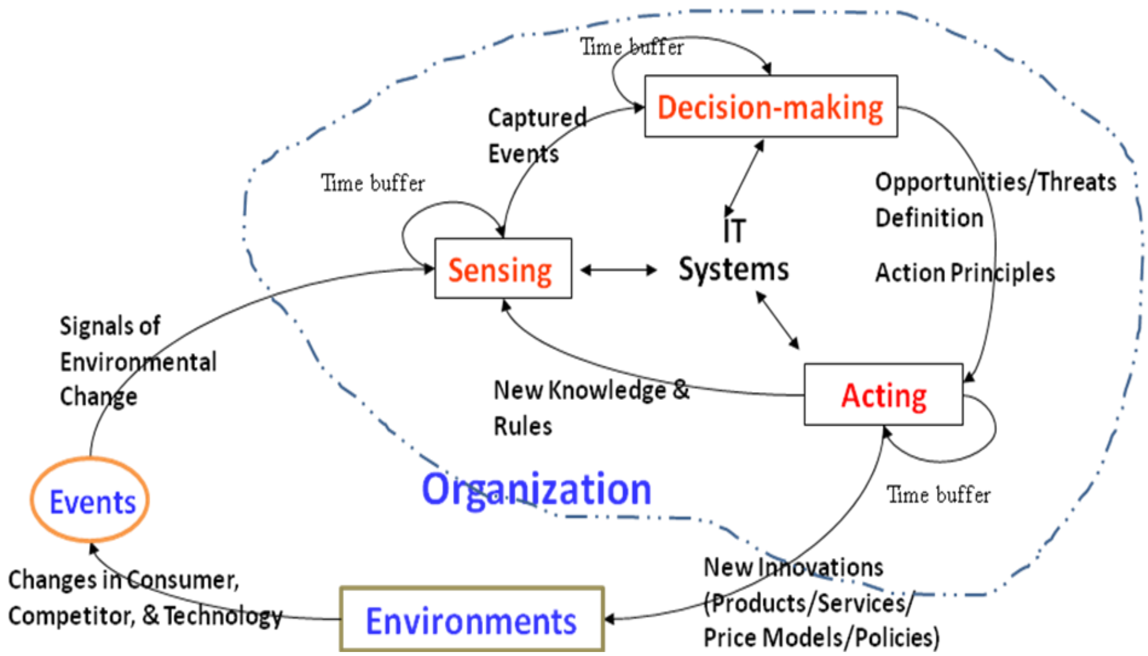
In chapter 4, the constructs developed in this chapter are used for a set-theoretic configurational theory approach, which aims to explore diverse holistic features of digital ecodynamics and the non-linear and non-additive but synergetic systemic relations among the key elements. In chapter 5, I develop a variance theory that explains the linear, additive relationships between these constructs in a way that explains the role of information technologies in enhancing organizational agility, innovation leadership and firm performance, and the contingency effects of environmental turbulence on the relationships.

2.1 Open-System Event Management Model

Based on the concept of "organization as flux and transformation with an information processing brain" from Morgan's images of organization (1989), I synthesize the existing environmental sensemaking and acting models (El Sawy 1985; Houghton et al. 2003; Kiesler and Sproull 1982; Thomas, Clark, and Gioia 1993) to explain how environments and organizations influence each other and co-evolve together over time, an open-system approach (Emery and Trist 1965). Figure 2-1 depicts the resulting event management model.

A number of models have been proposed to describe how organizations sense and respond to environmental change. For example, some propose a model of organizational adaptation consisting of scanning, interpreting, and responding processes (Daft and Weick 1984; Milliken 1990), and some suggest a sensemaking model consisting of information seeking and meaning ascription (Weick 1979, 1999). Some studies have examined models around the sequential relationship of scanning, interpretation, action and performance, and some have proposed a closed cycle of four sequential tasks: observe, orient, decide, and act (OODA) (Houghton et al. 2004). By synthesizing all these sensemaking and acting models, I suggest an open-system event management model, which explains how organizations and environments co-evolve continuously by exchanging impact and feedback with each other over time. For example, firms can enact environmental change by introducing new innovations like new products and pricing models to the market to which market players should (e.g., competitors, consumers, and regulators) respond. At the same time, they need to adapt to new environmental change enacted by other market players.

Figure 2-1: Open-System Event Management Model



This model defines three main tasks, sensing, decision-making, and acting -- which are a series of interconnected activities to identify and manage opportunities and threats -- that give rise to new innovations (Ardichvile et al. 2003; Teece et al. 1997). Table 2-1 describes key aspects of individual tasks.

Table 2-1: Event Management Tasks

Task	Explanations	Outputs
Sensing	Scan, monitor, and filter events generated from environmental change	Critical events
Decision -making	Gather, aggregate, structure, and evaluate data and information from diverse sources to understand the implications of the captured events to business, and define opportunities and threats	Opportunities and threats definition
	Make action plans to guide reconfiguration of resources and modify business processes, and to initiate new competitive actions to the market	Action principles
Acting	Reconfigure organizational resources and modify processes based on action principles	New configuration of resources & processes; New supply chain partnerships
	Introduce new competitive actions to the market, such as new products/services, new pricing models, and new policies	New products/services and pricing models, New policies for customers and suppliers

The *sensing* task refers to the strategic scanning of environmental events that can have great impact on organizational strategy, competitive action, and future performance (Daft and Weick 1984; El Sawy 1985; Kiesler and Sproull 1982; Milliken 1990; Thomas et al. 1993). Sensing task includes such activities as acquiring information about events, in which environmental change is manifested, and filters out relatively unimportant information based on predefined rules (El Sawy 1985). This task initiates decision-making and acting tasks (Daft and Weick 1984; Dutton and Duncan 1987) that lead to organizational adaptation to environmental change (Hambrick 1981) or enact new environmental change (Smircich and Stubbart 1985).

The *decision-making* task consists of several inter-related activities that interpret the captured events and define opportunities and threats (Thomas et al. 1993). Organizations gather, aggregate, structure, and evaluate relevant information from diverse sources to understand the implications of the captured events to their business (Thomas et al. 1993). Through these activities, they define opportunities and threats. Then, they make action principles to maximize the effect of opportunities and minimize the effect of threats (Haeckel and Norton 1993; Houghton et al. 2004). Action principles are guidelines to reconfigure resources and adjust business processes, and to initiate new competitive actions in the market.

The *acting* task consists of a set of activities to recombine organizational resources and modify business processes based on the action principles made from the decision-making task to address environmental change (Eisenhardt and Martin 2000; Teece et al. 1997). Organizations can change business processes with different procedures and resources, or redesign organizational structure (Dutton and Duncan 1987; Thomas et al. 1993). The acting task also includes organizations' new competitive actions to the market by introducing new products/services and new pricing models, and by changing policies with strategic partners and major customers (D'Aveni 1994; Dutton and Duncan 1987; Ferrier, Smith, and Grimm 1999; Thomas et al. 1993). These enacted events are new environmental changes to which other market players like competitors, key customers, and suppliers should respond. Sometimes, regulators also need to respond to these competitive actions to maintain healthy market conditions.

Example of event management

To help understand the suggested open-system event management model, I provide an example in a rapidly and unpredictably changing environment as follows:

Acting: A personal computer manufacturing and selling company launches several online sales Web pages weekly. Each Web page sells the same products but differently from other Web pages. Each page can have different designs, offers, procedures, and options. These Web pages drive changes in consumer purchasing behaviors.

Sensing: If a customer starts check-out, it is an event. If a customer finishes a purchase, it is an event. These events are captured by information systems. The systems (e.g., Dashboard embedded in a Web Analytics solution) monitor the ratio of the number of purchases to the number of check-outs, showing the percentage of real purchase. If the ratio increases in a Web page but decreases in other pages significantly, information systems (e.g., a Web analytics solution) run a statistics test to define a significance level of the captured event based on predefined rules and then, for the significant event, notify relevant people via email, message, call, or other channels.

Decision-making: If decision makers receive alerts or find some exceptions, they start analyzing data (e.g., click stream data) and find patterns that explain the reasons for the jump in the Web page and rapid drops in other pages. Then, they define opportunities or threats embedded in the captured event and make action principles to maximize the effects of opportunities and minimize the effects of threats. They decide key design parameters and define several sets of the key parameters.

Acting: Based on the new action principles, the company design new Web pages with the newly defined sets of parameters. Then, existing Web pages are replaced with new ones, and the corresponding business processes are modified to support these new Web pages.

As shown in this example, this model also explains how organizations destruct or modify existing products and introduce new innovative products that reflect changing market trends over time, an innovation creation cycle with continuous experiments.

2.2 Organizational Agility

Organizational agility is an organizational ability to successfully sense and respond to market opportunities and threats in a timely manner (Overby et al. 2006; Sambamurthy et al. 2003). By definition, agility enables organizations to successfully execute a series of tasks defined in the open-system event management model [Figure 2-1] that sense and manage opportunities and threats embedded in business events, which give rise to new innovations (Ardichvile et al. 2003).

I define three types of agility that correspond to individual event management tasks: sensing, decision-making, and acting agility [Table 2-2]. I introduce a time buffer concept in the event management to define agility. Each task has its unique time buffer, defined as "the amount of time that allows organizations to finish a task without delay so that it cannot affect other tasks dependent on it." If a task cannot be finished in the given time buffer, other tasks dependent on it either cannot be started or can be ineffective or very costly (Gerloff 1985, p.328). For example, a very costly car recall can occur when the information regarding an unfavorable variance is received too late to permit correction -- out of the given time buffer. As I will explain in the methods section, I use this time buffer concept for measuring each type of agility. In the survey questionnaire, I explicitly explain the time buffer concept and ask respondents to consider it when they answer each survey question that measures agility. The following table explains each type of agility.

Table 2-2: Organizational Agility

Type of Agility	Explanation
Sensing Agility	Detect and capture important business events in a timely manner
Decision-making Agility	Interpret the captured events, define opportunity and threat, and make action plans in a timely manner
Acting Agility	Reconfigure dynamically organizational resources, modify business processes, and introduce new innovations to the market in a timely manner

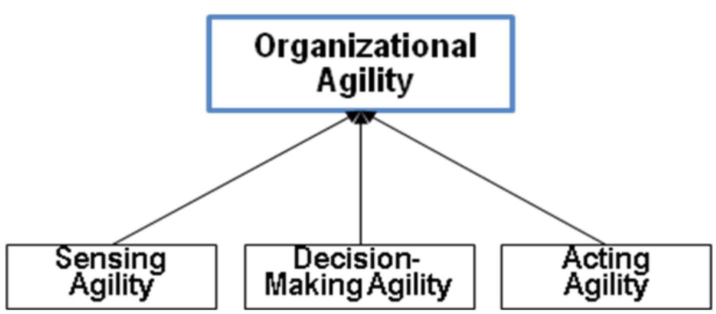
Sensing agility is an organizational ability to scan, monitor, and capture events from environmental change (e.g., customer preference change, competitors' new moves, and new technologies) in a timely manner.

Decision-making agility is an ability to gather, aggregate, structure, and evaluate relevant information from diverse sources to interpret the implications of captured events to business without delay, define opportunities and threats based on the interpretation of the events, and make action plans that guide how to reconfigure resources and make new competitive actions.

Acting agility is an ability to dynamically reconfigure organizational resources, modify processes, and restructure supply change relationships based on the action plans and introduce new products, service and pricing models to the market in a timely manner.

In sum, organizations can sense and respond to opportunities and threats in a timely manner by doing a sequence of event management tasks, each task corresponding to each type of agility. Thus, organizations can achieve a high level of agility by achieving high levels of three types of agility. Each type of agility represents the unique aspect of organizational agility, and the three together build a whole concept. This means that organizational agility is a formative higher-order construct consisting of three parts (Diamantopoulos and Winklhofer 2001; Edwards 2001). Defining organizational agility as a second-order construct is in the same vein with existing organizational dynamic capability studies (Pavlou and El Sawy 2006, 2010; Sambamurthy et al. 2003). Therefore, I define an organizational agility as a second-order formative construct consisting of three first-order constructs: sensing, decision-making, and acting agility, which is depicted in Figure 2-2.

Figure 2-2: Organizational Agility as a Second-Order Formative Construct



2.3 IT Systems for Event Management Tasks

The IS literature defines a number of different types of IT systems by considering specific task contexts because, according to the task-technology fit theory, some types of information technologies can support specific tasks better than other types of information technologies (Daft and Lengel 1986; Goodhue and Thomson 1995; Zigurs and Buckland 1998). For example, Sabherwal and Kirs (1994) define four types of IT systems in the context of academic institutions: information retrieval, electronic communication, computing facilities for students, and computer-aided education. Zigurs and Buckland (1998) define three types of IT systems for group decision making tasks: information processing, communication support, and process structuring. Pavlou and El Sawy (2006) define three types of IT systems specific to the new product development context: project and resource management, knowledge management, and cooperative work.

I define three types of IT systems specific to the event management task context---business intelligence systems, communication and collaboration systems, and business process and resource management systems.

To define these three types of IT systems, I first refer to the IS literature on organizational dynamic capabilities to cope with turbulent environments (Houghton et al. 2004; Overby et al. 2006; Pavlou and El Sawy 2006, 2010; Sambamurthy et al. 2003). For example, Sambamurthy et al. (2003) introduce knowledge management systems and process management systems that enhance organizational agility to sense and seize market opportunities. Nambisan (2003) and Pavlou and El Sawy (2006, 2010) introduce project and resource management, organizational memory and knowledge systems, and cooperative work systems that help dynamically reconfigure existing resources to develop new products reflecting market change. To successfully interpret situations and take appropriate actions, people or stakeholders need to communicate and share information relevant to the situation in a timely manner (Galbraith 1974; Malhotra et al. 2007; Tushman and Nadler 1978, p. 614), especially in turbulent environments (Majchrzak, Jarvenpaa, and Hollingshead 2007; Majchrzak, Logan, McCurdy, and Kirchmer 2006). Therefore, communication technologies are also a key system for successful event management.

To complement the literature on these technologies, I had a number of interviews with managers in business analytics departments in high velocity industries and with IT consultants working for enterprise-IS solution companies, including Oracle, SAP, and SAS. Further, I refer to research firms' reports on how agile companies use information technologies, including Gartner Group and McKinsey & Company. Industry research reports and IT solution companies introduce a number of IT systems for event management, such as business intelligence and analytics, complex event processing, event-driven architecture, service-oriented architecture, business process management, to name but a few.

I also conducted a pilot study with a successful small company in the IT service industry, which wisely uses different types of information technologies, such as communication and collaboration systems and business intelligence systems, for supporting its core business processes that aim to support customers needs in real-time.

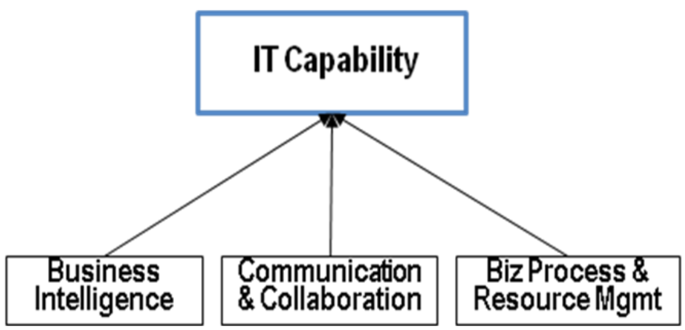
Although several IT systems can be defined, three types of IT systems seem to be essential for event management tasks: business intelligence, communication and collaboration, and process and resource management systems. Table 2-3 summarizes the main functions that each type of a system provides.

Table 2-3: IT Systems for Event Management Tasks

Type	Key Functions	Examples
Business Intelligence	• Providing access to multiple data sources • Rule-based exception handling • Helping managers know important business events in a timely manner • Accessing enterprise-wide consistent data immediately • Supporting what-if analysis • Presenting data visually	Digital Dashboard, Balanced Scorecard, Data Warehouse, Data Mining, OLAP (e.g, SAP Business Object, IBM Cognos, Oracle EssBase), Web Analytics (e.g., Omniture, Google Analytics), Rule-based Systems
Communication &Collaboration	• Disseminating relevant information to stakeholders in real-time • Supporting real-time information sharing within company and with key partners • Supporting real-time virtual video/audio conference • Supporting effective collaboration within company and with key partners	Video/Audio Conference Systems, e-mail, Collaboration Systems (e.g., Yammer, Google Wave, Lotus Notes), Mobile Applications (e.g., SMS, Digital Bulletin Board), Help Desk Sys. Instant Messaging, Blogs, Web 2.0, Web community
Business Process & Resource Management	• Presenting business processes visually • Dynamically modifying business processes • Streamlining & scheduling business processes • Automating business processes • Providing information about resource dependencies on tasks • Providing real-time information of resources	ERP, Supply Chain Mgmt Sys, Business Process Mgmt Sys, Workflow, Bar Code, RFID, Inventory Mgmt Sys, EDI (Electronic Data Interchange), Standard Electronic Business Interfaces (SEBI)

IT capability is a firm's ability to mobilize, reconfigure and deploy IT resources to support work processes and tasks (Bharadwaj 2000; Sambamurthy and Zmud 1997). Organizations can use the suggested three types of IT systems to support event management tasks, so I define a firm's IT capability as a second-order construct consisting of capabilities provided by the three types of IT systems. Each type of IT system represents the unique aspects of organizational IT capability to support event management tasks. This means that a firm's IT capability is a formative construct (Diamantopoulos and Winklhofer 2001; Edwards 2001). Defining organizational IT capability as a higher-order formative construct is in the same vein with existing IS strategy studies (Pavlou and El Sawy 2006, 2010). Therefore, I define an organizational IT capability as a second-order formative construct consisting of three first-order constructs, which is depicted in Figure 2-3.

Figure 2-3: IT Capability as a Second-Order Formative Construct



2.3.1 Business Intelligence (BI) Systems

Business intelligence (BI) systems are defined as a type of IT system that provides a set of functions for supporting organizational sensemaking of environmental change and acting. BI systems enable organizations to monitor and capture important business events by providing rule-based exception handling functions, and alert people about the captured events. BI systems allow managers to access enterprise-wide consistent data (e.g., data warehouse) and help them find out patterns and meanings from the data (Carte et al. 2005; Cooper et al. 2000). Further, BI systems provide what-if analysis and data visualization functions. BI systems encompasse widely accepted concepts, including data warehouse, data mining, balanced scorecard, and digital dashboard. In addition to these typical BI systems, the recent advancement in technologies enables organizations to handle real-time data (Watson 2005) in a way that monitors business events in real-time and proactively and reactively sends out information about events to relevant people who are responsible for managing the captured events (Anderson-Lehman et al. 2004; Chandy and Schulte 2009).

2.3.2 Communication and Collaboration (CC) Systems

Communication and collaboration (CC) systems are defined as a type of IT system that provides a set of interactive communication and collaboration functions. CC systems support real-time information dissemination, two-way communications between co-workers, and information sharing with key stakeholders, such as supply chain partners, key customers, and regulators. CC systems also support real-time virtual video/audio conference that supports a cooperative work. The real-time and rich communication functionalities help managers increase information use, reduce communication barriers, and increase interactions among members (Daft and Lengel 1986; Thomas et al. 1993; Zigurs and Buckland 1998). Thus, CC systems enable managers to collectively make sense of the market events in a timely manner.

2.3.3 Business Process and Resource Management (BPRM) Systems

Process and resource management (BPRM) systems help organizations quickly respond to environmental change by helping organizations manage processes and resources effectively and flexibly within enterprise and with key stakeholders (Merali 2002; Nambisan 2003; Overby et al. 2006; Pavlou and El Sawy 2006; Sambamurthy et al. 2003). This type of system provides functions that visually present the structures of processes, including the dependencies of activities within a process and the dependencies between processes (Nambisan 2003). It also provides real-time information about resources and their dependencies on tasks (Pavlou and El Sawy 2006). Thus, these functions can help firms dynamically redesign a process, add a new process, and rearrange and streamline processes. These functions also enable organizations to automate typical business processes like procurement, inventory management, and payment. Enterprise resource planning (ERP) systems, supply chain management (SCM) systems, point of sales systems, and inventory management systems are typical examples of BPRM.

2.4 Environmental Turbulence

While environmental change becomes more complex, unpredictable, non-linear, punctuational and discontinuous (Meyer et al. 2005), a stream of IS and strategic management studies tend to treat environmental turbulence as a thin unidimensional variable, which may not help develop deep and detailed understanding of phenomena in such increasingly turbulent environments (Davis et al. 2009; McCarthy et al. 2010). Environmental turbulence has multiple dimensions, and each dimension has unique characteristics (Appendix A).

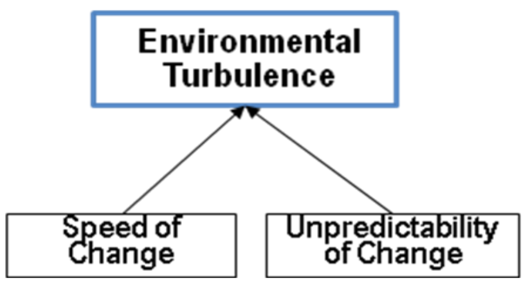
I unpack the dimensions of environmental turbulence in terms of environmental change because this dissertation focuses on how organizations sense and manage opportunities and threats generated from environmental change. I define environmental turbulence with the velocity concept. The velocity of environmental change has become central to the study of strategic management, which creates a number of critical business issues (Bourgeois and Eisenhardt 1988; Eisenhardt and Martin 2000; Fine 1998; Mendelson and Pillai 1999; Nadkarni and Narayanan 2007b). However, the environment velocity literature largely ignores the fact that velocity is a multi-dimensional construct. The velocity of change has two distinct dimensions: the speed (pace) of change and the direction of change (McCarthy et al. 2010; Morgan 1989, p. 73). The speed of change is the rate at which new opportunities emerge (Davis et al. 2009; Eisenhardt 1989), the rate at which new products and services are introduced (Fine 1998; Mendelson and Pillai 1999; Nadkarni and Narayanan 2007b), or the rate of change in the collective assumptions on environments (Nadkarni and Narayanan 2007a). Unpredictability as the direction of environmental change is the amount of disorder, showing no consistent similarity or pattern (Davis et al. 2009). High unpredictability makes it difficult to predict the direction of change, so managers are less able to adjust their structures to the changing environment (Galbraith 1973). Unpredictability comes from the deepening interdependency among environmental components, such as customers, competitors, technologies, regulators, or other stakeholders, and makes the environment turbulent (Dess and Beard 1985; Emery and Trist 1965).

