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Three Empirical Studies on Digital Innovation Management: New Organizing Logic of Antecedents and Consequences of Innovation

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy in Business Administration with a concentration in Information Systems

by

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Capital University of Economics and Business
Bachelor of Management in Management Information Systems, 2013

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Abstract

In the last decade, innovation has undergone considerable changes in most industries. Digital innovation may represent the use of digital technology in the innovation process or to the end outcome of innovation. Over the years, innovation has become open, global, and collaborative in nature and involves diverse stakeholders and distributed innovation processes (Nambisan 2013; Nambisan et al. 2017). The importance of innovation will continue to grow in the future, as the business environment becomes increasingly uncertain and competitive. With the rapid development of digitized technologies, in addition to innovation outcomes such as new products, platforms, and services, IS researchers have developed an emerging interest in innovation process describing the diffusing, assimilating, or adapting of information technologies in various contexts. As the management of digital innovation becomes more complex and distributed, besides focusing on internal dynamics within firm boundaries, external dynamics also increases in importance. Therefore, this dissertation aims to examine the new organizational logic of digital innovation management, investigating its antecedents and consequences. In particular, Essays 1 and 2 examine internal dynamics, emphasizing the impact of key antecedents such as IT diversification, business diversification, IT-enabled capabilities, and business strategy. Essay 3 goes further to shed light on external dynamics of IT infrastructure governance and environmental uncertainty on the relationship between innovation and firm performance.

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INTRODUCTION

ESSAYS 1 AND 2: INTERNAL DYNAMICS

Innovation management is an essential component of a firm's business strategy, and its importance will continue to grow, as the market environment becomes increasingly unpredictable and competitive. By enabling and facilitating the management of innovation knowledge (Thomke 2006), innovation production (Sudarsan et al. 2005; Thomke 2006), and external innovation collaboration (Chan et al. 2007; Thomke 2006), it is evident that information technologies have improved the speed and efficiency of firm innovation. Hence, there has been significant interest in the effective management of information technology investments (e.g.,Datz 2003; Jeffery and Leliveld 2004), especially in the realm of innovation management. Motivated by the need to advance our understanding of how information technology management may facilitate innovation creation, Essays 1 and 2 aim to examine the internal dynamics of IT, its complementary business factors, and their joint impact.

IT investment has been a significant portion of capital budgets in many modern organizations. Modern organizations recognize that they have portfolios of IT assets (e.g., applications, projects, and infrastructure). Each component of the portfolio serves a different purpose to support strategic business goals, such as to facilitate product innovations. For multi unit firms, the variance across business units' IT portfolio collectively reflect a firm's diversification in managing its IT infrastructure and application investment. Prior literature on IT-innovation topic tends to treat the information technology as a whole (e.g.,Kleis et al. 2012), without further differentiating individual IT components. Thus, Essay 1 first aims to understand the question: *whether the diversification of a firm's overall IT portfolio would facilitate its innovative creation?* In the broad literature of diversification, business diversification as a firm

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level strategy has been studied to some extent in the broad management literature as a source of competitive advantage (e.g., Gao et al. 2010; Ghoshal 1987; Hitt et al. 1994; Stern and Henderson 2004; Tanriverdi and Lee 2008). While technical and product knowledge are very different as they are originated in different stages of the value chain (Heely and Matusik 2004), some scholars have documented that technological diversification and business product diversification may influence each other (e.g., Granstrand et al. 1997). Thus, in Essay 1, we also wish to investigate the joint impact of IT portfolio and business diversification on firm innovation.

Besides the actual tangible IT assets, capabilities enabled by such IT tools are also valuable organizational assets to create sustained competitive advantage. Information technologies (IT) are increasingly being embedded into innovations. Because of the unique characteristics of enabling ITs, i.e., malleable, editable, open, transferable, etc. (Yoo et al. 2010), innovation has become a much less well-bounded phenomenon, often involving a diverse network of actors, such as customer, suppliers, and even rivals (Han et al. 2012; Nambisan et al. 2017). As a result, the management of innovation starts to involve those external actors, and information technologies have emerged as one key tool to facilitate such involvement. Thus, in Essay 2, we first identify two unique IT-enabled capabilities, i.e., analytical information processing capability (AIPC) (Saldanha et al. 2017) and external information integration capability (EIIC), and ask how these specific IT-enabled capabilities may influence innovation creation. Similarly, Essay 2 also utilizes a dual view of the IT-Business relationship. Leveraged upon Miles and Snow