These two dimensions of environmental change simultaneously determine the impact of change on business strategy and performance (McCarthy et al. 2010). For example, Nadkarni & Narayanan (2007b, p. 245) gave a good example of different organizational dynamics to manage environmental change in different high-velocity environments. Although both the circuit board and the semiconductor industries have high speed of change, the circuit board industry has experienced unpredictable and discontinuous change, while the semiconductor industry has experienced relatively predictable change. This example shows the importance of considering two distinct dimensions of environmental change when defining environmental turbulence.

On the other hand, the literature on business environments largely defines two different types of environment: general and task environment (Daft et al. 1988; Gerloff 1985, p. 19; Hall 1982; Morgan 1989; Osborn and Hunt 1974). A task environment is a specific environment in which organizations interact with customers, competitors, suppliers, shareholders and so on, while a general environment is a broader concept that includes economic, social, and cultural factors. The task environment is a context where an organization is operating its everyday tasks. Individual organizations have relatively different task environments, while they have relatively similar general environments that essentially affect task environments (Gerloff 1985; Hall 1982; Morgan 1989), as the 2008 global economic crisis did.

This dissertation focuses on change in task environments as described in the open-system event management model [Figure 2-1]. I define the velocity of task environments in terms of customer, competitor and technology (Daft et al. 1988). For example, the increasing environmental velocity implies that changes in consumers' preferences, competitors' competitive actions or technologies become faster and more unpredictable. Further, I conceptualize environmental turbulence as a formative second-order construct with the first-order constructs of speed and unpredictability [Figure 2-4].

Figure 2-4: Conceptualization of Environmental Turbulence



2.5 Top Management Team Energy

Existing strategic management and IS studies demonstrated the importance of top managers' role in getting important information about and adapting to business environmental change. For example, according to theories of top management team (TMT), TMT energy plays a critical role in the successful organizational sensing and responding to environmental change (Eisenhardt 1989; Hambrick 1981; Hambrick et al. 1996; Kiesler and Sproull 1982). T|MT energy has also proved one of the most important factors for information systems success, including BI systems (Cooper et al. 2000; Wixom and Watson 2001). Top managers' energetic initiatives for changing their organizations can help employees overcome resistance to change (Markus 1983), and successfully drive employees to adopt and use information systems for their business event management. Further, top management teams play an important role in fostering innovation by encouraging experimentation, communication, and collaboration (McAfee and Brynjolfsson 2007). This study investigates how TMT energy interacts with other constructs in digital ecodynamics. In chapter 4, with a set-theory configurational theory approach, I will investigate the role of TMT energy in configurations for achieving a high level of agility, innovation leadership, and competitive performance. In chapter 5, I will control the effect of TMT energy on IT capability, agility, innovation leadership, and firm performance.

In the next chapter, I explain how I develop measurements and collect data for the constructs developed in this chapter. Further, I investigate the validity of constructs using collected data.

CHAPTER 3: RESEARCH METHODS

This dissertation uses multiple methods. At the stage of conceptual model development, I had a case study and field interviews in order to complement and enhance conceptual models that I built based on the literature. The case study and field interviews have enhanced an initial theoretical framework that explains how and what kinds of information technologies organizations use to successfully sense and respond to market opportunities and threats. As a result, the theoretical framework became more relevant to practice. For data collection, field survey method was used. Fuzzy-set qualitative comparative analysis (fsQCA), an emerging configurational method, was used for analyzing data for exploring diverse holistic features of digital ecodynamics (Chapter 4). In chapter 5, partial least squares (PLS) analysis is used for testing a variance theory that explains the relationships between key constructs that developed in chapter 2.

3.1 A Case Study and Field Interviews

I executed a case study in a small company with around 60 employees in Southern California, which is selling services for digital homes and small businesses. Through this case study, I could better understand the organizational dynamics of coping with environmental change and the role of information and communication technologies. I could learn that there are configurational patterns and fit among organizational agility, information technologies, and environmental turbulence that enable organizations to achieve competitive advantage. Organizations do not need all types of IT systems to achieve a high-level of agility and performance, but instead they need some types of information technologies that are most appropriate for supporting their core business processes. Further, in accordance with the event management model [Figure 2-1], this company's top management team is executing a continuous cycle of experiments of sensing, decision-making, and acting, so it can understand and respond to environmental change in a timely manner. One of the most interesting findings is that top managers' energy and commitment to change plays a key role in moving fast to keep pace with the environmental velocity.

In addition to this case study, I had interviews with managers in high velocity industries, and with IT consultants working for enterprise IS solution companies, including Oracle, SAP, and SAS in order to better understand the role of information technologies in organization's successful sensemaking and responding to environmental change. The example of a computer company's event management in Chapter 2 is constructed from the results of these interviews. As is in the case study, agile companies in high velocity environments are continually executing short-term experiments with business intelligence and communication technologies to successfully capture and respond to market opportunities and threats generated from changing environments. These interviews also helped me enhance the theoretical constructs that I developed from the literature; for example, three types of information technologies that I defined in Chapter 2.

Further, I found that managers at different levels in an organizational hierarchy use different communication channels in sensemaking and responding to environmental change. For example, top managers can directly contact employees at any level who possibly have information helpful for top managers' sensemaking (directive channel). Lower level managers regularly report on-going issues to their upper level managers (upward channel). Managers at the same hierarchical level are sharing information with each other, meaning a horizontal communication channel. Therefore, in agile organizations managers at different levels communicate and collaborate using several different communication channels (i.e., directive channels, operative channels, upward channels) (Gerloff 1985, pp. 283-285; Wofford et al. 1977, pp. 342-349). I also confirmed that three types of IT systems (BI, CC, BPRM systems) that this study defines are used intensively for supporting organizational sensemaking and responding to rapidly changing business environments.

3.2 Measurement Development

Whenever possible, I used existing scales from the literature in order to increase reliability and validity. When I had to develop new measures, I followed scale development procedures (Bagozzi and Phillips 1982; Boudreau, Gefen, and Straub 2001). For the defined constructs (i.e., agility, IT capability, environmental turbulence, and firm performance), I made a pool of items from the literature, and used the original items for measuring the constructs whenever possible. Using statistical analyses, including factor analysis, reliability tests, and construct validity tests, I made a final set of items for each construct.

3.2.1 Measurement Instrument

All variables were measured by multiple items with a seven-point Likert scale, in which higher values were associated with higher levels of the constructs, except for six reverse coding items.

3.2.1.1 Firm Performance

To measure different levels of environmental turbulence, this study collected data from diverse industries differing in their velocity. Accounting measures for a firm's financial performance (e.g., ROA, ROE) are quite different across industries, meaning that some level of ROA representing high performance in one industry, for example, may not represent high performance in other industry. Therefore, it is difficult to use accounting measures for defining a general criterion based on which a firm's performance is defined as either high, or medium, or low in this study. This study uses four self-report items to measures firm performance: general success, market share, growth rate, and profitability compared to major competitors (Lee and Choi 2003; Pavlou and El Sawy 2006). After factor analysis and validity tests, the third item (growth rate) was excluded.

1 = Strongly Disagree, 7 = Strongly Agree

Compared to competitors, our company:

1. is more successful (PERF1).
2. has a greater market share (PERF2).
3. is growing faster (PERF3).
4. is more profitable (PERF4).

Although this study uses self-report survey items to measure firm performance, the literature shows that subjective performance measures correlate strongly with objective performance (Dess and Robinson, 1984). I collected financial data (ROA) for each company and compared with performance measured by the survey data. The statistic test shows a highly significant relationship between these two performance measures, partly relieving some concerns caused by managers' self-reported firm performance.

Dependent Variable: **ROA**	Beta	t	Sig.
(Constant)	-0.864	0.389	
Subject Performance Measure 0.191	**1.907**	**0.060**	

Dependent Variable: **ROA**	Beta	t	Sig.
(Constant)	0.193	0.847	
Perceived Performance Measure	**0.264**	**2.648**	**0.009**
Organization Size	-0.290	-2.906	0.005

In addition to this measure of competitive advantage, which represents more aspects of financial success, I also define another measure of competitive advantage, that is, a firm's *innovation leadership*. The final outputs of the event management, which enable organizations to achieve competitive advantage, are innovations like new products and service (Ardichvili et al. 2003; Pavlou and El Sawy 2006, 2010; Sambamurthy et al. 2003). Therefore, a firm's innovation leadership is a good measure that represents an agility-related firm performance. I measured a firm's innovation leadership in terms of both product and process perspective as follows (Utterback 1996; McGrath 2001):

Please choose which best describes your thoughts on the competitive stance of your company as a leader or a follower.

Our company is in terms of:	Leader	Follower	Neither
1. Product innovation (LDR1)	1	2	3
2. Process innovation (LDR2)	1	2	3

3.2.1.2 Organizational Agility

Organizational agility is not a dichotomous variable like “exist” or “not-exist”, but instead a matter of degree (Overby et al. 2006). All individual firms have some levels of agility. Agility does not mean an organizational ability to reduce time latencies for all tasks to zero. Instead, each task has a time buffer -- the amount of time that allows organizations to finish the task without affecting the schedule of other tasks. Thus, agility is an organizational ability to finish tasks within the allowed amount of time. Depending on the task, the time buffer can be a minute, hour, day, or month (Anderson-Lehman et al. 2004). I explained this time buffer concept to survey participants in the questionnaire. To develop items for measuring sensing, decision-making, and acting agility, this study referenced existing scales (Jaworski and Kohli 1993) and the major features of each agility that I defined in the earlier chapter [Table 2-2].

The following questions are about how your company makes sense of and manages environmental change in a timely manner or without delay. By "**a timely manner**" or "**without delay**", we mean that a task is done within the allowed time for it. So, a timely finished task does not negatively affect the schedule of other tasks.

Sensing Agility (Reverse Coding) (1 = Strongly Disagree, 7 = Strongly Agree)

1. Our organization is slow to detect changes in our customers’ preferences on products (SEN1).
2. Our organization is slow to detect changes in our competitors’ moves (e.g., new promotions, products, and prices) (SEN2).
3. Our organization is slow to detect changes in technologies (SEN3).

Decision-making Agility (1 = Strongly Disagree, 7 = Strongly Agree)

1. Our organization analyzes important events about customer/competitor/technology without delay (DM1).
2. Our organization finds out opportunities and threats from changes in customer/competitor/technology in a timely manner (DM2).
3. Our organization makes an action plan to meet customers’ needs without delay (DM3).
4. Our organization makes an action plan to react to competitors’ strategic moves without delay (DM4).
5. Our organization makes an action plan on how to use new technology without delay (DM5).

Acting Agility (1 = Strongly Disagree, 7 = Strongly Agree)

1. Our organization can reconfigure our resources in a timely manner (ACT1).
2. Our organization can modify/restructure processes in a timely manner (ACT2).
3. Our organization can adopt new technologies in a timely manner (ACT3).
4. Our organization can introduce new products in a timely manner (ACT4).
5. Our organization can change price quickly (ACT5).
6. Our organization can change strategic partnerships in a timely manner (ACT6).
7. Our organization can solve our customers' changing needs and complaints without delay (ACT7).

3.2.1.3 Top Management Team Energy

As I explain in chapter 2, top management team plays an important role in organizational change to keep pace with the environmental velocity and achieve competitive advantage in turbulent environments (Cooper et al. 2000; McAfee and Brynjolfsson 2007). I define two new survey items that measure top management team energy in a way that captures a top management team's commitment to change[3].

Top Management Team Energy (1 = Strongly Disagree, 7 = Strongly Agree)

1. Our top management team is energetic (TMT1).
2. Our top management team drives dynamic change (TMT2).

[3] Four items were initially developed to measure TMT energy. The two other items are: "our top management team knows what happens across the company" and "our top management team actively exchanges information with each other". These two items were excluded for further analysis because they seem redundant or overlap with items measuring IT capability, and are likely to measure other construct like TMT entropy.

3.2.1.4 IT Capability

As defined in the previous chapter, organizational IT capability for supporting event management tasks was measured in terms of three IT systems: business intelligence (BI), communication and collaboration (CC) and business process and resource management (BPRM) systems. I developed new items based on the major functions for each type of IT system as explained in Table 2-3.

We would like to know what kinds of Information systems your organization uses to sense and manage environmental change in a timely manner, without delay.

Business Intelligence (BI) (1 = Almost Never, 7 = Always)

Examples of such information systems that help make sense of environmental change and make an action plan include digital dashboard, balanced scorecard (BSC), Internet information search support systems (e.g., Web mining), real-time data analysis systems, data warehousing, data mining, and the like.

To what extent do the following statements reflect the use of information technology in your organization?

Information systems in our organization:

1. support to acquire information from diverse sources about changes in customers, competitors, and technologies (BI1).
2. filter out unimportant events related to customers, competitive actions, and technology change based on predefined rules (BI2).
3. help appropriate managers to know important events about customers, competitors, and technologies in a timely manner (BI3).
4. support to access to relevant data in a timely manner (BI4).
5. provide enterprise-wide integrated, consistent data (BI5).
6. support what-if analysis which shows “how the outcomes can change when the situations change” (BI6).

Communication and Collaboration (CC) (1 = Almost Never, 7 = Always)

Examples of information systems that help share and communicate right information to the right person include video/audio conference systems, email systems, Blog, Web community, collaboration systems (e.g., Lotus Notes, Yammer), help desk systems, chatting systems (e.g., Windows Messenger, Skype), mobile application systems (e.g, SMS, Bulletin Board), and the like.

Information systems in our organization:

1. support disseminating relevant information to people who need it (CC1).
2. support information sharing within the company (CC2).
3. support exchanging relevant information with key partner companies and customers (CC3).
4. support virtual conferences with real-time video & audio (CC4).
5. support effective collaboration between employees (CC5).
6. support effective collaboration with key partner companies and customers (CC6).

Business Process and Resource Management (BPRM) (1 = Almost Never, 7 = Always)

Examples of information systems that help manage business processes and resources to cope with rapidly changing business environments include business process management (BPM) systems, workflow systems, enterprise resource planning (ERP) systems, supply chain management (SCM) systems, inventory management systems, and the like.

Information systems in our organization:

1. visually present business processes (BPRM1).
2. support the design and creation of new business processes (BPRM2).
3. support streamlining and scheduling processes. (BPRM3).
4. automate business processes (BPRM4).
5. provide information about what human and other resources are needed for business processes (BPRM5).
6. provide real-time information about resource availability (BPRM6).

3.2.1.5 Environmental Velocity[4]

To measure the velocity of environmental change, I used three items that measure the task environmental velocity (Daft et al. 1988). I defined three items individually for measuring the speed and the unpredictability of change in customers, competitors, and technologies.

The following questions are to understand your **business environments.** We are especially interested in c*hange in customer preference, competition, and technology.*

Customers refer to those individual consumers or business customers that purchase the products or services provided by your business division.

Competitors include major competitors who make products that compete with your company's products. Change in competitors refers to competitive moves and actions by competitors, such as introduction of new products/prices/promotions to the market.

Technology change includes any new production or process techniques and methods, innovation in materials, and general trends in research and science to your company.

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4 There was another construct to measure environmental turbulence, the magnitude of change. This construct was excluded for further analysis because it is not a dimension of change (velocity) but rather the result of change. The factor analysis showed that its items are loaded on speed construct, meaning a dependency with speed.

Speed of Environmental Change

Please check the number on the scale that best describes your thoughts on the speed of change in each row.

	Very Slow (Low)			Moderate			Very Fast (High)
1. The speed of change in our customers' product preferences is (SPD1)	1	2	3	4	5	6	7
2. The speed of change in competitors' moves is (SPD2)	1	2	3	4	5	6	7
3. The speed of change in the technology in our industry is (SPD3)	1	2	3	4	5	6	7

Unpredictability of Environmental Change (Reverse Code)

Please check the number on the scale that best describes your thoughts on the unpredictability of change in each row.

	Very Unpredictable			Moderate			Very Predictable
1. The direction of change in our customers' product preferences is (UNP1)	1	2	3	4	5	6	7
2. The direction of change in competitors' moves is (UNP2)	1	2	3	4	5	6	7
3. The direction of change in the technology in our industry is (UNP3)	1	2	3	4	5	6	7

3.2.1.6 Firm Size

I define a firm's size as a control variable for outcome variables, since it is a well-known factor that influences firm performance and organizational capability. Firm size is typically measured by either the number of employees or a firm's revenue. To decide whether a company is small/medium business or large, I follow the definition provided by the Korean Government agency for administering small and medium companies, "Small and Medium Business Administration (http://eng.smba.go.kr/)." The definition considers not only the number of employees and sales revenue but also other factors such as gross capital, industry types, and whether it is a child company of a large company. By following the criteria, I designate each firm as either SMB or large. For example, in the manufacturing industry, a company that has less than 300 employees, or its gross capital is less than $8M (assuming 1000 Korean Won = 1 US Dollar) is defined as SMB. By following the criteria, I designate each firm as either SMB or large. This definition can more precisely measure the firm size effects, because the support by Korean government for a company is different depending on whether it is either SMB or large.

3.2.2 Pilot Test

Before administering the full-scale survey, I conducted a pilot survey from industry managers, business school professors, and business major PhD students in the USA to test face and content validity of the survey. I corrected such problems as equivocal wording, syntax errors, overuse of jargon, overtime-to-finish the questionnaire, difficult-to-complete the questionnaire, and any biasing factors in the scale (Babbie 1973). Then, I translated English to Korean using a translation committee approach (van de Vijver and Leung 1997). A committee of bilinguals, which consists of three professors and a PhD student in business schools who all are fluent in both English and Korean, participated in translation. After translating the questionnaire to a Korean version, I tested it with managers of Korean companies, and corrected all possible problems in the same way that I had with the English version.

3.3 Data Collection

3.3.1 Survey Administration

3.3.1.1 Key Respondents

Existing studies on sensemaking typically use data collected from top managers because top managers may play a key role in sensing and managing environmental change (Hambrick, 1981; Thomas, Clark, and Gioia 1993; Thomas and McDaniel 1990; Zajac and Shortell 1989). However, in turbulent environments, organizational sensemaking of environmental change occurs over all the levels of organizational hierarchy (Meyer et al., 2005). As I explained in the earlier section, I found strong support for this argument from the case study and filed interviews. Thus, I design a survey to cover from top to middle managers. I tried to collect more than one response from a company, especially for a large company, in order to measure constructs that more effectively represent a firm's characteristics. Further, for the same reason, I tried to collect data from diverse divisions so that the collected data can measure constructs representing a firm.

3.3.1.2 Sampling Frame

I administered survey questionnaires to companies in diverse industries differing in the level of changing velocity in South Korea. South Korea is one of the fastest recovering countries from the global economic crisis started from 2008 according to the OECD statistics on *Quarterly Growth Rates of real GDP* (http://stats.oecd.org/index.aspx?queryid=350). Therefore, the data set from Korean companies is relevant for this study, allowing us to explore how organizations successfully cope with turbulent environments and achieve competitive performance. Korea is also famous for its advanced information technologies; for example, it ranks first in high-speed internet coverage in the world and its economy relies heavily on the high tech industry.

The survey used two major sample frames: a sample of companies associated with a university research center and a sample of companies related with professors in major Korean business schools. In return for their participation in the survey, I promised to provide them with an executive summary. To reduce a selection bias possibly caused by my networks with the university research center and professors, I used a two-stage sampling method, as explained as follows. I met a representative of a company, and explained the purposes of the survey. If the representative agreed to participate in the survey, I emailed an online-survey URL to the representative and then the representative administered the survey to at least two managers from different business areas in the company. These representatives also introduced me to managers of other companies, who were possibly interested in participating in the survey. I contacted professors in major Korean business schools. I explained the survey and then the professors administered the online URL or paper questionnaires to managers of some companies that they had advised or taught.

These two sampling frames do not represent a specific group, for example, the SIC code 7372 software industry or the telecom industry. The main purpose of this dissertation is not to explore one specific industry or any group of organizations who share the same velocity of change. Instead, it aims to explore the dynamics of sensemaking and responding of companies in diverse industries of which changing velocity is different. Therefore, the sample frame for this dissertation does not necessarily become such a group representing a specific category of companies who share common aspects of products, structure, strategies, etc. Further, non-random samples of organizations caused by social contacts for data collection are not essential features for configurational theory building (Doty et al. 1993; Fiss 2011; Ketchen et al. 1993). Especially, fuzzy-set methods do not need a representativeness of the sample because it does not assume that the data are drawn from a specific probability distribution (Fiss 2011). Further, calibration that I use in this dissertation for rescaling the interval scale to a fuzzy membership score can reduce sample dependence because set membership is defined relative to substantive knowledge rather than the sample mean (Fiss 2011).

However, there are some requirements for the sample of this dissertation. Companies for the sample need to use information and communication technologies for sensing and responding to environmental change, and also they need to operate in multiple industries differing in the level of velocity.

3.3.2 Response Characteristics

Most of the data (91%) has been collected in 5 weeks starting April 2010. All incomplete responses were excluded from data analysis. Firm level response rate was 93%, and individual level (the ratio of the number of complete responses to the total number of responses) was 90%. This high response rate can be explained either by the sampling method or by the interesting topic of research (when considering the on-going global economic crisis). Table 3-1 explains the response characteristics of the survey sample in terms of personal participants and firms. As shown in the statistics, the sample data seem very randomly distributed in terms of both respondents' personal characteristics (experience, working areas, level in hierarchy) and firm characteristics (firm size, industries) -- thus they do not show any sampling problems such as a selection bias and non-representativeness.

Table 3-1: Characteristics of the Survey Sample

Sales Revenue	Number of Firms	%
Less than $ 100 million	38	35.8%
100 million - 1 billion	28	26.4%
Over 1 billion	40	37.7%

Number of Employees	Number of Firms	%
Less than 100	26	24.54%
100 - 1000	34	32.1%
1000 - 10000	29	27.4%
Over 10000	17	16.0%

Average Working Experience = 13.3 Years

Experience (Years)	Num of Respondents	%
Less than 5	10	4.6%
5 - 7 years	23	10.6%
8- 10 years	42	19.3%
11 - 15 years	76	34.9%
Over 15 years	67	30.7%

Working Area	Num of Respondents	%
Business Strategic Planning	51	23.4%
Sales & Marketing	53	24.3%
Finance/Accounting	10	4.6%
Production/Procurement	22	10.1%
Information Technology	15	6.9%
R&D	27	12.4%
General Management	40	18.3%

Response Rate	
Num of companies contacted	114
Num of companies participated in the survey	106
Num of respondents started the survey	242
Num of respondents completed the survey	218
Response rate (firm level)	93%
Response rate (individual level)	90%

Industry	*Sub-Industry*	Num of Firms	Num of Respondents	% (Firm)
Construction		12	26	11.3%
Finance		7	15	6.6%
Service	IT/SI	18	31	17.0%
	Non-IT/SI	9	21	8.5%
Manufacturing	General Consumer Goods	5	11	4.7%
	Steel/Stone/Wood Products	8	14	7.5%
	Machinery	8	12	7.5%
	Electrical Equipment	14	27	13.2%
	Transportation Equipment	7	12	6.6%
Transportation		4	10	3.8%
Retail/Utility		6	16	5.7%
Telecom/Network		8	23	7.5%

Manager Level	Num of Respondents	%
Chief Officer	30	14%
Senior Manager	117	54%
Junior Manager	71	33%

3.4 Measurement Validation

When there was more than one response from a firm, average scores across items for each construct were calculated. This method averages out the biases of individual responses and justifies normality assumptions, making parametric statistical methods more appropriate (Gresov et al. 1989; McGrath 2001). The intraclass correlation coefficient (ICC) was relatively large, 25.2%, meaning that 25.2 percent of the total variance in performance is accounted for purely by the grouping of responses into firms (Luke 2003). So, the advantage of collecting more than one response from a firm is statistically justified.

3.4.1 Reliability

I assessed Cronbach's alpha and composite reliability to validate internal consistency (Werts, Linn, and Joreskog 1974). Table 3-2 shows descriptive statistics and correlations for all constructs. The high composite reliabilities greater than 0.7 for all constructs indicate internal consistency (Nunnally 1978). All Cronbach alpha values are greater than 0.7, an evidence of reliability (Bagozzi and Edwards 1998; Fornell and Larcker 1981).

3.4.2 Discriminant and Convergent Validity

When the square root of a construct's average variance extracted (AVE) is greater than its correlations with other constructs, then the construct has discriminant validity (Chin 1998). When its AVE is greater than 0.5, then the construct has convergent validity (Fornell and Bookstein 1982; Fornell and Larcker 1981). In Table 3-2, all the square roots of AVEs are greater than correlations and also greater than 0.5. Therefore, the constructs' discriminant and convergent validity are acceptable. Further, as shown in Table 3-3, all standardized item loadings are greater than 0.7, meaning that all items are loaded on their latent constructs, adding additional evidence for convergent validity (Gefen et al. 2000). All items are loaded on their corresponding factors, which are much higher than all cross loadings, signifying that all measures demonstrate adequate convergent and discriminant validity (Chin 1998).

Table 3-2: Correlation Matrix and Composite Reliability for Principal Constructs

	Item#	Mean	STD	Reliability	Cronbach α	PERF	SPD	UNP	SEN	DM	ACT	BI	BPRM	CC	TMT	LDR
PERF	3	4.53	1.04	0.93	0.88	0.90										
SPD	3	4.92	1.10	0.92	0.87	-0.09	0.89									
UNP	3	3.97	0.91	0.89	0.81	0.00	0.30	0.85								
SEN	3	4.73	1.00	0.92	0.88	0.35	0.20	0.09	0.90							
DM	5	4.26	0.95	0.91	0.88	0.26	0.11	0.05	0.21	0.82						
ACT	7	4.24	0.94	0.92	0.89	0.25	0.34	0.08	0.20	0.28	0.78					
BI	6	3.98	1.03	0.95	0.93	0.34	0.31	0.21	0.33	0.19	0.52	0.86				
BPRM	6	3.91	1.10	0.96	0.94	0.27	0.23	0.16	0.21	0.15	0.42	0.69	0.88			
CC	6	4.38	1.00	0.93	0.90	0.34	0.22	0.07	0.40	0.14	0.29	0.57	0.59	0.82		
TMT	2	5.05	1.10	0.97	0.94	0.41	0.16	0.20	0.37	0.26	0.38	0.44	0.39	0.41	0.97	
LDR	2	4.24	2.24	0.90	0.78	0.59	0.05	0.03	0.38	0.24	0.28	0.32	0.26	0.28	0.47	0.90

- Square roots of average variances extracted (AVE's) shown on diagonal.
- Correlations greater than 0.25 are significant at the 0.01 level; greater than 0.19 are significant at the 0.05 level.

Table 3-3: PLS Component-based Analysis: Indicator and Cross Loadings

	PERF	SPD	UNP	SEN	DM	ACT	BI	BPRM	CC	TMT	LDR
PERF1	0.961	-0.026	0.119	0.128	-0.04	-0.064	-0.013	0.013	-0.056	0.008	-0.05
PERF2	0.804	0.01	0.059	-0.031	0.081	-0.083	-0.129	0.051	0.108	-0.116	0.215
PERF4	0.924	0.018	-0.189	-0.107	-0.039	0.155	0.147	-0.067	-0.051	0.111	-0.168
SPD1	0.119	0.919	0.107	0.064	-0.068	0.03	-0.138	0.015	-0.103	0.107	0.007
SPD2	-0.164	0.885	-0.054	0.036	0.107	-0.102	0.046	-0.006	0.117	-0.063	0.042
SPD3	0.044	0.862	-0.059	-0.106	-0.039	0.074	0.1	-0.01	-0.012	-0.049	-0.052
UNP1	-0.124	0.011	0.901	0.029	-0.075	0.005	-0.069	0.036	-0.005	0.016	0.065
UNP2	-0.127	0.015	0.896	0.076	0.003	-0.013	0.041	0.009	-0.049	-0.14	0.254
UNP3	0.291	-0.03	0.747	-0.12	0.084	0.009	0.034	-0.052	0.061	0.141	-0.366
SEN1	-0.012	-0.049	-0.049	0.907	-0.02	0.055	-0.081	0.051	0.023	0.083	-0.053
SEN2	-0.035	0.051	-0.048	0.872	0.012	-0.023	0.076	0.084	-0.038	-0.034	0.094
SEN3	0.049	-0.003	0.101	0.907	0.008	-0.032	0.005	-0.141	0.016	-0.051	-0.044
DM1	-0.039	0.113	-0.079	0.09	0.791	0.015	-0.07	-0.138	0.101	0.012	-0.093
DM2	-0.048	0.039	-0.055	0.156	0.831	0.13	-0.247	0.042	-0.028	-0.148	0.083
DM3	-0.043	0.022	0.059	-0.022	0.827	0.026	-0.108	0.051	0.014	-0.009	0.087
DM4	-0.036	-0.098	0.046	-0.002	0.843	-0.14	0.226	-0.03	-0.024	0.13	-0.024
DM5	0.163	-0.064	0.021	-0.212	0.825	-0.026	0.186	0.065	-0.055	0.012	-0.059
ACT1	0.04	-0.173	-0.092	0.001	-0.045	0.722	0.109	0.062	-0.203	0.313	-0.077
ACT2	-0.039	-0.11	-0.118	-0.108	0.078	0.815	-0.028	-0.024	-0.004	0.376	-0.187
ACT3	-0.143	0.037	0.025	0.077	-0.027	0.817	-0.004	0.034	0.135	-0.091	0.064
ACT4	-0.14	-0.011	0.135	0.197	0.016	0.805	0.001	0.048	0.1	-0.228	0.162
ACT5	0.123	0.096	0.033	-0.078	0.081	0.788	-0.043	-0.12	0.108	-0.269	0.078
ACT6	0.029	0.248	0.033	-0.158	0.033	0.743	0.082	-0.099	0.002	-0.252	0.06
ACT7	0.176	-0.069	-0.019	0.046	-0.145	0.785	-0.122	0.09	-0.163	0.137	-0.108
BI1	0.132	0.02	0.044	0.028	-0.035	-0.082	0.872	-0.076	0.115	0.047	-0.095
BI2	0	-0.038	-0.062	0.053	-0.175	0.067	0.812	0.142	-0.114	0.035	-0.021
BI3	0.188	0.154	0.021	0.103	0.015	-0.069	0.975	-0.04	-0.073	-0.208	-0.171
BI4	0.019	0.062	0.014	0.103	-0.009	-0.096	0.968	-0.107	0.081	-0.067	-0.011
BI5	-0.235	-0.08	-0.054	-0.064	0.04	0.062	0.714	0.007	0.053	0.292	0.105
BI6	-0.131	-0.136	0.033	-0.248	0.176	0.139	0.811	0.09	-0.073	-0.083	0.217
BPRM1	0.058	0.174	0.024	-0.021	-0.058	-0.253	-0.001	0.853	0.093	0.043	0.062
BPRM2	0.107	-0.116	-0.043	0.009	-0.018	0.092	-0.022	0.865	-0.013	0.132	-0.159
BPRM3	0.049	-0.037	-0.025	0.037	-0.015	0.11	-0.024	0.908	-0.018	0.049	-0.17
BPRM4	-0.164	-0.066	0.116	-0.09	0.053	-0.034	0.019	0.854	0.001	0.011	0.187
BPRM5	0.059	0.014	0.022	0.079	0.053	0.054	-0.02	0.877	-0.015	-0.081	-0.048
BPRM6	-0.114	0.03	-0.089	-0.017	-0.013	0.026	0.048	0.946	-0.046	-0.151	0.137
CC1	-0.083	0.031	0.051	0.032	-0.001	0.034	-0.126	-0.103	0.923	0.048	0.095
CC2	-0.075	0.054	0	0.052	-0.087	0.008	-0.06	-0.069	0.819	0.127	0.032
CC3	-0.011	-0.175	0.063	-0.009	-0.03	0.028	-0.098	0.162	0.849	0.005	-0.079
CC4	-0.059	0.063	-0.049	-0.08	-0.023	0.026	-0.066	0.031	0.805	-0.147	0.219
CC5	-0.02	0.05	-0.045	-0.021	0.027	-0.032	0.207	-0.124	0.819	0.02	0.031
CC6	0.237	-0.016	-0.023	0.02	0.105	-0.059	0.126	0.106	0.728	-0.064	-0.272
TMT1	-0.013	0.005	-0.007	0.067	0.031	-0.016	-0.006	-0.032	-0.023	1.006	-0.068
TMT2	0.013	-0.005	0.007	-0.067	-0.031	0.016	0.006	0.032	0.023	0.939	0.068
LDR1	0.092	-0.026	0.007	0.067	-0.01	0.025	-0.033	0.032	-0.116	0.001	0.852
LDR2	-0.092	0.026	-0.007	-0.067	0.01	-0.025	0.033	-0.032	0.116	-0.001	0.957

3.4.3 Assessment of Common Method Bias

Because this dissertation uses a single method (i.e., survey) to collect data, I test whether data has a common method bias using Harmon's single-factor test (Padsakoff and Organ 1986). Table 3-4 shows the results. Eleven factors have eigenvalues greater than one, the same number of latent variables that I defined. Further, no one factor accounts for the majority of the variance. Therefore, no evidence for a common method bias is found.

Table 3-4: Harmon's Single-Factor Test

Sums of Squared Loadings		
Total	% of Variance	Cumulative %
5.277	11.472	11.472
4.643	10.093	21.565
4.433	9.638	31.203
3.875	8.423	39.626
3.587	7.798	47.424
3.295	7.164	54.587
2.643	5.747	60.334
2.614	5.682	66.017
2.355	5.119	71.136
1.915	4.163	75.299
1.239	2.693	77.992

3.5 Second-Order Constructs

I assessed the dimensionality of the second-order constructs. Higher-order constructs should fall under the category of aggregate multi-dimensional constructs, formed by some algebraic combination of their dimensions (Law, Wong, and Mobley 1998). A second-order formative construct is formed by calculating the weights of its first-order constructs (Edwards 2001) using a principal components factor analysis (Diamantopoulos and Winklhofer 2001). I examined the path weights from the first-order constructs to the second-order constructs and treated the weights of the formative construct as betas in a regression analysis (Edwards 2001).

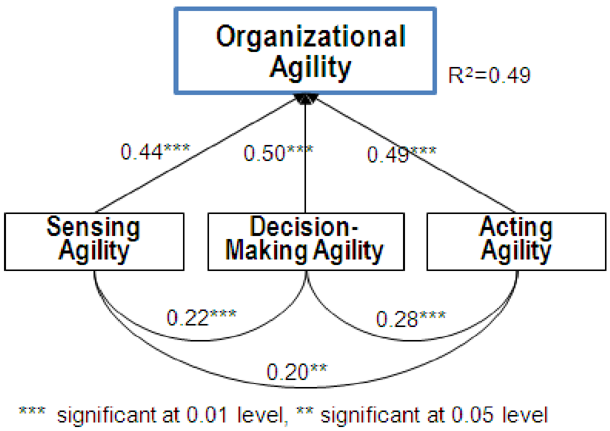
3.5.1 Organizational Agility as a Second-Order Construct

As developed in the conceptual development chapter, I defined organizational agility as a second-order construct consisting of three first-order constructs --- sensing, decision-making, and acting agility [Figure 3-1]. The weights of individual paths from the first-order constructs to organizational agility are calculated using a principal components factor analysis. The impact of all first-order constructs on organizational agility is significant ($p < 0.01$). All the correlations between the first-order constructs are significant. Each first-order construct of a second-order formative construct represents a unique domain and aspects of the second-order construct (Diamantopoulos and Winklhofer 2001), meaning the first-order constructs do not necessarily move in the same direction. Therefore, the correlations between first-order constructs are not necessarily high.

The resulting formula for organizational agility is as follows:

Organizational Agility = 0.44 ×Sensing Agility + 0.50 ×Decision-Making Agility + 0.49 ×Acing Agility

Figure 3-1: The Formative Second-Order Construct of Organizational Agility

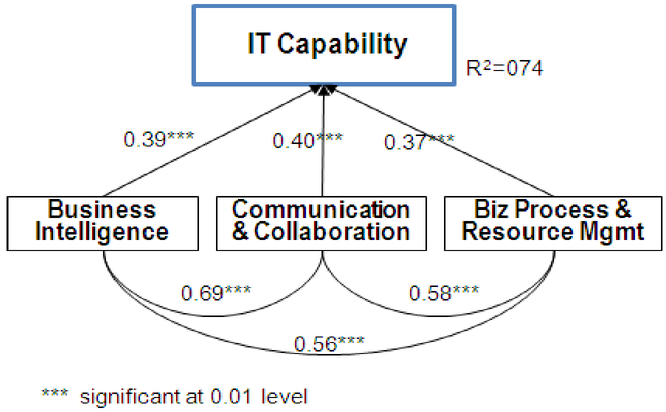


3.5.2 IT Capability as a Second-Order Construct

In the same way, I defined IT capability as a second-order construct consisting of three first-order constructs --- business intelligence, communication & collaboration, and business process & resource management [Figure 3-2]. The resulting formula for an organizational IT capability is as follows:

IT Capability = 0.39 ×Business Intelligence + 0.40 ×Communication & Collaboration + 0.37 ×Business Process & Resource Management

Figure 3-2: The Formative Second-Order Construct of IT Capability

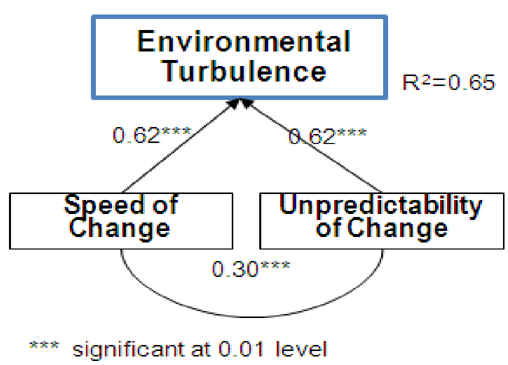


3.5.3 Environmental Turbulence as a Second-Order Construct

In the same way, I defined environmental turbulence as a second-order construct consisting of two first-order constructs --- the speed of environmental change and the unpredictability of environmental change [Figure 3-3]. The resulting formula for environmental turbulence is as follows:

Environmental Turbulence = 0.62 ×Speed of Change + 0.62 ×Unpredictability of Change

Figure 3-3: The Formative Second-Order Construct of Environmental Turbulence



3.5.4 Validity of Second-Order Constructs

Table 3-5 shows descriptive statistics and correlations for all second-order constructs. The high composite reliabilities greater than 0.7 for all constructs indicate internal consistency (Nunnally 1978). All the square roots of AVEs were greater than correlations and also greater than 0.5. Therefore, the constructs' discriminant and convergent validity are acceptable (Chin 1998; Fornell and Larcker 1981).

Table 3-5: Correlation and Composite Reliability for Second-Order Constructs

	Mean	STD	Reliability	IT	AGILITY	PERF	ENV	TMT	LDR
IT	4.7	1.1	0.90	0.86					
AGILITY	6.3	1.0	0.74	0.48	0.70				
PERF	4.5	1.0	0.93	0.36	0.40	0.90			
ENV	5.5	1.0	0.79	0.26	0.22	-0.07	0.81		
TMT	5.1	1.1	0.93	0.45	0.43	0.38	0.16	0.93	
LDR	4.2	2.2	0.90	0.33	0.42	0.59	0.03	0.45	0.90

- Square roots of average variances extracted (AVE's) shown on diagonal.
- Correlations greater than 0.25 are significant at the 0.01 level; greater than 0.19 are significant at the 0.05 level.

In the next chapter, using a set-theoretic configurational theory approach, I explore diverse holistic features of digital ecodynamics, which explain non-linear, non-additive but synergetic systemic interactions among the constructs developed in chapter 2 and 3.

CHAPTER 4: EXPLORING THE HOLISTIC NATURE OF DIGITAL ECODYNAMICS WITH A CONFIGURATIONAL THEORY APPROACH

D*igital ecodynamics,* "the holistic confluence among environmental turbulence, dynamic capabilities, and IT systems—and their fused dynamic interactions unfolding as an ecosystem [Figure 1-1]," creates messy, complex phenomena (Burgelman and Grove 2007; El Sawy et al. 2010), often resulting in nonlinear, discontinuous, and punctuated change (Meyer et al. 2005). Such phenomena can be more effectively captured by a configurational theory approach than by traditional variance theory approach that focuses on explaining two-way linear and additive relationships (Ackoff 1994; El Sawy et al. 2010; Fiss 2007; Meyer et al. 2005). Especially, a set-theoretic configurational theory approach can identify which elements are necessary and/or sufficient conditions for the outcome of interest, the two core building blocks of causality. Further, it expresses relationships by "half-verbal-conceptual and half-mathematical-analytical language (Fiss 2007; Ragin 2000)," which can help more effectively describe the holistic complex fabric of digital ecodynamics. Therefore, I use a set-theoretic configurational theory approach to investigate the dynamic and complex interactions among information technology, organizational agility and environmental turbulence in a way that explains how they simultaneously and systemically combine to result in the outcome of interest (i.e., innovation leadership, firm performance and agility) (El Sawy et al. 2010; Fiss 2011). I use fuzzy set qualitative comparative analysis (fsQCA) that is originally more appropriate for exploring diversity of a complex system and building new theories (Fiss 2011; Ragin

2000, 2008; Rihoux and Ragin 2009). By comparing differences and similarities among several configurations, this study extracts some patterns. Based on the findings, this study suggests some propositions that explain holistic systemic features of digital ecodynamics and the role of key elements in creating competitive firm performance.

4.1 Fuzzy-Set Qualitative Comparative Analysis (fsQCA)

Understanding how IT systems, organizational dynamic capability and environmental turbulence simultaneously interact and combine to result in competitive advantage is an essential part of advancing knowledge of successful sensing and managing opportunities and threats. A set-theoretic configurational theory approach is used as inquiring systems for exploring complex fused interactions among IT, agility, and environmental turbulence (Churchman 1971; El Sawy et al. 2010). Fuzzy set qualitative comparative analysis (fsQCA), a set-theoretic method, provides several unique benefits for advancing holistic and systemic understanding around digital ecodynamics (El Sawy et al. 2010). Table 4-1 summarizes key aspects of fsQCA as inquiring systems (El Sawy et al. 2010; Fiss 2007, 2011; Kogut 2010; Ragin 2008; Rihoux and Ragin 2009).

In addition to capturing the holistic features of a system, fsQCA can find out which elements of a configuration are core and essential to make the outcome of interest and which elements are peripheral. Core elements have a strong causal relationship with the outcome of interest, while peripheral elements are causal conditions of which causal relationships with the outcome are relatively weak (Fiss 2011). fsQCA also shows which elements exist or do not exist in a configuration to result in the outcome (Fiss 2011;

Ragin and Fiss 2008). Thanks to these properties, it can suggest several different configurations of core/peripheral and present/absent elements that result in the same outcome, meaning that a system can reach the same outcome through different paths from different initial conditions -- equifinality (Fiss 2007, 2011). fsQCA can investigate the causal relationships between the characteristics of a configuration and the outcome of interest. In digital ecodynamics, multiple configurations of IT, organizational dynamic capability, and environmental turbulence can result in high performance (El Sawy et al. 2010) and fsQCA can effectively capture a holistic and detailed causal dynamics within a configuration and between configurations regarding high performance.

Table 4-1: Key Aspects of Configurational Theories as Inquiring Systems (Excerpted from El Sawy et al. 2010)

Aspect	Explanation
Holistic and Systemic Perspective as Lens	This is a view of phenomena as clusters of interconnected structures and processes that need to be understood simultaneously -- rather than separable entities whose elements can be understood in isolation or in separable interaction with each other. It is not individual independent variables that are connected to dependent variables, but holistic patterns and combinations of causal elements that influence preferable outcomes. It is also not about which causal variable has the biggest effect, but how different elements combine to determine the outcome. Additivity of individual variables is no longer assumed, and the theory seeks to uncover "causal combinations" (or "causal recipes" or "constellations").Thus, the analysis of causality does not self-destruct the holistic properties of the phenomenon that the researcher is trying to capture.
Equifinality as Possibility	Configurational theories allow for situations of equifinality where a system can reach the same outcome from different initial conditions and through many different paths. Therefore, different causal recipes may yield similar outcomes. This property accommodates the reality of contextual and managerial differences in organizational settings.

Table 4-1 (Contined)

Aspect	Explanation
Limited Diversity as Reality	Mathematically, a number *n* of elements will yield an unwieldy 2^n permutations, and thus the higher the *n*, the more the number of possible configurations, making it difficult to infer causality. However, the theoretical and empirical reality of the management context results in a limited diversity of configurations in practice, making the inference of causality manageable through the researcher's theoretical and contextual understanding. There is still the problem of unobserved configurations, but unobservability is a problem that is endemic of empirical settings with all types of theories.[5]
Research Propositions as Causal Recipes	While variance theories express hypotheses as correlational expressions and process theories as longitudinal unfolding of pathways, configuration theories express hypotheses as causal recipes that specify the contextually relevant elements that in combination produce particular outcomes. The variety of combinations and their related outcomes help uncover the causal patterns.
Rich Combinatorial Causality as Benefit	Research propositions in configurational theories can have structures that theoretically specify both which elements should be present and which element should be absent in the causal recipe. Moreover, research propositions can specify which are the core elements and which are the peripheral elements that influence the outcomes, and how often they appear in instances can indicate their relative importance. Thus, configuration theories can accommodate asymmetric and multi-faceted causality, including suppression, substitution, and complementarity effects.
Discontinuity & Non-Linearity as Normal	The nature of configurations is inherently discontinuous, making them suitable to study non-linear phenomena that exhibit punctuated equilibria. In the structure of configuration theory, the causes leading to the presence of an outcome can be different than those leading to the absence of an outcome (termed causal asymmetry), thus accommodating non-linearity in causation. Furthermore, as different from variance theories, configuration theories do not annul anomalies which are often of special interest in conditions of environmental turbulence.

[5] In fsQCA, counterfactual analysis is used to count on the cases (i.e., remainders) that are important for theory building but not empirically found (Ragin 2000, 2008; Fiss 2011).

Another attractive feature of fsQCA is that it can handle fuzzy variables of which values range from 0 to 1. Organizational agility is not a dichotomous variable like "present" or "absent", but instead a matter of degree (Lu and Ramamurthy 2011; Overby et al., 2006; Sambamurthy et al. 2003). All individual firms have some levels of agility. fsQCA can calibrate a firm's organizational agility into a fuzzy membership score ranging from 0.0 to 1.0 (Ragin 2000). Calibration is a process of transforming interval scale values to fuzzy set membership scores based on three qualitative anchors: full membership, full non-membership, and the crossover point of maximum ambiguity regarding membership in the set of interest (Fiss 2011; Rgain 2008). The set membership score represents the extent to which each case is a member of, for example, a high level of agility. Since the calibration process is based on both existing knowledge of the context and cases and the empirical data, it can more exactly define a group of cases that have similar memberships (Ragin 2008; Fiss 2011).

This study uses a 7-point Likert scale: 1 = lowest, 4 = ambiguous (crossover), 7 = highest level of agility. This study defines the interval scale 2 as the anchor for full non-membership, 4 as the crossover point, and 6 for the full membership anchor for the set of high level of agility. The fsQCA software[6] automatically rescales the interval scale into a fuzzy membership score using the direct method of calibration using three anchors (Ragin 2008, p. 86). To briefly explain the concept of direct calibration, it transforms an

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[6] fsQCA version 2.5 is downloadable for free from www.fsqca.com.

interval variable using the distance of the variable value from the crossover point, with the values of full membership and full non-membership as the upper and lower bounds (Fiss 2011). Then, the distance is transformed into the metric of log odds, which is centered around zero and has no upper or lower bound[7].

For other variables, including IT capability, environmental turbulence, firm performance, innovation leadership, and top management team (TMT) energy, this study uses the same interval scales for three anchors of full membership, full non-membership, and the crossover point. As such, calibration can tie attributes of cases to substantive theoretical concepts by infusing fuzzy sets with membership anchors based on empirical and theoretical knowledge.

Further, by comparing common and different features between cases, fsQCA can take out attributes that are not related to the outcome of interest. fsQCA uses a set-subset relationship to find out causal patterns (Fiss 2011; Ragin 2008; Rihoux and Ragin 2009). For example, to find out which configurations result in high performance, fsQCA examines cases that have membership in the set of high-performing organizations. Then it identifies attributes associated with high performance using Boolean algebra and a set of algorithms that reduce logically numerous combinations into a small number of appropriately parsimonious configurations (i.e., intermediate between too complex and too parsimonious configurations)[8].

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[7] A more detailed explanation is available at Ragin (2008, pp 86-94).

[8] For more detailed explanation of fsQCA steps, refer to Ragin (2008) and Ragin and Fiss (2008).

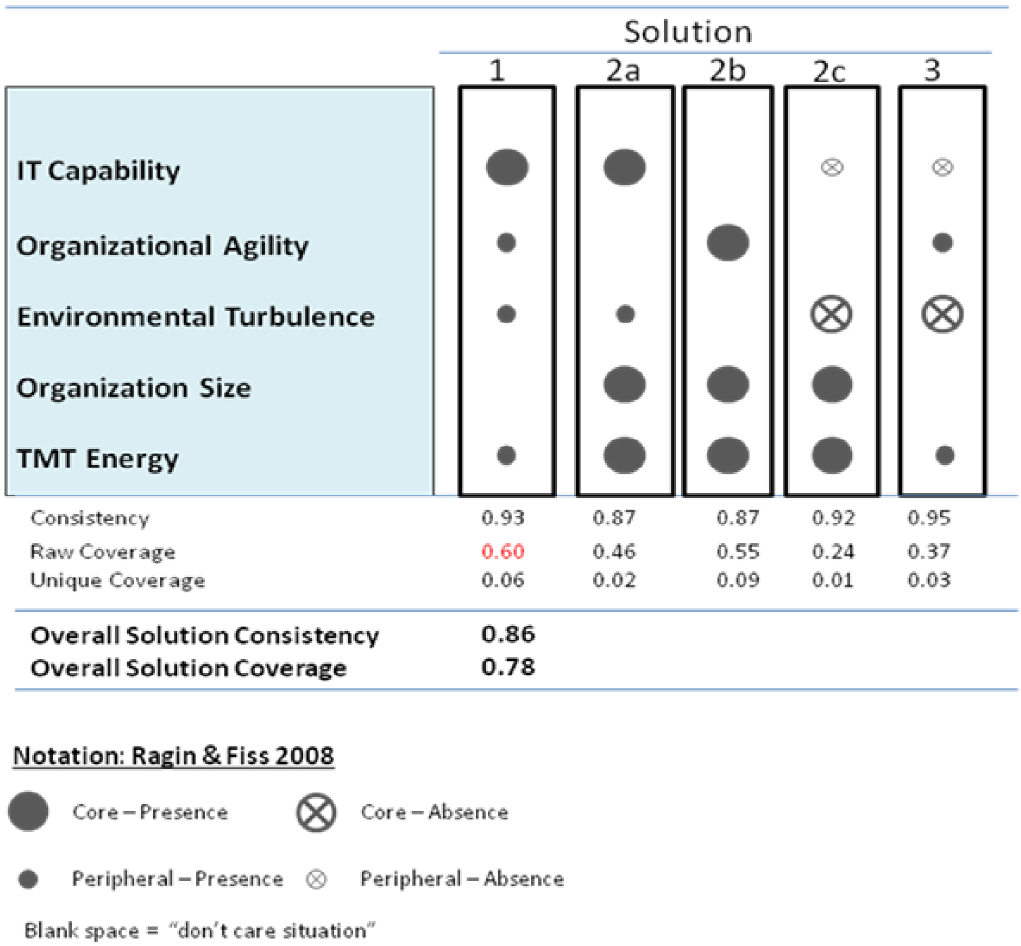
4.2 Configurations for Firm Performance

I present the configurations of IT capability, organizational agility, environmental turbulence, and other organizational factor such as organizational size and TMT energy (i.e., top managers' strategic commitment to change), which I found from fsQCA. I first extract several patterns embedded in the configurations by comparing structures of configurations based on John Stuart Mill's concepts of the "method of difference" and the "method of agreement" (Fiss 2011; Rihoux and Ragin 2009). Then, based on the findings, this study suggests some propositions about holistic systemic features of digital ecodynamics and the role of key elements in creating competitive firm performance.

4.2.1 Configurations for Achieving High Performance

Figure 4-1 shows the results of fuzzy-set analysis of high performance. The configurations are expressed by the notation systems from Ragin and Fiss (2008). The dark shaded circles indicate the presence of an element, crossed-out circles indicate the absence of an element, large circles indicate core elements, and small circles indicate peripheral elements. Blank spaces indicate a "don't care situation," in which the causal element may be either present or absent.

Figure 4-1: Configurations for Achieving High Performance



I set the minimum acceptable frequency of cases for solutions at 3, and the lowest acceptable consistency cutoff at 0.9, which is above the minimum recommended threshold of 0.75 (Ragin 2008). Overall, 77 cases fell into configurations exceeding the minimum solution frequency. Of these cases, 66 also exceeded the minimum consistency threshold of 0.9 for higher performance.

There are five different configurations that result in high performance, meaning five different paths to the same outcome (i.e., equifinality). Consistency for five configurations ranges from 0.87 to 0.93, acceptable levels (Ragin 2008). Consistency roughly means that the degree to which a configuration of conditions consistently result in the outcome of interest (Ragin 2008). Raw coverage roughly means the extent to which each configuration covers the cases of outcome, in other words, the proportion of cases having outcome to the total cases (Ragin 2008). Therefore, it shows what percent of cases having the outcome follow the path. For example, in Figure 4-1 the first configuration covers 60 percent of high performing cases, in other words, 60 percent of high performing cases have this configuration. Unique coverage means the part of the coverage of a configuration for the outcome that does not overlap with other configurations. Generally, raw coverage implies the importance of each path (i.e., configuration) to the outcome (Ragin 2008). But without an acceptable level of consistency, high coverage is meaningless. Therefore, configurations with high consistency need to be found first, and then coverage needs to be considered (Ragin 2008, p. 55). Overall solution consistency roughly means that the degree to which these configurations consistently result in high performance (Ragin 2008). Therefore, we can roughly say that these five solutions can consistently result in high performance with 87 percent. Overall solution coverage roughly means that the extent to which these configurations cover high performing cases (Ragin 2008). In a fuzzy set relation, it explains what percent of membership for the outcome set can be captured by the configurations of conditions. Thus, these five configurations can explain 78 percent of high performing cases. By comparing these five configurations, I could find four strong patterns as follows:

- **Pattern 1)** In turbulent environments, IT plays a core role in achieving high performance (1, 2a), and in stable environments IT should absent for a configuration to result in high performance (2c, 3).
- **Pattern 2)** In turbulent environments, regardless of organizational size, organizational agility with IT capability and TMT energy can most effectively achieve high performance (1 – highest coverage with great consistency).
- **Pattern 3)** Large organizations with agility and energetic TMT can achieve high performance (2b).
- **Pattern 4)** TMT energy is possibly a necessary condition for high performance when considering it exists in all configurations of high performance.

One of the goals with fsQCA is to find out necessary conditions for outcomes. Pattern 4 suggests TMT energy as a possible necessary condition for high performance. In the next section, I test if TMT energy is a necessary condition for high performance with a set membership plot.

4.2.2 Configurations for Achieving High Performance with TMT Energy as a Necessary Condition

I further investigate the role of TMT energy as a necessary condition for high performance using the fsQCA set-subset relationship plot. A set-theoretic approach can find out necessary and sufficient conditions for high performance using set-subset relationships. For example, if a set A includes the set of high performing cases, and A is a necessary condition for high performance. On the other hand, if a set B is a subset of the set of high performing cases, then B is a sufficient condition for high performance. The fsQCA can find out necessary and sufficient conditions using set-subset membership relationships (Ragin 2000, 2008; Rihoux and Ragin 2009). Figure 4-2 shows a perfect example of a necessary condition for outcome, where the membership values of cases for a condition are consistently greater than the membership values of cases for outcome (i.e., all cases are located below the diagonal).

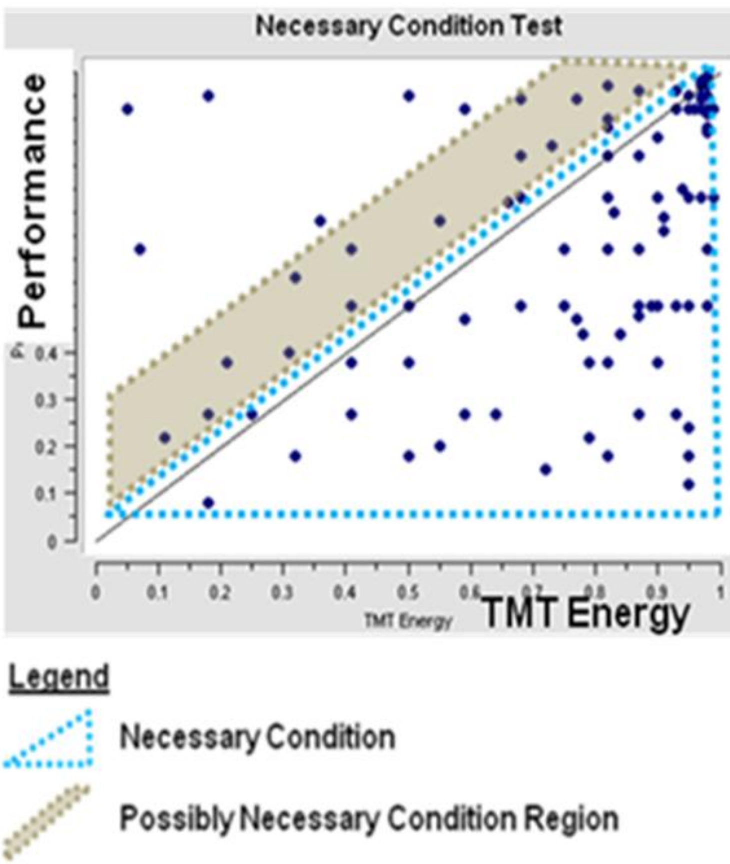
Figure 4-2: Example of a Necessary Condition for the Outcome

Necessary Condition

With this membership plot that fsQCA provides, I examine whether TMT energy is a necessary condition for high performance. Figure 4-3 depicts the membership distribution of cases in terms of TMT energy and firm performance. As we can see, high percent of cases are positioned below the diagonal, or some cases are just little above the diagonal. Especially most cases of high performance are either lower right of the diagonal or around the diagonal. Therefore, this plot suggests an additional evidence of top management team energy as a necessary condition for high performance. In addition, a necessary condition test with fsQCA shows that consistency of TMT energy for performance is 0.90 and coverage is 0.76.

Based on the three evidences (i.e., Pattern 4 from Figure 4-1, Figure 4-3, and the values of consistency and coverage), I define top management team as a necessary condition for high performance.

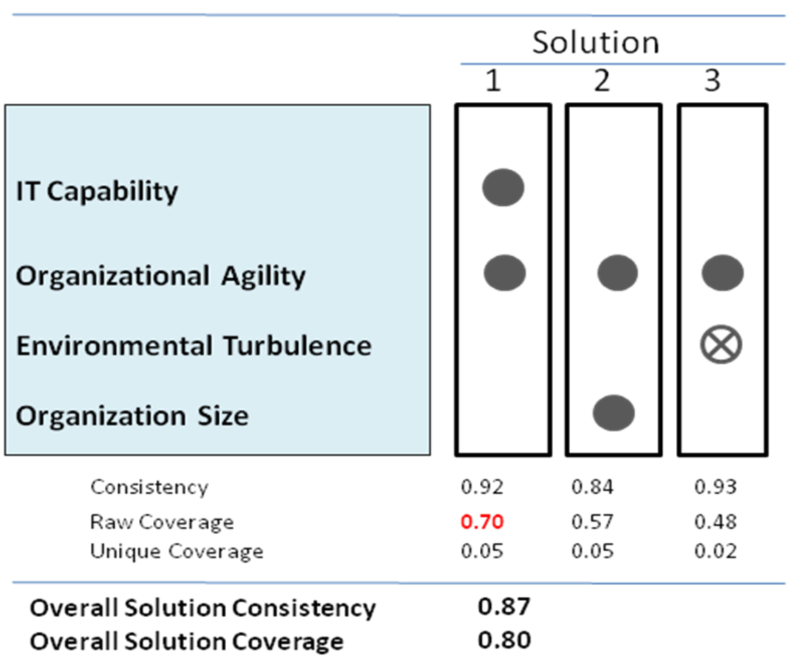
Figure 4-3: Top Management Team as a Necessary Condition for High Performance



By assuming TMT energy as a necessary condition, I executed another fsQCA by excluding TMT energy. However, TMT energy needs to be included in the interpretation of the results as a necessary condition for high performance. Overall, 101 cases fell into configurations exceeding the predefined frequency cutoff of 3. Of these cases, 68 exceeded the predefined consistency threshold of 0.9 for high performance.

Figure 4-4 shows the three resulting configurations for achieving high performance. It becomes much clearer that organizational agility plays a core role in all configurations of achieving high performance. Further, the first configuration consisting of IT capability and agility as core elements has the highest coverage, meaning that organizational agility with IT capability together can most effectively achieve high performance, on condition of TMT energy.

Figure 4-4: Configurations for Achieving High Performance with TMT Energy as a Necessary Condition



4.2.3 Configurations for Achieving Low Performance

When investigating relationships, set-theoretic approach is not based on correlations that assume causal symmetry, but instead it is based on set-theory and Boolean algebra that can capture one-way causal direction of a relationship by showing necessary and sufficient condition separately (Fiss 2007; Ragin 2000, 2008). Further, configurations resulted from fsQCA are expressed with core/peripheral elements and present/absent elements. Thus, the structures of configurations for high performance can be different from those of configurations for low performance, meaning that fsQCA can investigate causal relationships that are asymmetrical (causal asymmetry). Figure 4-5 shows the multiple configurations for low performance, which have different structures from configurations for high performance.

Figure 4-5: Configurations for Achieving Low Performance

	Solution				
	1a	1b	2	3a	3b
IT Capability	⨂	⨂	⨂	⊗	●
Organizational Agility	⨂	⨂	●	●	●
Environmental Turbulence	⬤	⬤		●	⊗
Organization Size		●	⨂		●
TMT Energy	●		●	⨂	⨂
Consistency	0.80	0.79	0.73	0.87	0.88
Raw Coverage	0.54	0.37	0.27	0.42	0.23
Unique Coverage	0.01	0.02	0.06	0.03	0.02
Overall Solution Consistency	**0.76**				
Overall Solution Coverage	**0.70**				

Overall, 89 cases fell into configurations exceeding the minimum solution frequency of 2. Of these cases, 24 exceeded the minimum consistency threshold of 0.75 for low performance.

There are three types of first-order equifinality, which means that there are three types of configurations having different sets of core elements that result in low performance: (1a, 1b), 2, and (3a, 3b). Configuration 1a and 1b are an example of second-order equifinality, which means that multiple configurations with same core elements and different peripheral elements result in the same outcome. Configuration 1a and 1b also shows a substitution effect of two elements, that is, TMT energy or organizational size are substitutable with each other in a configuration.

By comparing these configurations for low performance, I extract some patterns:

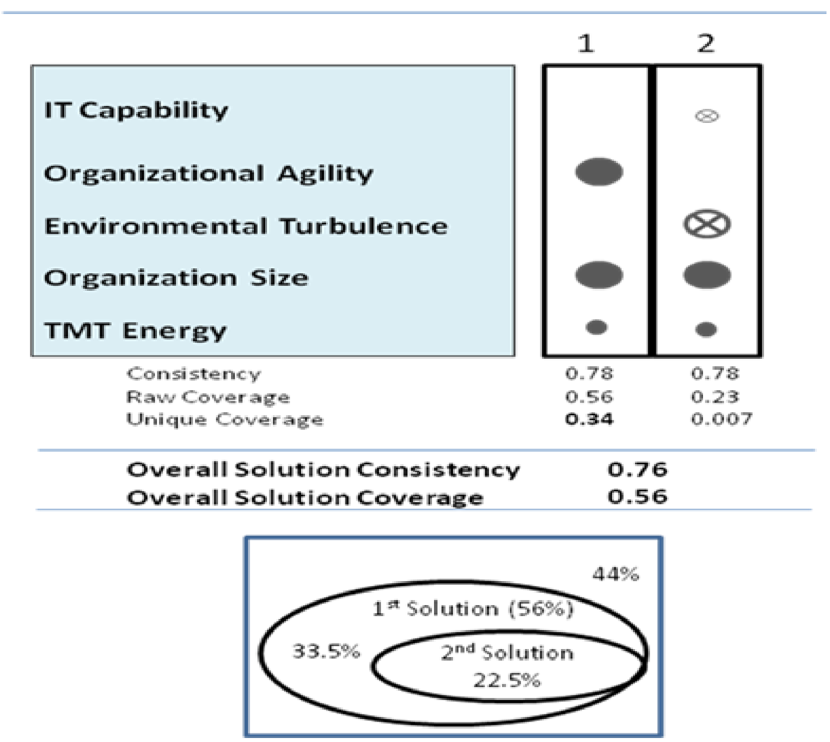
- **Pattern 5)** In turbulent environments, firms without IT capability and agility achieve low performance (1a, 1b).
- **Pattern 6)** IT in stable environments can inhibit organizations from achieving high performance (3b).
- **Pattern 7)** TMT energy is a core absent element for low performance both in turbulent and stable environments (3a, 3b).

4.3 Configurations for Achieving Innovation Leadership

In turbulent environments, organizational ability to continuously innovate new products is key to achieving a series of temporary competitive advantage (Brown and Eisenhardt 1997; D'Aveni 1994, Eisenhardt and Sull 2001). Organizational agility enables organizations to detect and seize market opportunities quickly (Sambamurthy et al. 2003), thus directly helping organizations introduce innovative products to the market quickly and adopt new technologies to create innovative processes (i.e., innovation leadership).

Figure 4-6 shows the results of fuzzy-set analysis of high innovation leadership. Overall, 77 cases fell into configurations exceeding the minimum solution frequency of 3. Of these cases, 52 exceeded the minimum consistency threshold of 0.75 for low performance. There are two configurations that result in a high level of innovation leadership. The unique coverage of the 2nd solution is almost zero while that of the 1st solution is high (0.34). This means the 2nd solution is a subset of the 1st solution or a specific type of 1st configuration as depicted in Figure 4-6.

Figure 4-6: Configurations for High Innovation Leadership



Several patterns can be extracted from these configurations:

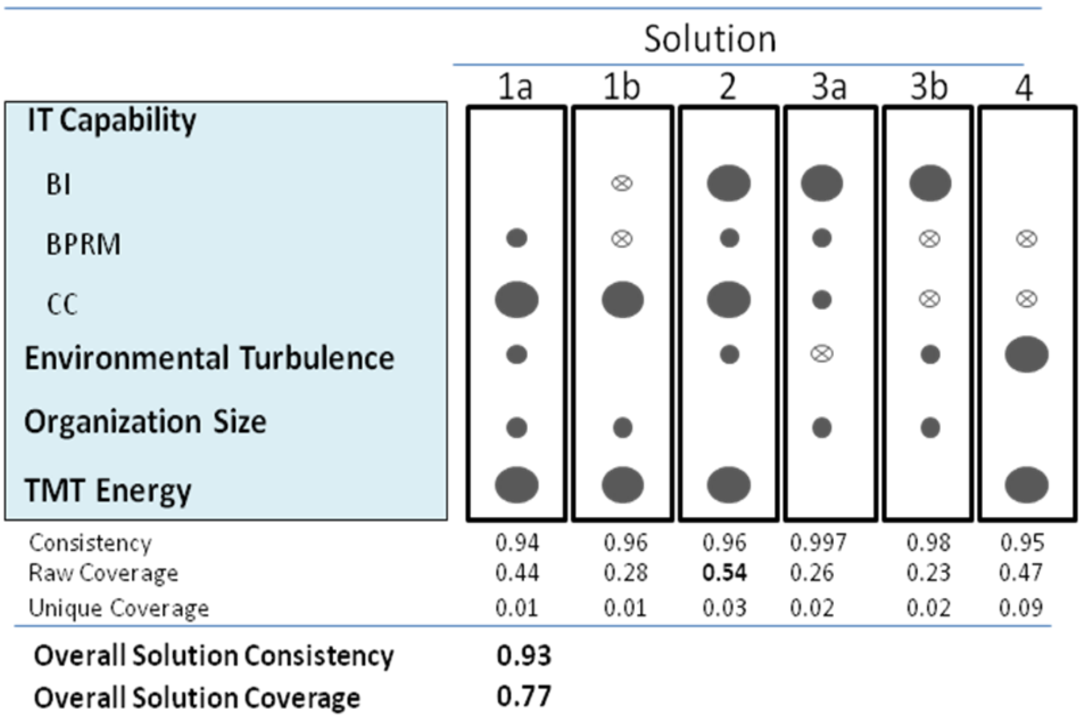
- **Pattern 8)** Agility plays a key role in achieving high innovation leadership (1).
- **Pattern 9)** In stable environments, agility does not matter, but only large organizations have strong innovation leadership (2).
- **Pattern 10)** IT does not matter for innovation leadership when agility plays a key role.
- **Pattern 11)** TMT energy is possibly a necessary condition for achieving innovation leadership.

4.4 Configurations for Achieving Organizational Agility

IS studies on organizational agility argued that IT capability enables organizations to achieve a high level of agility and flexibility to cope with turbulent environment (Pavlou and El Sawy 2006, 2010; Sambamurthy et al. 2003). Different types of IT systems that provide different functions can play different roles in increasing organizational capabilities in turbulent environments (Pavlou and El Sawy 2010).

This dissertation suggests three types of IT systems that can provide multiple functions that can help effectively execute event management tasks: business intelligence, communication and collaboration, and business process and resource management systems. Functions that these systems provide as explained in Table 2-3 can increase organizational agility. With this theoretical background, this study investigates how different types of IT systems systemically enhance organizational agility. Figure 4-7 shows the results of fuzzy-set analysis of high organizational agility. Overall, 62 cases satisfy the minimum solution frequency of 2 and consistency cutoff of 0.9. There are four types of solution to achieve high level of organizational agility. All configurations have very high consistency ranging from 0.94 to 0.99. Overall solution coverage is 0.77, meaning 77 percent membership of organizations with a high level of agility are covered by these configurations.

Figure 4-7: Configurations for a High Level of Organizational Agility



The resulting configurations show that IT is a core element for achieving a high level of agility (1, 2, 3). As an enabler for organizational agility, BI and CC systems play a core role, while BPRM systems play a peripheral role. On the other hand, configuration 1b and 3b provide evidence that IT can play different roles as either an enabler or inhibitor for organizational agility. In 1b, when CC systems play an enabler role, while

BI and BPRM are likely to be an inhibitor for agility. In 3b, BI systems are an enabler and CC and BPRM are to be an inhibitor for agility.

Patterns extracted from these configurations are:

- **Pattern 12)** There are generally two ways to achieve agility: IT-enabled agility (1, 2, & 3) and non-IT-enabled agility (4).
- **Pattern 13)** IT can play an opposing role of either enabler or inhibitor for organizational agility (1b, 3b).
- **Pattern 14)** Either BI (3) or CC systems (1) play key roles in achieving a high level of agility. Both together can most effectively achieve a high level of agility (2). BPRM plays a peripheral role.
- **Pattern 15)** TMT energy is possibly a necessary condition for achieving a high level of agility.

4.5 Developing Holistic Propositions for Digital Ecodynamics

Table 4-2 summarizes all the patterns that I found from configurational analysis for high and low firm performance, innovation leadership, and a high level of organizational agility. By finding commonalities among these patterns, I build propositions that explain holistic systemic dynamism among IT, agility, and environmental turbulence.

Table 4-2: Summary of Patterns Extracted from Configurations

Outcome	Patterns Extracted from Configurations
Firm Performance	**Pattern 1)** In turbulent environments, IT plays a core role in achieving high performance, and in stable environments IT should absent for a configuration to result in high performance. **Pattern 2)** In turbulent environments, regardless of organizational size, organizational agility with IT capability and TMT energy can most effectively achieve high performance. **Pattern 3)** Large organizations with agility and energetic TMT can achieve high performance. **Pattern 4)** TMT energy is possibly a necessary condition for high performance when considering it exists in all configurations of high performance. **Pattern 5)** In turbulent environments, firms without IT capability and agility achieve low performance. **Pattern 6)** IT in stable environments can inhibit organizations from achieving high performance. **Pattern 7)** TMT energy is a core absent element for low performance both in turbulent and stable environments.
Innovation Leadership	**Pattern 8)** Agility plays a key role in achieving high innovation leadership. **Pattern 9)** In stable environments, agility does not matter, but only large organizations have strong innovation leadership. **Pattern 10)** IT does not matter for innovation leadership when agility plays a key role. **Pattern 11)** TMT energy is possibly a necessary condition for achieving innovation leadership.
Organizational Agility	**Pattern 12)** There are generally two ways to achieve agility: IT-enabled agility and non-IT-enabled agility. **Pattern 13)** IT can play an opposing role of either enabler or inhibitor for organizational agility. **Pattern 14)** Either BI or CC systems play core roles in achieving a high level of agility. Both together can most effectively achieve a high level of agility. BPRM plays a peripheral role. **Pattern 15)** TMT energy is possibly a necessary condition for achieving a high level of agility.

4.5.1 Multifaceted Roles of IT

Pattern 1 and 6 describe the different roles of information technologies for firm performance: in turbulent environments IT can be an enabler for high performance, but in stable environments IT can be an inhibitor for high performance. In stable environments, information technologies for event management tasks do not significantly help organizations to achieve competitive advantage. There could be other alternative paths to competitive advantage in such slowly and predictably changing environments (Davis et al. 2009; Fine 1998). Thus, too much investment in IT may be costly in stable environments (Overby et al. 2006).

Pattern 13 and 14 explain the different roles of IT for organizational agility. IT can enable organizations to successfully sense and respond to market opportunities and threats by supporting relevant functions for timely event management tasks (Sambamurthy et al. 2003). On the other hand, IT also can hinder organizations from moving fast and changing flexibly due to its fixed artifacts and inflexibility in legacy systems (Galliers 2006; Lu and Ramamurthy 2011; Retting 2007; van Oosterhout et al. 2006). In Figure 4-7, in the configuration 1b, when CC systems are a core present element, BI and BPRM systems need to be peripheral absent elements (1b). Also, in configuration 3b, when BI systems play a core role, CC and BPRM systems should not exist for enhancing agility. This example demonstrates how some types of IT systems play an enabler role for agility and at the same time some types of IT systems play an inhibitor role.

Based on these commonalities among these patterns, I suggest a proposition about the multifaceted roles of IT as follows:

Holistic Proposition 1. *Patterns extracted by a configurational theory approach can effectively explain the multifaceted roles of information technologies in digital ecodynamics as either an enabler or an inhibitor for organizational agility and performance. Specifically, these two opposing roles of information technologies can be simultaneously captured by rich combinatorial expressions of core/peripheral and present/absent elements.*

4.5.2 IT-enabled Agility for Competitive Advantage in Turbulent Environments

Pattern 2, 3, 5, 8, 10, and 12 extracted from configurational analyses show that organizational agility is key to achieving high performance, and the combination of IT capability and agility is one the most effective paths to high performance. Pattern 12, 13, and 14 explain that IT can be one of the most effective ways to achieve a high level of agility, and with pattern 10, explain IT can indirectly increase innovation leadership by increasing organizational agility. Pattern 1 and 9 implies that IT-enabled organizational agility plays key role in increasing innovation leadership and performance especially in turbulent environments.

This interpretation is supported by the literature on IT-enabled organizational agility, which argues information technologies provide digital options or functions that enable organizations to successfully sense and response to market opportunities and threats, and eventually achieve competitive performance (Pavlou and El Sawy 2006; Sambamurthy et al. 2003). Therefore, I suggest the following proposition:

Holistic Proposition 2. *The fused dynamic interactions of IT, agility, and environmental turbulence create multiple paths to innovation leadership and high firm performance. IT-enabled organizational agility is one of the most effective ways to achieve innovation leadership and high performance, especially in turbulent environments.*

4.5.3 Different Roles of IT Systems in Enhancing Agility

Pattern 14 explains how different types of IT systems play different roles in enabling organizational agility depending on different contexts. As explained in Table 2-3, different types of IT systems provide several different types of functions that help organizations to sense environmental events, access to enterprise-wide consistent database, communicate and share relevant information in real-time, make a collective sesnsemaking and decision, and innovate and introduce new products rapidly (Nambisan 2003; Pavlou and El Sawy 2006; Sambamurthy et al. 2003). Configurations in Figure 4-7 are examples that show such different roles of IT systems in enhancing organizational agility. BI and CC systems play a core role, while BPRM systems play a peripheral role. Thus, BI and CC systems can directly help organizations successfully sense and respond to market opportunities and threats in a timely manner, while BPRM systems may complement BI and CC systems by feeding raw data to, for example, data warehouse, data mining, balanced-scored systems, and communication systems.

Thus, I suggest a proposition about the different roles of IT as an enabler for organizational agility:

> **Holistic Proposition 3.** *IT systems play different roles in enhancing different types of organizational agility. BI and CC systems play core roles in increasing organizational agility, while BPRM systems play a peripheral role.*

4.5.4 Configurational Transformation to IT-enabled Agile Organizations

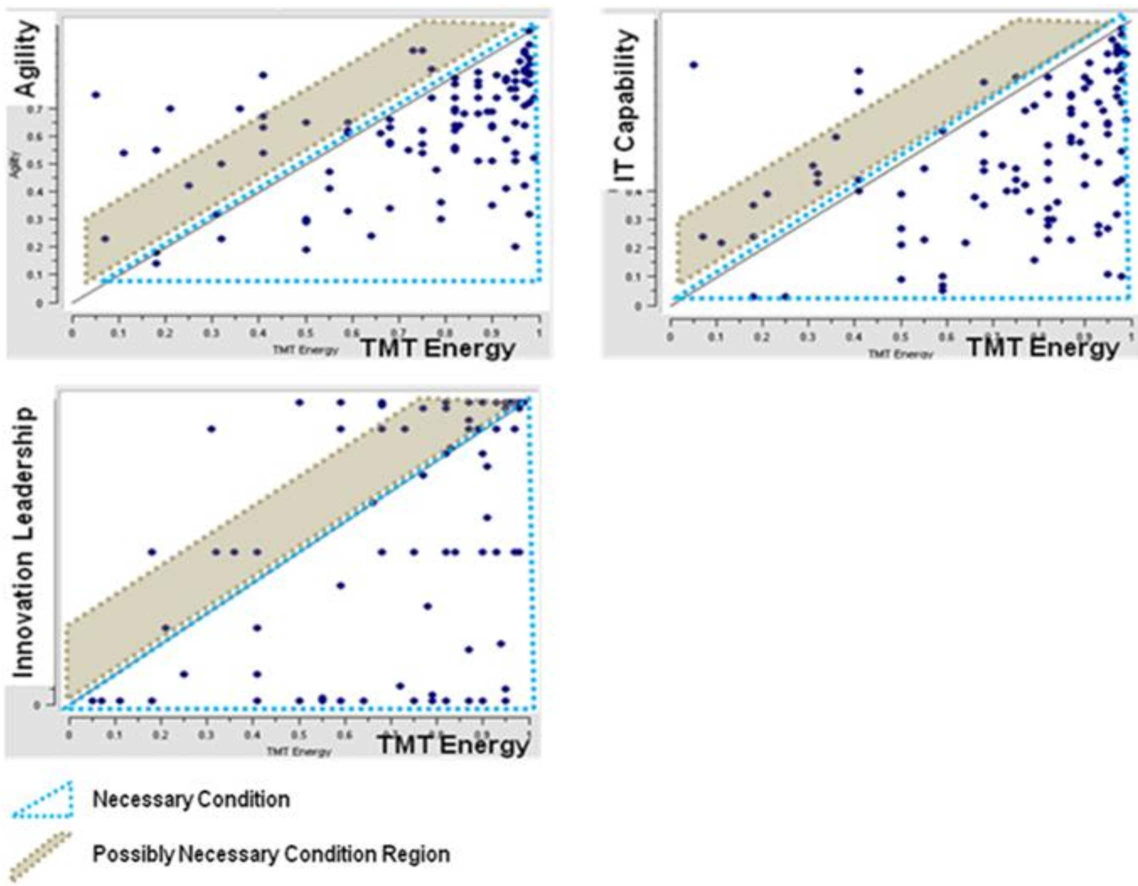
Pattern 1 provides the evidence of causal asymmetry, which means that the causes leading to the presence of an outcome is different from those leading to the absence of an outcome (Fiss 2011). This study gives an example of causal asymmetry in digital ecodynamics -- the causal structures of configurations for high performance [Figure 4-1] are different from those of configurations for low performance [Figure 4-4]. Configurations in Figure 4-1 and 4-4 depict which elements play core or peripheral roles, and which elements should exist or absent for a configuration to result in high or low performance. In a set-theoretic configurational theory approach, a causal structure is expressed by a combination of core/peripheral and present/absent elements. Therefore, causal asymmetry means that, for example, one core element that exists in high performing configurations may be absent in low performing configurations. Thus, a low performing configuration cannot become a high performing configuration by changing the values of its elements. Instead, a configurational transformation from low performance to high performance needs a structural change, meaning a non-linear punctuational change (El Sawy et al. 2010). The patterns in Table 4-2 explain holistic systemic interactions among the key configurational elements. The patterns describe which elements are core/peripheral and present/absent for a configuration to have a high level of agility, innovation leadership and high performance. Thus, patterns can show the role of information technologies in configurational transformation to agile organizations. Therefore, I suggest a proposition of organizational transformation as follows:

> **Holistic Proposition 4.** *The different structures of configurations for high performance and low performance (i.e., causal asymmetry) suggest that low performing organizations will need to have a non-linear, punctuational transformation to become high performing agile organizations. The patterns extracted from configurational analysis help effectively undergo non-linear configurational transformation to an IT-enabled agile organization in turbulent environments.*

4.5.5 TMT Energy as a Necessary Condition for IT-enabled Agile Organizations

Pattern 3, 4, 7, 11, and 15 show that TMT energy is possibly a necessary condition for high performance, innovation leadership, and a high level of organizational agility. Using the membership plot that fsQCA provides, I further test whether TMT energy is a necessary condition. Figure 4-8 depicts the membership distributions of cases in terms of TMT energy and other constructs. Most cases are positioned below the diagonal, or some cases are little above the diagonal. Especially most cases of high level of agility, IT capability, and innovation leadership are either lower right of the diagonal or around the diagonal. Therefore, based on the patterns in the configurations and the evidences from these plots, TMT energy can be considered a necessary condition for innovation leadership, agility and IT capability. Thus, TMT energy is causally connected with all these constructs, but by itself is not sufficient for enhancing IT capability, organizational agility, and innovation leadership.

Figure 4-8: Top Management Team Energy as a Necessary Condition



The literature supports the importance of TMT energy, for example, for the successful organizational sensing and responding to environmental change (Eisenhardt 1989; Hambrick 1981; Hambrick et al. 1996; Kiesler and Sproull 1982), and for information systems success (Cooper et al. 2000; Wixom and Watson 2001). Top managers' energetic initiatives for changing their organizations can help employees overcome resistance to change (Markus 1983).

The patterns around TMT energy found in this study empirically justify the important and comprehensive role of TMT in transforming to IT-enabled innovative agile organizations. The meaning of TMT energy is beyond simple support for change. Top managers actively engage in organizational change as major actors for successful transformation to the agile organization. I propose a proposition of TMT energy as follows:

Proposition 5: *Top management team energy is a necessary condition for transformation to IT-enabled agile organizations.*

This chapter discovered diverse holistic features of digital ecodynamics with a set-theoretic configurational theory approach. I explained non-linear and non-additive but synergetic systemic interactions among the key constructs of configurations. In the next chapter, I will develop a variance theory of IT-enabled organizational agility in turbulent environments.

CHAPTER 5: RELATIONSHIP INVESTIGATION WITH A VARIANCE THEORY APPROACH

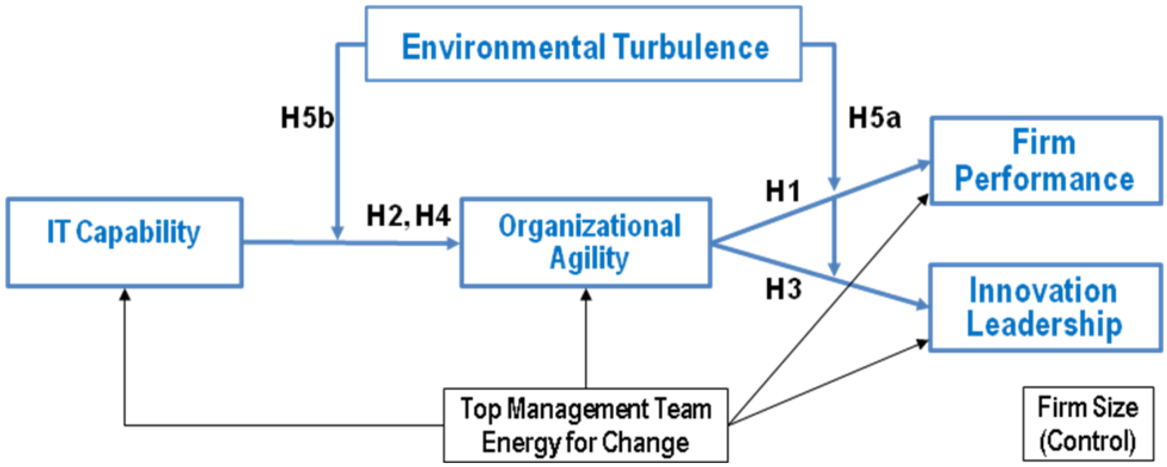
In this chapter, I develop a variance theory that explains the linear, additive relationships between the key constructs in a way that explains the role of information technologies in enhancing organizational agility, innovation leadership and firm performance, and the contingency effects of environmental turbulence on the relationships.

5.1 Research Model for IT-enabled Agile Organizations

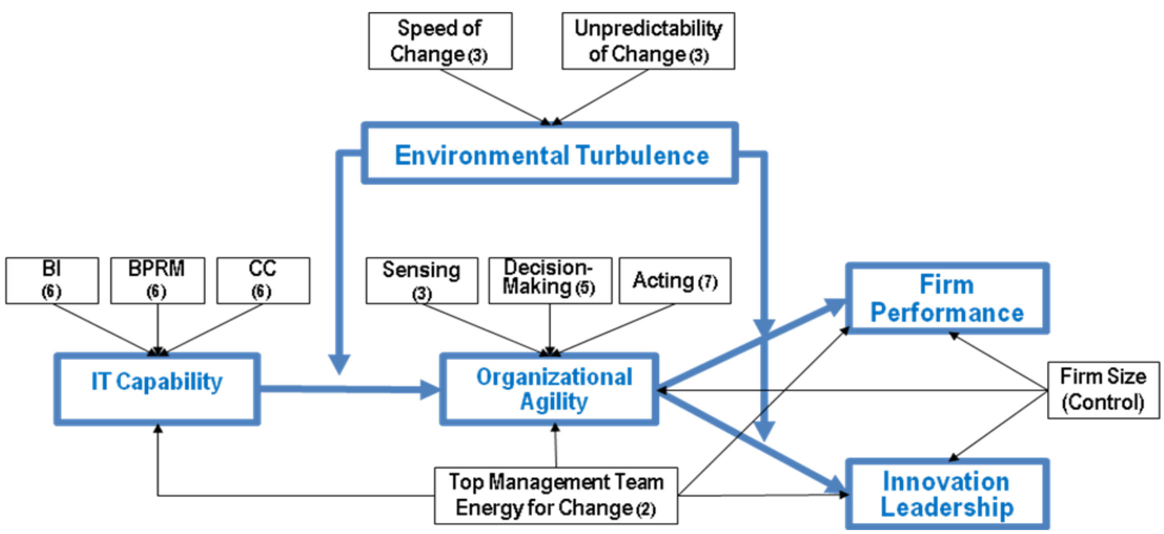
Compared to a configurational model that describes holistic, systemic interactions (e.g., Figure 4-1), the variance theory model describes "mechanical" linear, additive relationships as depicted in Figure 5-1. This research model describes the relationships between key constructs. First model (a) shows the relationships between IT capability, organizational agility, environmental turbulence, innovation leadership and firm performance. The second model (b) explains the details of the research model, which shows how each second-order construct is built by its first-order constructs.

Figure 5-1: Research Model

a. 2nd-Order Construct Model



b. Details of the Proposed Research Model



* The number in each construct means the number of items that are used to measure it.

5.1.1 IT Capability, Agility and Firm Performance

The literature on IT-enabled organizational agility argues that information technologies are one of the most effective ways to achieve a high-level of organizational capability to successfully sense and response to market opportunities and threats, which in turn achieve competitive performance (Overby et al. 2006; Sambamurthy et al. 2003), especially in turbulent environments (Pavlou and El Sawy 2006).

5.1.1.1 Effects of Organizational Agility on Firm Performance

Agility is an organizational ability to successfully sense and respond to market opportunities and threats in a timely manner (Overby et al. 2006; Sambamurthy et al. 2003). Agility enables organizations to successfully execute a series of event management tasks of timely sensing, decision-making and acting. Organizations that promptly sense and respond to market opportunities and threats can achieve high performance (Grewal and Tansuhaj 2001; Overby et al. 2006). Frequent strategic scanning of environments increases firm performance (Daft et al., 1988). For example, frequent sense and response to the market with new products/services increases the profit of airlines (Smith et al. 1991) and of hospitals (Shortell et al. 1990; Zajac and Shortell 1989).

Competitive action theory explains that rapid and frequent actions enable a firm to outperform its competitors in high-velocity and hyper-competitive environments (D'Aveni 1994; Ferrier et al. 1999). Acting agility enables organizations to quickly introduce new products to the market (Overby et al. 2006; Thomas et al. 1993).

However, frequent competitive actions (e.g., new innovations – products, service, and pricing models) that do not reflect changing environments may not help organizations achieve high performance. Sensing agility helps organizations in a timely manner capture important business events so that they can understand trends of changing environments (Thomas et al. 1993; Weick 1999). Then, decision-making agility helps organizations define opportunities and threats in a timely manner by interpreting the implications of the captured events to their businesses. It also helps organizations enact new competitive actions in a timely manner by making action plans. Therefore, sensing and decision-making agility enable organizations to take the right actions that reflect changing environments. Organizational agility that consists of these three aspects of organizational capability to sense and manage opportunities and threats can help organizations achieve competitive performance. Therefore, I propose the following hypothesis:

H1: ***Organizational agility is positively associated with firm performance.***

5.1.1.2 Effects of IT Capability on Firm Performance

Information technologies, as explained in the first chapter, have great effects on businesses in many different ways. The impact of IT on firm performance has been a key issue in the IS literature (Barua and Mukhopadhyay 2000; Kettinger et al. 1994; Wheeler 2002). While some argued that IT does not matter (Carr 2003), since the mid 90s, many studies demonstrated the positive impact of IT on firm performance (Bharadwaj et al. 1999; Brynjolfsson and Hitt 1993; Kohli and Devaraj 2003).

Although these studies demonstrate that IT can increase firm performance at the industry level, they do not explain how individual organizations achieve different performance by using information technologies. Recently, IS studies on organizational dynamic capability argued that the impact of IT capability on firm performance is realized through organizational dynamic capability (e.g. Overby et al. 2006; Pavlou and El Sawy 2006, 2010; Sambamurthy et al. 2003). Information technologies can be an enabler of organizational agility by providing several digital options that can be used any time by organizations for timely sensing and responding to market opportunities, which eventually increase firm performance (Sambamurthy et al. 2003). In accordance with these studies, this dissertation suggests three types of IT systems that can provide multiple functions that can help organizations effectively execute event management tasks. Such functions increase organizational agility, which in turn increase firm performance. Based on these theoretical arguments, I suggest the following hypotheses:

H2a: ***IT capability is positively associated with firm performance.***

H2b: ***Organizational agility mediates the impact of IT capability on firm performance.***

5.1.2 IT Capability, Agility and Innovation Leadership

Innovation leadership implies that organizations have strong control over new product and process standards. Innovation leaders continually introduce new high quality products that consumers could like over time. Such quality products in the long run heighten a firm's market status and reputation (Podolny, 1993) and enable a firm to sustain strong control over market standards and competitive advantage (Podolny, Stuart, and Hannan, 1996). To sustain innovation leadership, market leaders continually change standards by introducing new innovations to which their competitors should respond. Such leaders introduce new innovations at the speed with which they can sustain their control over the market and sustain competitive advantage (Brown and Eisenhardt 1997, 1998).

Organizational exploration for new alternatives increases diversity within an organization, which helps an organization create new innovations (March 1991; McGrath 2001). Sensing agility enables an organization to effectively explore diverse information from business environments, which increases organizational internal diversity and thus innovative capacity (McGrath 2001). The literature on marketing and entrepreneurial orientation has shown that timely sensing of customers' changing preference, competitors' new actions and emerging technologies helps organizations to introduce innovative products frequently, increasing a firm's innovation leadership (Covin and Slevin 1990; Gatignon and Xuereb 1997).

In sum, in high velocity environments, innovation leadership can be sustained by frequent introductions of new innovations to the market. Agility is an organizational ability to successfully execute event management tasks that sense and respond to market opportunities by introducing new innovations. Thus, organizational agility can effectively increase innovation leadership.

On the other hand, IT enables organizations to effectively execute event management tasks. However, as I explained earlier, the impact of IT on the successful event management is realized through organizational agility. Thus, IT increases organizational agility, which in turn increases innovation leadership. Based on this theoretical rationale, I suggest the following hypotheses:

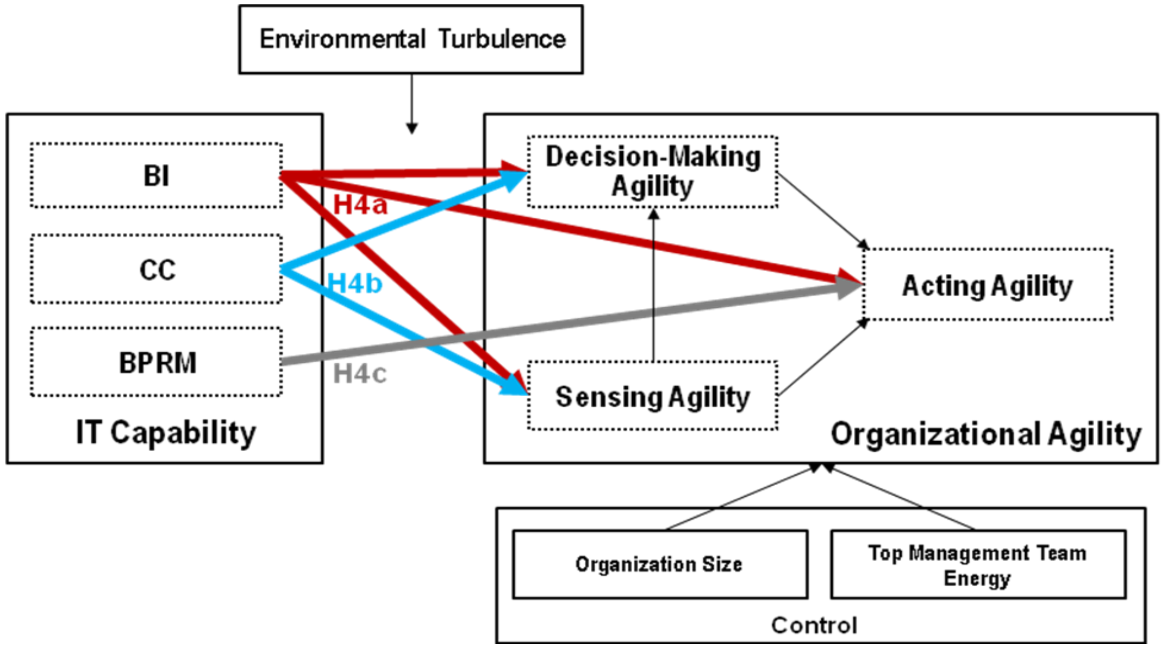
H3a: ***Organizational agility is positively associated with innovation leadership.***

H3b: ***IT capability indirectly influences innovation leadership through organizational agility.***

5.1.3 The Detailed Relationships between IT Systems and Agility

In chapter 2, I define three types of IT systems that provide multiple functions supporting event management tasks: business intelligence (BI), communication and collaboration (CC), and business process and resource management (BPRM) systems. Further, I define three types of organizational agility that are related to individual event management tasks: sensing, decision-making, and acting agility. I explain the detailed relationships between three types of IT systems and three types of agility in this section. Figure 5-2 depicts the hypothesized relationships between IT systems and organizational agility.

Figure 5-2: Research Model for IT-enabled Organizational Agility



5.1.3.1 Business Intelligence Systems and Agility

BI systems provide a set of functions that enable organizations to sense and manage business events in a timely manner [Table 2-3]. BI systems enable organizations to monitor and capture important business events using rule-based exception handling, and alert managers about the captured events in real-time (Carte et al. 2005; Cooper et al. 2000). In addition to such typical BI functions, the recent advancement in BI systems enables organizations to handle data (Watson 2005) in a way that monitors business events in real-time and proactively and reactively sends out information about events to relevant people who are responsible for managing the captured events (Anderson-Lehman et al. 2004; Chandy and Schulte 2009). Therefore, BI systems help organizations to develop a high level of sensing agility.

BI systems provide functions that enable managers to access enterprise-wide consistent data (e.g., data warehouse), help find out patterns from the data, and compare several alternative models with what-if analysis and data visualization. Real-time information provided by BI systems enables managers to increase the speed of strategic decision-making (Eisenhardt 1989), while information delay and incomplete data restrain managers from making a decision in a timely manner (Wixom and Watson 2001). Therefore, BI systems enable organizations to increase decision-making agility.

Further, BI systems create actionable knowledge by transforming data into knowledge and intelligence based on which managers make responses to events in a timely manner (Carte et al. 2005). The types of events that can be captured by BI systems need to be pre-defined. For example, rule-based systems can capture only pre-defined events. Data also need to be defined before being stored in enterprise data warehouse. Reports that are automatically generated about business events and processes can include only predefined data. Thus, business intelligence systems are more likely to handle routine events. Further, BI systems can provide multiple alternative sets of procedures that help managers respond to such routine events in a timely manner or automate the processes for some well-defined events, such as procurement and payment. Therefore, BI systems can increase organizational acting agility. By considering all these together, I propose:

H4a: ***Business intelligence systems are positively associated with three types of organizational agility: sensing, decision-making, and acting agility.***

5.1.3.2 Communication and Collaboration Systems and Agility

Communication and collaboration (CC) systems provide a set of functions that enable organizations to interactively communicate information and collaborate between key stakeholders [Table 2-3]. CC systems support real-time information dissemination, two-way communications between co-workers, and information sharing within an organization and between a focal company and important market players, such as supply chain partners, key customers, and regulators. CC systems also support real-time video/audio conference (e.g., Skype). The real-time communication and collaboration enabled by CC systems help increase information use, reduce communication barriers, and increase interactions among business users (Daft and Lengel 1986; Majchrzak et al. 2005; Zigurs and Buckland 1998). For organizations to successfully interpret situations, people or stakeholders need to communicate and share information relevant to the situation (Galbraith 1974; Malhotra et al. 2007; Tushman and Nadler 1978, p. 614). Especially in turbulent environments, real-time information sharing and collaboration help managers develop common ground and collective sensemaking (Majchrzak et al. 2006, 2007; Pavlou and El Sawy 2010). Further, these functions provided by CC systems enable managers to increase the speed of strategic decision-making (Eisenhardt 1989). Thus, based on this theoretical background, I propose a hypothesis about the relationship between CC systems and agility:

H4b: ***Communication and collaboration systems are positively associated with organizational sensing and decision-making agility.***

5.1.3.3 Business Process and Resource Management Systems and Agility

Business process and resource management (BPRM) systems provide a set of functions that enable organizations to quickly respond to environmental change by helping organizations manage processes and resources effectively and flexibly within an organization and between organizations (Nambisan 2003; Pavlou and El Sawy 2010; Sambamurthy et al. 2003). This type of system provides functions that visually present the structure of processes, including the dependencies between tasks or business processes (Nambisan 2003). It also provides real-time information about resources and their dependencies on tasks (Pavlou and El Sawy 2006). Thus, these functions can help firms redesign or add a new process quickly, and rearrange or streamline processes effectively. These functions also enable organizations to automate typical business processes like procurement, inventory management, and payment [Table 2-3]. Therefore, I suggest a hypothesis about the relationship between BPRM systems and agility:

H4c: ***Business process and resource management systems are positively associated with acting agility.***

5.1.4 The Contingency Effect of Environmental Turbulence

The main goal of organizational agility is to sense and respond to opportunities and threats that are generated from environmental change (Overby et al. 2006; Pavlou and El Sawy 2006; Sambamurthy et al. 2003). As environments are changing faster and more unpredictably, new opportunities and threats are more frequently created (Brown and

Eisenhardt 1997; D'Aveni 1994; Eisenhardt 1989; Eisenhardt and Sull 2001). Therefore, as environments become more turbulent, the proposed relationships between IT, agility, innovation leadership and performance become more significant (Lawrence and Lorsch 1967; Mintzberg 1979; Pavlou & El Sawy 2006, 2010).

Rapidly and unpredictably changing environments more frequently create opportunities and threats (Eisenhardt 1989). In such high velocity environments, competitive advantage gained by a strategic position or an innovation can be temporary (Tanriverdi et al. 2010). In order to create a series of temporary competitive advantages, organizations need to quickly sense market change and frequently introduce innovations that reflect the changing market trends (Brown and Eisenhardt 1997; D'Aveni 1994; Eisenhardt and Martin 2000; Eisenhardt and Sull 2001; Sambamurthy 2000).

However, in stable environments in which change is relatively slow and predictable, there is enough time to gather and process relevant information and do rational analysis (Fine 1998), and organizations are less likely to fail in sensing and responding to environmental change (Davis et al. 2009). Competitive advantage gained through a specific position and a combination of rare and valuable resources can be sustained for a long time (Barney 1991; Porter 1980). Therefore, they do not need to quickly move away from such a beneficial position, but instead enjoy such benefits until the position does not give any more competitive advantage. Fast moves with reconfiguration of resources can disrupt existing competitive advantage (Moorman and Miner 1998). Therefore, depending on environmental turbulence, organizational agility to sense and respond to environmental change can have different impacts on a firm's competitive advantage. So, I suggest the following hypothesis of environmental contingency effect:

H5a: ***Only in turbulent environments, organizational agility positively influences firm performance and innovation leadership.***

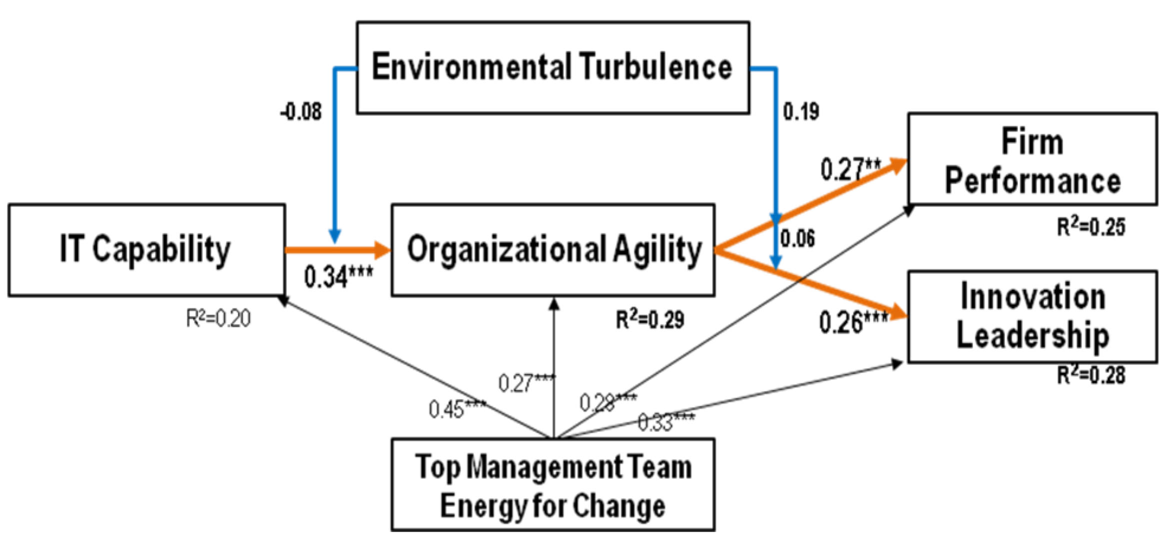
In turbulent environments, organizations become easily overloaded by an increasing amount of information (Galbraith 1974), and market information becomes quickly obsolete and often unavailable (Eisenhardt 1989). In such turbulent environments, information technologies are especially useful for managing the increasing amount of information by increasing information processing capacity and reducing information processing needs (Bensaou and Venkatraman 1995), for example, filtering unimportant events out. IT systems are more effective for reconfiguring resources to develop new products in turbulent environments than in stable environments (Pavlou and El Sawy 2006). In stable environments, there are many ways to sense and respond to slowly and predictably changing environments other than information technologies (Davis et al. 2009). Thus, IT systems can be an effective way to sense and respond to market opportunities and threats in turbulent environments, but not in stable environments. So, I suggest the following hypothesis of environmental contingency effect on the relationship between IT and agility:

H5b: ***Only in turbulent environments, IT capability positively influences organizational agility.***

5.2 The Results of PLS Analysis

This section presents the results of hypothesis test. To test the proposed hypotheses, I use structural equation modeling (SEM). Among multiple alternative methods for SEM, I use the partial least squares (PLS), which is a component-based multiple regression iteration method that aims to enhance predictive power (Chin 1998). PLS can define a latent variable as either formative or reflective. Therefore, PLS can handle the proposed research model in this dissertation that consists of both formative and reflective constructs. With 106 firm-level data and 100 bootstrap samples, PLS path coefficients are estimated (Chin et al. 2003). Figure 5-3 depicts the results of PLS analysis for the proposed research model.

Figure 5-3: Results of PLS Analysis for the Proposed Research Model



*** significant < 0.01, ** < 0.05, * < 0.1

Firm size are controlled for firm performance, innovation leadership, and agility. In this second-order construct model, firm size has no impact on firm performance, innovation leadership and agility.

As I explained in chapter 2, TMT energy is an important factor that influences organizational change, sensing and responding to market change, innovation, and firm performance, so I control the effect of TMT energy. TME energy significantly influences all constructs as shown in Figure 5-3. Thus, findings from both a configurational theory approach and a variance theory approach demonstrate the important role of TMT energy in IT-enabled agile organizations.

5.3 Hypothesis Test

5.3.1 Test of Hypotheses about the Role of Agility

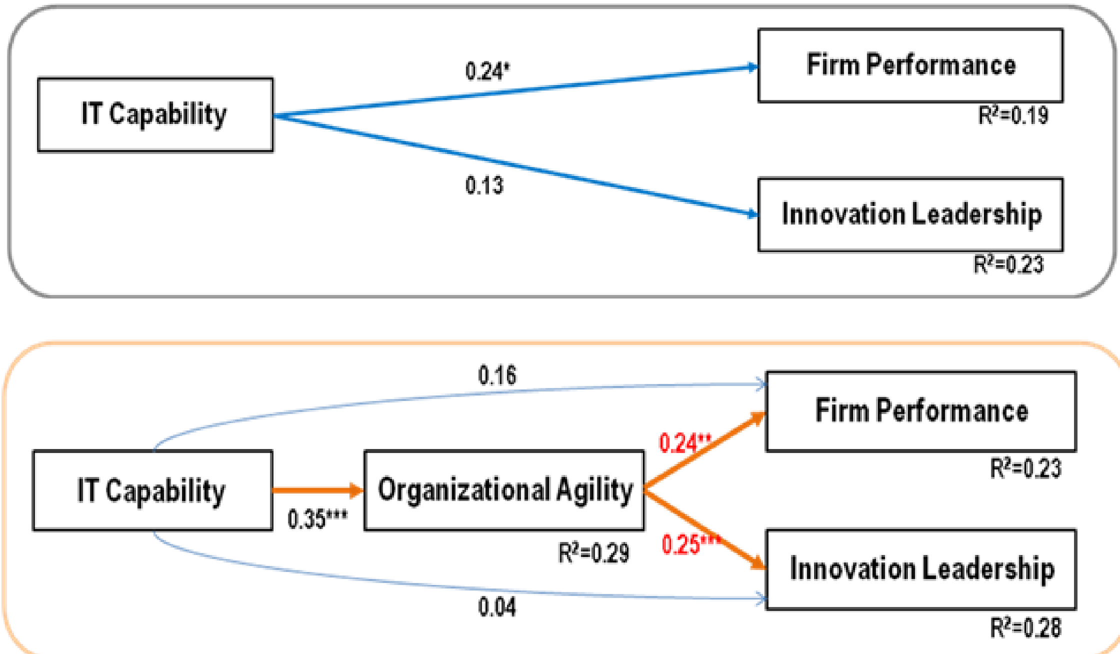
As shown in Figure 5-3, organizational agility has significant positive relationships with firm performance and innovation leadership, supporting hypotheses **H1** and **H3a**.

To test the mediating role of organizational agility in the process in which IT influences firm performance and innovation leadership, two models are compared [Figure 5-4]. I control the impact of firm size and TMT energy on firm performance, innovation leadership, and agility. The direct model attests whether IT capability directly influences firm performance. The PLS results show that IT capability is positively associated with firm performance, supporting **H2a**. The second model puts organizational agility between IT capability and firm performance. The relationship between IT capability and firm performance is not significant, while the relationships between IT capability and agility and between agility and firm performance are significant. This supports **H2b**, which explains the mediating role of agility in the relationship between IT capability and firm performance. Thus, IT capability indirectly influences firm performance through organizational agility.

In the same way, the direct model attests whether IT capability directly influences innovation leadership. The PLS results show that the relationship between IT capability and innovation leadership is not significant. In the second model where organizational agility sets between IT capability and innovation leadership, the direct relationship between IT capability and innovation leadership is not significant, but the relationships between IT capability and agility and between agility and innovation leadership are significant. These results support **H3b**, which explains that IT capability indirectly influences innovation leadership through organizational agility.

By introducing organizational agility into the model, the explained variances of firm performance and innovation leadership (i.e., R^2 values) are increased. This enhanced model fit supports the important role of IT-enabled organizational agility in enhancing innovation leadership and firm performance.

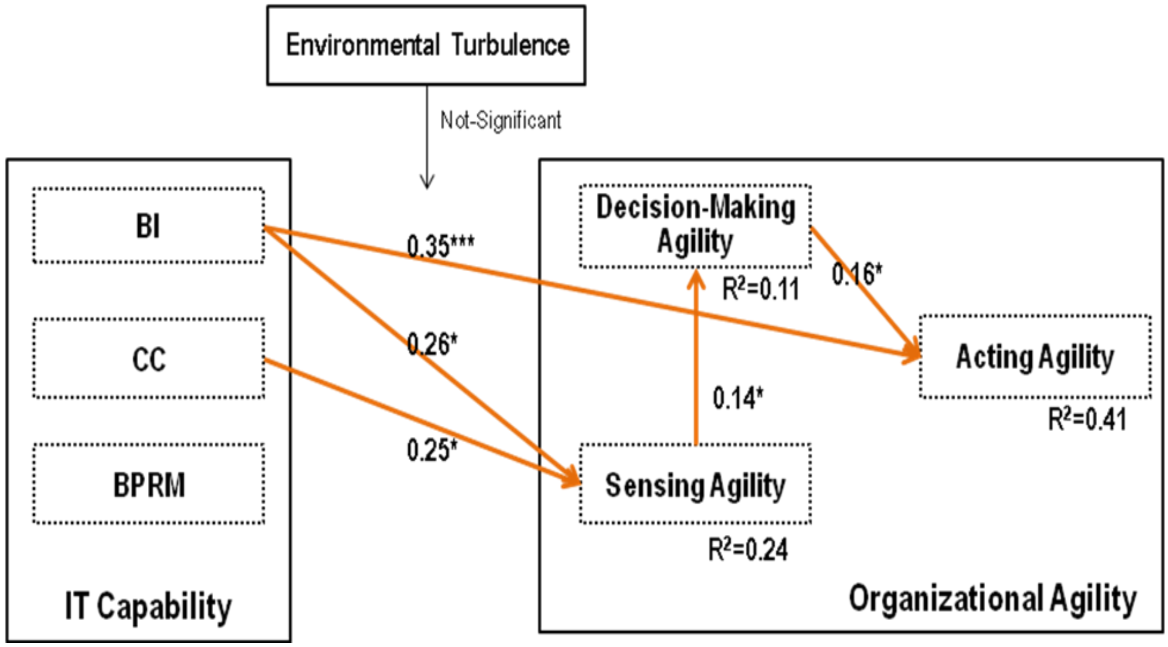
Figure 5-4: Test of the Mediating Role of Organizational Agility



5.3.2 Test of the Relationships between IT systems and Agility

Figure 5-5 shows the results of PLS analysis for testing hypotheses about the detailed relationships between the three types of IT systems and the three types of agility. I control the impact of firm size and TMT energy on the three types of agility. BI systems positively influence sensing agility and acting agility, but indirectly influence decision-making agility through sensing agility, so **H4a** is partly supported. CC systems positively influence sensing agility, but indirectly influence decision-making agility through sensing agility, so partly supporting **H4b**. BPRM systems do not significantly influence organizational agility, not supporting **H4c**.

Figure 5-5: Test of the Relationships between IT systems and Agility



These findings explain the different roles of IT systems in developing different types of agility. Pavlou and El Sawy (2010) also find similar patterns. They demonstrate different types of IT systems supporting for new production development tasks play different roles in enhancing two different types of dynamic capabilities.

By considering the findings from both a configurational theory approach and a variance theory approach in this study, we can develop a more complete understanding of the role of IT systems in enhancing organizational agility. The findings from a configurational theory describe the roles of IT systems as core/peripheral and present/absent at the system level. The findings from a variance theory describe the roles of IT systems as significant/insignificant and show the level of individual variables as high or low to result in a desirable outcome. If we rely on, for example, only the findings from a variance theory approach, BPRM systems do not matter for enhancing organizational agility because the relationship between BPRM systems and organizational agility is not significant. This result seems counterintuitive. However, if we consider also the findings from a configurational theory, BPRM systems matter for enhancing organizational agility. BPRM systems play a peripheral role, which means BPRM systems may complement other types of IT systems for enhancing organizational agility; for example, by feeding raw data for BI systems (e.g., data warehouse, data mining, balanced-scored systems).

5.3.3 Test of the Contingency Effect of Environmental Turbulence

In Figure 5-3, no contingency effect of environmental turbulence is found. Environmental turbulence does not have significant moderation effects on the relationships between IT capability and agility and between agility and firm performance and innovation leadership. This result can imply that the relationships between all these constructs are significant both in turbulent and in stable environments. If this is true, it may be partly explained by the definition of organizational agility -- organizational ability to sense and respond to market opportunities and threats in a timely manner. In this definition, the part "in a timely manner" means that there is some time buffer for every task. That is, within the given time, organizations need to finish the task, not necessarily in real-time but in a way that the delay in one task does not affect other tasks dependent on it. This concept is clearly included in theorizing. Further, this concept was explicitly explained in the survey questionnaire as shown in Chapter 3. Therefore, organizational agility can play an important role in enhancing performance both in stable and turbulent environments. Pavlou and El Sawy (2006) found similar relationships that explain the impact of IT-enabled dynamics capability on competitive advantage remains significant across different levels of environmental turbulence.

On the other hand, this insignificant moderating effect can be caused by a methodological limitations of PLS. PLS analysis uses a cross-multiplying method to test a moderating effect (Chin et al. 2003). PLS multiplies all measures of each factor to create a new interaction variable. For example, if the relationship between X1 and Y is hypothesized to be moderated by X2, then PLS creates a new interaction variable (i.e., X1*X2) by cross-multiplying all measurement items of X1 and X2. This method has some benefits compared to other methods that measure moderating effects, but it still has some issues. It cannot clearly distinguish the between-group effect from the within-group effect. The effects from within-group and between-groups are fused into the new interaction variable, so the results cannot exactly show the pure moderating effects.

There are some methods to handle this issue; for example, 1) hierarchical linear modeling (multi-level analysis) and 2) grouping data into different sets and comparing the results of individual analyses with separate data sets. I use the latter. I make three data groups that are different in their levels of environmental turbulence: hyper-turbulent, moderately turbulent, and stable environments. Then, I compare the results of PLS analysis for individual data groups in order to examine how the relationships between constructs are changing over different environmental turbulence.

I use ***fuzzy set membership scores*** calibrated from the 7-point Likert interval scale of environmental turbulence in order to categorize individual cases into one of the three groups – hyperturbulent, moderately turbulent, stable environments. Fuzzy set membership is especially appropriate for grouping cases, because, as I explained in Chapter 4, calibration is a process that transforms an interval scale into a set membership score using three anchors – full membership, full non-membership, and crossover point. Thus, the set membership score represents the extent to which each case is a member of, for example, a hyperturbulent environment. Since the calibration process is based on both existing knowledge of the context and cases and the empirical data, it can more exactly define a group of cases that have similar memberships (Ragin 2008; Fiss 2011).

Each firm is categorized into one of the three groups based on its membership score:

- ✓ Membership score below 0.5 into the stable environment group,
- ✓ Membership score between 0.5 and 0.82 into the moderately turbulent environment group, and
- ✓ Membership score above 0.82 into the hyperturbulent environment group.

Table 5-1 summarizes this grouping process and the resulting data sets. There are 29 firms in the hyperturbulent environment group, 47 in the moderately turbulent environment group, and 30 in the stable environment group. In the 7-point Likert scale, scale 4 means the most ambiguous case that is neither turbulent nor stable. Thus, it is reasonable to treat a case with less than 4 as stable environments.

Table 5-1: Grouping Cases using Fuzzy-Set Membership

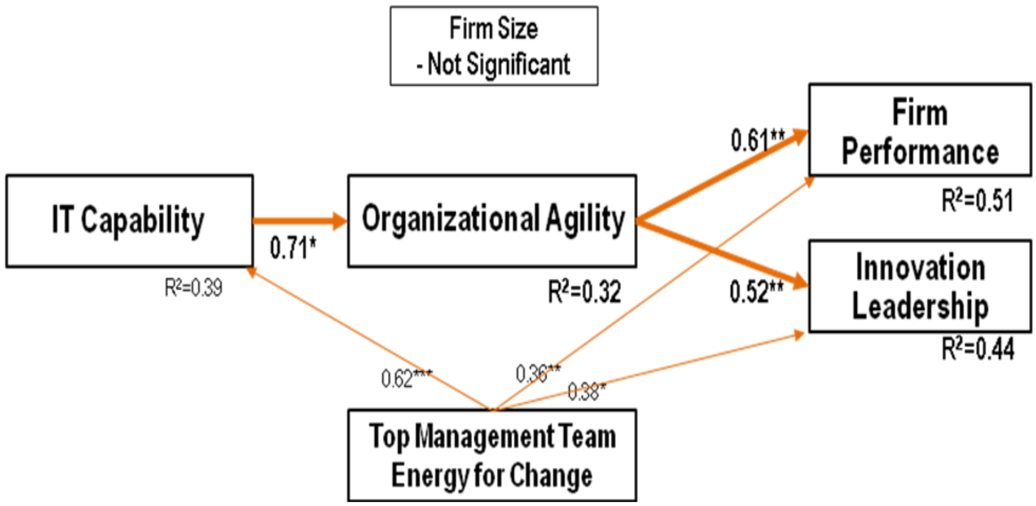
Group	**Fuzzy Membership Score (0~1)**	**Corresponding 7-point Likert Scale**	**Number of Firms**
Hyperturbulent	0.82 ~ 1.0	5 ~ 7	29
Moderately Turbulent	0.5 ~ 0.82	4 ~ 5	47
Stable	0 ~ 0.5	1 ~ 4	30

Figure 5-6 shows the results of PLS analysis for each group. By comparing the PLS analysis results for these three groups, the contingency effect of environmental turbulence is more exactly captured, which cannot be extracted when all data are mixed and when between-group effect is fused with within-group effect.

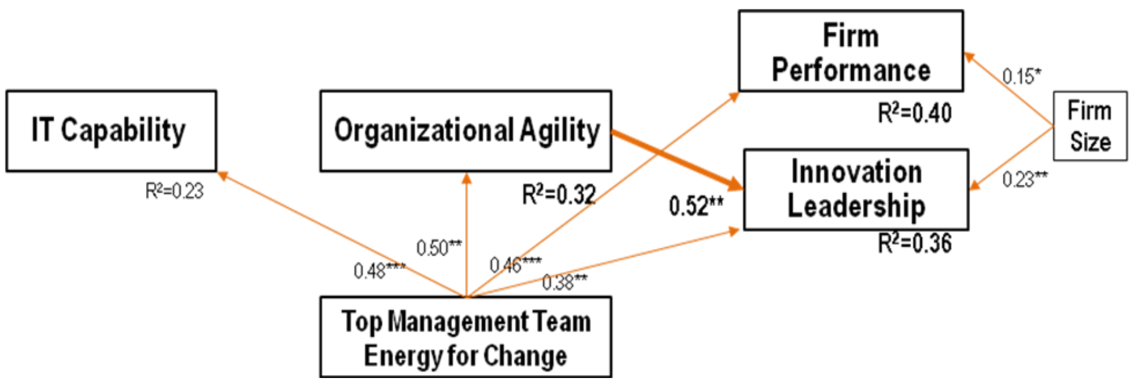
In hyperturbulent environments, all relationships are significant and the PLS path coefficients become greater compared with those in the mixed model shown in Figure 5-3. The impact of IT capability on agility becomes 0.71 from 0.34, an increase of 0.37. The impact of agility on firm performance and innovation leadership are also increased. The explained variance (i.e., R^2 value) of firm performance and innovation leadership almost doubled. Thus, the proposed research model is well suited for hyperturbulent environments.

Figure 5-6: Comparison of Models for Different Environments

a. Hyperturbulent Environments



b. Moderately Turbulent Environments



c. Stable Environments

*** significant < 0.01, ** < 0.05, * < 0.1

In moderately turbulent environments, most relationships suddenly become insignificant. IT does not matter for enhancing organizational agility. Organizational agility does not enhance performance, although it still enhances innovation leadership. Organizational size has a positive impact on performance and innovation leadership. So, in such moderately turbulent environment, large companies perform better than small and medium companies. TMT energy becomes one of the most important factors that increase IT capability, agility, performance, and innovation leadership.

In stable environments, all relationships become insignificant. Organizational agility and TMT energy do not matter. Firm performance and innovation leadership are not explained by organizational agility. IT does not enhance agility. As I explained earlier, in stable environments, there can be many alternatives to achieve performance other than agility (Davis et al. 2009, Fine 1998).

All these findings support the argument for the contingency effect of environmental turbulence on IT-enabled organizational agility and performance. Thus, **H5a** and **H5b** are supported.

CHAPTER 6: IMPLICATIONS AND INSIGHTS

This dissertation focuses on developing an understanding of 1) how information technology, organizational agility, and environmental turbulence simultaneously and systemically combine to result in competitive firm performance, and 2) the role of information technologies in successful sensing and responding to market opportunities and threats. Digital ecodynamics -- fused dynamic interactions among IT, organizational agility, and environmental turbulence -- create messy, complex phenomena from which many new opportunities and threats are generated. Thus, a timely sensing and managing opportunities and threats becomes a key issue for organizations to survive and thrive in digital ecodynamics.

To develop a more complete understanding of the holistic nature of digital ecodynamics and the role of IT in transformation to agile organizations, this study uses two approaches that are theoretically and methodologically different but complementary to each other. Using a set-theoretic configurational theory approach, this study explores the dynamic and complex interactions among IT, organizational agility and environmental turbulence in a way that explains how they simultaneously and systemically combine to result in high performance and innovation leadership. At the same time, based on a variance theory approach this dissertation develops a theory that explains "mechanical" and more generalizable relationships between IT, organizational agility, environmental turbulence, innovation leadership, and firm performance with the aim to advance theories in IT-enabled agile organizations.

6.1 Key Findings and Interpretations

This dissertation explored the holistic nature of digital ecodynamics using a set-theoretic configurational approach. It opened the black box of digital ecodynamics and investigated a complex causal fabric among IT, agility, environmental turbulence, and other organizational factors (i.e., top management team energy and organizational size). The resulting configurations explained that individual elements play different roles -- core vs. peripheral, present vs. absent, or don't care – depending on different contexts. This rich combinatorial expression of the systemic interactions of the configurational elements enables the complex diversity of digital ecodynamics to be presented in a meaningful way to show, for example, equifinal paths to the same outcome and the multifaceted roles of information technologies.

First, this study found multiple configurations that result in competitive firm performance, showing equifinaltiy that explains a system can reach the same outcome from different initial conditions through different paths. This is a unique feature that can be explained by a configurational theory approach. By comparing similarities and differences of the multiple configurations, I found two groups of configurations that achieve high performance: IT-enabled vs. non-IT-enabled. In turbulent environments, IT plays a core role in achieving high performance, and non-IT-enabled configurations can achieve high performance only in stable environments. By considering TMT energy as a necessary condition, this study could find that organizational agility plays the most important role in achieving competitive firm performance, and organizational agility and information technologies together make the most effective path to high performance in turbulent environments.

The findings from a variance theory approach showed that IT-enabled agility positively influences firm performance. The results also showed the mediating role of organizational agility in the process in which information technologies influence firm performance. That is, information technologies indirectly influence firm performance through organizational agility. Therefore, this dissertation empirically demonstrated the theoretical argument made by IS studies -- i.e., organizational agility mediates the impact of IT capability on firm performance (Overby et al. 2006; Sambamurthy et al. 2003).

Second, the resulting configurations showed the multifaceted roles of IT as either an enabler or an inhibitor for organizational agility. Several patterns extracted from configurations explain the two opposing roles of information technologies in configurations. Different types of IT systems can be either an enabler or an inhibitor in the same configuration. Further, the same type of IT systems can be either an enabler or an inhibitor over different configurations. As such, this study provides a rich understanding of the multifaceted roles of IT.

Third, the patterns extracted from fuzzy set Qualitative Comparative Analysis (fsQCA) showed that organizational agility plays the most important role in achieving innovation leadership. Further, the PLS results showed that IT alone does not directly influence innovation leadership, but indirectly through organizational agility.

Fourth, this dissertation investigated the detailed relationships between three types of agility and three types of IT systems. Configurations from fsQCA show that there are two ways to achieve a high level of agility: IT-enabled vs. Non-IT-enabled. The IT-enabled path is more effective than non-IT enabled path. In the configurations of IT-enabled agility, either business intelligence (BI) systems or communication & collaboration (CC) systems plays a key role. Further, these two systems together make the most effective path to achieve a high level of agility among all the resulting configurations. Business process and resource management (BPRM) systems play a peripheral and complementary role in achieving a high level of agility. The PLS results showed that BI systems can increase both sensing and acting agility directly, CC systems increase especially sensing agility, and BPRM systems do not have significant relationships with any type of agility. BI and CC systems indirectly increase decision-making agility through sensing agility. These findings imply that each type of IT systems plays a different role in enabling different types of organizational agility.

Fifth, the results from fsQCA and PLS analysis showed that there is a contingency effect of environmental turbulence on the relationships between IT, agility, innovation leadership, and firm performance. Most importantly, IT-enabled agility can increase innovation leadership and firm performance only in hyperturbulent environments. Further, in hyperturbulent environments, organizations without IT-enabled agility have low performance. In stable environments, IT-enabled agility does not matter for innovation leadership and firm performance. This finding can be explained by the theoretical argument that explains that in stable environments organizations can have many alternatives to achieve competitive advantage (Davis et al. 2009; Fine 1998). In stable environments, fast moves by IT-enabled agility can be costly (Overby et al. 2006).

Organizations need to enjoy the competitive advantage gained by the current position until the environmental change makes the benefits of the position disappear (Barney 1991; Porter 1980; Wade and Hulland 2004).

Finally yet importantly, top management team energy plays a key role in the causal dynamics in transformation to IT-enabled agile organizations that achieve innovation leadership and competitive performance. Using fsQCA, this study found TMT energy is a necessary condition for IT capability, agility, innovation leadership, and firm performance. PLS analysis results also showed that TMT energy has significant positive relationships with all these constructs, however only in hyperturbulent environments. In stable environments, like IT-enabled organizational agility TMT energy can be costly because the charged TMT energy is likely to make organizations move fast.

6.2 Theoretical Implications

This dissertation aims to answer the call for exploring the complex messy phenomena in digital ecodynamics (El Sawy et al. 2010) and to answer the call for rigorous empirical research for IT-enabled organizational agility (Overby etl al. 2006; Sambamurthy et al. 2003).

6.2.1 Implications for Digital Ecodynamics

This dissertation contributes to both the IS and the strategic management literature by enhancing the understanding of the holistic systemic nature of digital ecodynamics -- the complex fused dynamics of IT systems, organizational agility and environmental turbulence. The IS literature largely ignores environmental turbulence or treats it as a thin variable, while the strategic management literature largely ignores the role of IT in theoretical models (El Sawy et al. 2010; Orlikowski 2009; Zammuto et al. 2007). Both literatures also largely build theories on the premise of stable, equilibrium environments. However, environments become more turbulent in a broad range of industries (D'Aveni 1994; Wiggins and Ruefli 2005), and have been constantly changing with frequent punctuational discontinuities and jolts (Brwon and Eisenhardt 1998; Meyer et al. 2005; Morgan 1986). Recently some studies investigated the relationships between IT, organizational dynamic capability, and environmental turbulence (Pavlou and El Sawy 2006, 2010), but mostly focusing on the dyadic relationships.

This dissertation contributes to IS strategy for digital ecodynamics by developing a better understanding of the holistic nature of digital ecodynamics using the set-theoretic configurational approach as an inquiring system. The findings capture diverse holistic features that describe synergetic and complementary interactions among IT systems, organizational agility and environmental turbulence that can be captured only at the system level, therefore overcoming the reductionism issue (Fiss 2007; Ragin 2008).

This dissertation also opened the black box of a configuration in a way that explains the complex interactions among the key elements of digital ecodynamics. It described how the elements of a configuration intermingle with each other and how individual elements play different roles as core/peripheral and present/absent. Thus, this dissertation overcomes the limitations of existing methods for studying digital ecodynamics because traditional methods like cluster analysis stop when they find configurations of the outcome and do not explain the dynamics between the configurational elements (Fiss 2007, 2011).

This dissertation contributes to the literature on strategic advantage in turbulent environments by suggesting a new holistic configurational way to think of the nature of a competitive arena. In frequent punctuated nonlinear change, configurational theories can better explain how a system shifts from one state to another state (El Sawy et al. 2010; Fiss 2007, 2011; Meyer et al. 2005). The results of fsQCA describe how multiple configurations could achieve a similar level of performance, either high or low firm performance. By comparing configurations of high performance and configurations of low performance, which have possibly different structures with different roles of elements, this study shows how one configuration moves from one state (e.g. high performance) to another (e.g. low performance) by restructuring its elements.

On the other hand, a configuration of IT, organizational agility, environmental turbulence, and other organizational factors (e.g. TMT energy, size, and the like) can be considered a path-dependent competitive position, which cannot be easily imitated by competitors. However, at the same time, the concept of equifinaltiy in the configurational theory provides multiple paths to competitive advantage. Thus, organizations can choose the best configuration that requires minimum costs and risks, which means they can find the best configuration by considering their own unique and idiosyncratic resources and capabilities. Therefore, this dissertation suggests a configurational way to achieve competitive advantage in environmental jolts and disequilibria, which is under studied in the IS and the strategic management literature (Tanriverdi et al. 2010).

6.2.2 Implications for IT-enabled Organizational Agility

This dissertation answered the call for rigorous empirical research on IT-enabled agility and competitive advantage (Lu and Ramamurthy 2011; Overby et al. 2006; Sambamurthy et al. 2003).

First, this dissertation contributes to the IT-enabled organizational agility literature by investigating the multifaceted roles of IT as either an enabler or an inhibitor for organizational agility. The patterns extracted from configurations show that IT systems can be either an enabler or an inhibitor depending on different contexts. Thus, this study provides a rich understanding of the multifaceted roles of IT.

Second, this dissertation contributes to the IT-enabled organizational agility literature by developing new theoretical constructs and measurements for organizational agility and IT capability both in the first-order and the second-order level. To develop theoretical constructs of organizational agility and IT capability, this study suggested an open-system event management model which explains how organizations sense and respond to market opportunities and threats. Based on this theoretically developed model, this study develops three types of organizational agility (i.e., sensing, decision-making and acting agility. Organizational agility was defined as a second-order formative construct consisting of these three first-order agility constructs so that it can fully capture an organization-wide ability to sense and respond to market opportunities and threats. Further, this study develops three types of IT systems that support event management tasks: business intelligence (BI), communication and collaboration (CC), and business resource and process management (BPRM) systems. IT capability is defined as a second-order formative construct consisting of these three first-order IT system constructs so that it can represent full aspects of organization-wide IT capability for supporting event management tasks. This study tests the validity of these constructs using statistical analysis with the collected firm-level field survey data. The second-order constructs of agility and IT capability are multi-dimensional and fully represent the features of organizational ability to manage environmental change.

Third, this dissertation contributes to the IT-enabled agility literature by adding empirical evidence that IT is an enabler of organizational agility and by demonstrating IT indirectly improves firm performance through organizational agility. Using the findings from both fsQCA and PLS analysis, this dissertation empirically showed that IT-enabled organizational agility is the most effective way to achieve competitive performance and innovation leadership. The PLS findings also show the mediating role of organizational agility between IT capability and firm performance.

Fourth, this dissertation contributes to the IT-enabled agility by investigating the detailed relationships between three types of IT systems and three types of agility. The results showed that different types of IT systems play different roles in developing different types of agility. This finding sheds light on the role of IT in organizational sensing and managing market opportunities and threats.

Fifth, this dissertation contributes to the IT-enabled agility by showing a contingency effect of environmental turbulence on IT-enabled agile organizations. It shows that only in hyperturbulent environments, IT-enabled organizational agility is a useful way to achieve competitive advantage.

Last but not least, this dissertation contributes to the IS strategy literature in competitive advantage in turbulent environments. In hyperturbulent environments, competitive advantage cannot be sustained for a long time because the rapidly and unpredictable changing environment makes existing competitive advantage temporary (Brown and Eisenhardt 1997; Eisenhardt 1989; Fine 1998; Mendelson and Pillai 1998), which is gained by rare and valuable resources or a strategic position (Barney 1991; Porter 1980). In such high velocity environments, organizations can survive and thrive only by continually creating a series of temporary competitive advantages and keeping pace with environmental change (Brown and Eisenhardt 1997; Eisenhdardt and Brown 2000; Tanriverdi et al. 2010). This dissertation empirically demonstrates that IT-enabled agility is one of the best ways to quickly sense and respond to market opportunities and threats, and most importantly IT-enabled agility positively influences innovation leadership and firm performance only in hyperturbulent environments.

6.2.3 Implications of Multiple Theoretical Lenses for Complex Systems

This study aims to explore the causal dynamics in digital ecodynamics and investigate the role of IT in enabling organizational agility in turbulent environments. The first goal is to answer the call for developing a better understanding of the holistic nature of digital ecodynamics (El Sawy et al. 2010). The second goal is to empirically investigate linear and additive relationships between IT and organizational agility and firm performance (Sambamurthy et al. 2003) and the contingency effect of environments (Overby et al. 2006; Pavlou and El Sawy 2006). To achieve the goals I adopted two perspectives that are theoretically and methodologically different but complementary to each other: a set-theoretic configurational theory approach and a variance theory approach. As I explained in section 1.5, each approach has its unique features and two approaches together could develop a more complete understanding of the complex messy phenomena from both a holistic perspective and a mechanical perspective. In section 6.1, the findings from both approaches are integrated together to better explain the multifaceted roles of IT, indirect relationships between IT and innovation leadership and firm performance, different roles of IT systems for enhancing agility, and the contingency effect of environments.

6.2.4 Implications of Top Management Team Energy

One of the interesting patterns I found in this study is the critical role of top management team energy in successful transformation to IT-enabled agile organizations. In the results of both fsQCA and PLS analysis, TMT energy has significant relationships with IT capability, organizational agility, innovation leadership and firm performance especially in hyperturbulent environments. While studies of IT implementation in the IS research literature have identified top management team support as a critical success factor for the last thirty years, it has always been conceptualized as support and championing rather than energy and engagement. However, the notion of TMT energy is beyond the concept of support and championing. It implies that top managers are the major actors in the organizational level transformation, not just supporters for the department or division level IT project. The study of the IT-enabled agile organization and its dynamics in hyperturbulent environments brings the notion of TMT energy to the foreground, and there is an exciting research opportunity around understanding more about the causal dynamics of how TMT energy can help harness the power of IT systems for successful organizational transformation to agile enterprises.

6.3 Implications for Practice

This dissertation contributes to practical, managerial knowledge by showing how to transform to the IT-enabled agile organization with minimum costs and risks. The resulting multiple configurations imply multiple alternative paths to a high level of agility, innovation leadership and high performance. Organizations can choose the best path among the alternatives by considering their current conditions. Then, the findings from the variance theory approach help to decide appropriate levels of individual constructs to undergo a transformation through the chosen path.

This dissertation also suggests new perspectives for managers that explain different IT systems play different roles in enhancing different types of agility. BI systems increase sensing and acting agility, and CC systems increase sensing agility. BPRM systems play a complementary role by helping other types of systems, for example by feeding data to BI systems (e.g., data warehouse, digital dashboard, balanced scorecard). Further, this dissertation shows the importance of business environments when organizations choose the best path to achieve high performance. IT-enabled organizational agility is a effective way to achieve competitive advantage only in hyperturbulent environments. Thus, managers need to very carefully consider their business environments and types of IT systems when they invest in information technologies. Organizations in stable environments may not need to invest too much in IT systems, because 1) a high level of IT capability does not necessarily enhance organizational agility, and 2) IT-enabled organizational agility does not necessarily increase firm performance. In stable environments, IT-enabled agility can be costly. On the other hand, in hyperturbulent environments, organizations can benefit from investing in BI and CC systems. BI and CC systems are one of the best ways to develop organizational agility that enable organizations to successfully sense and respond to market opportunities and threats in a timely manner.

6.4 Limitations

This study uses a cross-sectional data set, thus having some issues for capturing causalities between constructs. As a method for the configurational theory approach, fsQCA can relieve this issue somewhat. It is based on set-theory and Boolean algebra and thus can find out necessary and sufficient conditions for the outcome of interest (Fiss 2007, 2011; Ragin 2000, 2008; Rihoux and Ragin 2009). For example, this dissertation finds that TMT energy is a necessary condition for IT capability, agility, innovation leadership, and firm performance. The resulting configurations are sufficient conditions for the outcomes. However, in fsQCA, a configuration of constructs is treated as one predictor for the outcome. On the other hand, PLS analysis is based on correlations to estimate the path coefficients. Therefore, PLS cannot show causality using a cross-sectional data set. For example, the significant relationship between IT capability and agility can mean causality either from IT capability to agility or from agility to IT capability (Sambamurthy et al. 20003). However, the fsQCA results in this study show that IT capability is a core element of configurations of a high level of agility. Since the configurations are a sufficient condition for agility, the relationship between IT and agility can be one-directional causality. While fsQCA can show a one-directional causality from a configuration to the outcome (Fiss 2007, 2011), it cannot show the causalities between the configurational elements. A longitudinal study can more exactly find out the causalities between IT and agility. Further, a longitudinal study with fsQCA can show how one configuration of high performance becomes a configuration of low performance over time and show what makes such change, meaning that fsQCA with longitudinal data can show punctuational, discontinuous, nonlinear change of a system over time.

The sample data for this dissertation were collected from companies in South Korea. Therefore, there is a generalizability issue. The findings from this study may not be extended to other countries that have different country level variations in the key constructs; for example, cultural difference between Korea and other countries can be one issue. Korea has more collectivism than individualism, and more masculinity than femininity (Hofstede 1980; House et al. 2004). So, the findings from this dissertation can be applicable to the countries that have similar cultures. Future research can collect data from other countries and compare their findings with the findings from this study.

6.5 Insights for Future Research

6.5.1 The Multifaceted Role of IT

In the IS literature, there are still disputes about the role of IT as enabler vs. disabler for organizational agility (Lu and Ramamurthy 2011). This dissertation shows that IT can be both an enabler and an inhibitor for organizational agility. Especially in hyperturbulent environments, IT plays a core role in enhancing organizational agility and firm performance. The findings from both fsQCA and PLS analysis show that in stable environments IT is not an enabler for agility, but instead a high level of IT capability should be absent to enhance firm performance. Organizations do not need to rapidly sense and respond to market change in slowly changing environments, so a high level of IT capability to enhance organizational agility can be costly. Further, it showed that different types of IT systems can be either an enabler or an inhibitor, and the same type of IT systems can be an enabler in one context but an inhibitor in the other context.

For example, in Figure 4-7, the configuration 1a and 1b show that BI and BPRM should not exist for a high level of agility when CC systems play a core role. In Figure 4-1, in stable environments IT should not exist to result in high performance. In stable environments, too much investment in IT for environmental event management tasks may be costly. However, when IT systems are an inhibitor, they are peripheral elements in the configurations. So, future research can explore a more strong evidence for the opposing roles of IT as an enabler or an inhibitor for organizational agility by finding IT as core absent element.

Further, fsQCA can be used for finding out how information technologies can enact new environmental change and shape business environments. This study focused on the role of IT from the organizational perspective and did not show configurations of hyperturbulent environments. Future research can explain the role of IT as a shaper for environmental turbulence or as a supporter for adaptation to environmental change.

This dissertation defined organizational agility using a time buffer concept. Every organizational event management task has some amount of time to finish so that it does not affect other tasks dependent on it. Thus, organizations do not need to have high-levels of agility for all tasks, and even a too high level of agility can be costly. Therefore, it can be very fruitful to find out the curvilinear relationship (e.g. inverted U shape) between the level of IT-enabled agility and firm performance (Overby et al. 2006).

6.5.2 Theory for Digital Ecosystems

This dissertation investigates complex, messy phenomena in digital ecodynamics, defined as "the holistic confluence among environmental turbulence, dynamic capabilities, and IT systems—and their fused dynamic interactions unfolding as an ecosystem (El Sawy et al. 2010)." This dissertation focuses on how the interactions among IT, organizational agility, and environmental turbulence result in high performance using both the set-theoretic configurational approach and a variance theory approach. By definition, digital ecodynamics is a process of creating digital ecosystems. Thus, the findings from this dissertation may not be extended to explain the dynamics in the resulting new ecosystems. Current theories in the IS or strategic management literature are mainly based on the premise of linear, additive and incremental change. Thus, such theories cannot effectively explain how organizations can achieve competitive advantage in new digital ecosystem in which changes are more likely to be nonlinear, punctuational (Burgelman and Grove 2007; El Sawy et al. 2010; Meyer et al. 2005).

Thus, future research can benefit from using multiple theoretical lenses for exploring new digital ecosystems (El Sawy et al. 2010; Fiss 2011; Ragin 2008), such as the smart phone ecosystem, that both the practice and the academics do not clearly understand[9].

6.6 Conclusion

Organizational sensemaking and responding to opportunities and threats in turbulent environments are so complex that studies on this topic cut across multiple disciplines including information systems, strategic management, entrepreneurship, and marketing (Ardichvili et al. 2003; Jaworski and Kohli 1993; Sambamurthy et al. 2003; Weick 1999). Using multiple theoretical lenses, this study develops a more complete understanding of the role of information technologies in successful opportunities and threats managements in digital ecodynamics. This study opens the black box of digital ecodynamics and investigates the dynamic interactions among IT, agility, environmental turbulence, and other organizational factors from both a holistic configurational theory perspective and a

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[9] For example, Nokia, the number one mobile phone manufacturer in the world, announced that the company is standing on a burning platform and will create a new strong ecosystem by allying with Microsoft (WSJ - 2011 February) -- http://blogs.wsj.com/tech-europe/2011/02/09/full-text-nokia-ceo-stephen-elops-burning-platform-memo/. But, the existing theories and practical knowledge may not effectively guide how to make the new ecosystem strong.

mechanical variance theory perspective. It discovers the multifaceted roles of information technologies in enhancing organizational agility and firm performance in digital ecodynamics. Further, by showing the possibility of rich theoretical development around digital ecodynamics using multiple theoretical lenses, this dissertation entices future research to advance theories on the role of information technologies in digital ecodynamics.

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APPENDIX: TYPOLOGY OF ENVIRONMENTS

Conceptualiz-ation of Environments (Substantive Area)	Unit of Analysis	Theoretical Constructs	Study	Key Insights
Environmental Change	Industry	Velocity Clockspeed (Pace of Change) Unpredictability (Direction of Change)	Bourgeois & Eisenhardt (1988); Eisenhardt (1989); Davis et al. (2009) Fine (1998); Mendelson & Pillai (1998); Nadkarni & Narayanan (2006b); McCarthy et al. (2010)	In high-velocity environments, meaning the speed at which new opportunities emerge is high or the speed at which new product/process/structure are introduced is high, create critical issues threatening organizational survival. The speed of environmental change determines organizational strategy and structure.
	Industry	Disequilibrium Discontinuity Punctuational	Meyer et al. (2005) Bogner & Barr (2000) Siggelkow & Rivkin (2005)	Environments are always in a state of flux with frequent punctuational discontinuities. Theories and methods for equilibrium environments cannot explain environments in disequilibrium. Non-linear, non-hierarchical, time-paced perspectives and different units of analysis need to be considered together. For example, conventional sense-making does not work but only continual adaptive sense-making can deal with perpetuated hyper-turbulent environments.
	Industry	Velocity Unpredictability Complexity Ambiguity	Davis et al. (2009)	While environmental change is multidimensional, there is little insight within the black box of the environmental dynamism (Davis et. al., 2009). By unpacking the black box, we can understand precisely and in detail the dynamics between environmental change and organizational change.

Conceptualiz-ation of Environments (Substantive Area)	**Unit of Analysis**	**Theoretical Constructs**	**Study**	**Key Insights**
Industry Structure	Industry	Competitive forces Life Cycle Product-differentiation Concentration	Porter (1980) Utterback & Abernathy (1975) Kleper (1995)	Industry structure determines or explains competitive dynamics and influences consequences of what happen. For example, competitive forces determine industry entries and exits, industry life cycle determines entrepreneurial orientation, and industry concentration explains competitiveness.
	Industry	Competitiveness	Schumpeter (1939) D'Aveni (1994) Wiggins & Ruefli (2005)	Environments consist of a gale of creative destruction, or intense and rapid competitive moves, which determine organizations' strategy and structure. These moves become faster over time in all industries.
Cognitive, Social Structure	Group	Cause Map Collective Mind Cognitive Map	Weick (1977) Weick & Roberts (1993) Axelrod (1976)	Top management team's collective understanding of environments represents an organization's environments like conceived uncertainty and speed of change, etc.
		Conceived Clockspeed	Nadkarni & Narayanan (2006a)	
	Industry	Social norm, form, structure	Meyer & Rowan (1977) DiMaggio & Powell (1983)	Isomorphism: to get legitimacy and resource, organizations need to adopt socially taken-for-granted forms.
Network of Organizations and Stakeholders	Organizat-ion Field	Task environments General environments	Daft et al. (1988) Sawyerr (1993) Elenkov (1997) Hall (1982) Osborn & Hunt (1974)	Two levels of organizational environments: task environments (customer, competitor, technology) directly affect organizational tasks, while general environments (economic, regulatory, socio-cultural, political) affect tasks indirectly.
	Organizat-ion	Transaction cost	Williamson (1979)	Interdependent organizations comprise environments and affect individual organizations' strategy and structure.

Conceptualiz-ation of Environments (Substantive Area)	**Unit of Analysis**	**Theoretical Constructs**	**Study**	**Key Insights**
	Network of stakeholders	Boundary Contingency	Miles et al. (1974)	
	Organization Field	(Hyper) Turbulence Interdependency	Emery & Trist (1965) McCann & Selsky (1984)	Different types of environments having different levels of unpredictability in interdependencies among environmental actors determine organizational structure.
Population Ecology and Resource	Industry/ Population	Density Competition Legitimacy Resource	Hannan & Freeman (1984) Hannan et al. (1995)	Environments are explained in terms of the nature and distribution of resources. Industry entries and exits can be explained by the industry density in terms of dynamics between legitimacy, competition, and resource.
	Industry	Munificence Concentration Interconnected-ness	Pfeffer & Salancik (1978)	Environments vary with respect to their levels of munificence (availability of critical resource), concentration (power and authority over resource distribution), and interconnectedness/dependency (number and patterns of linkages between organizations).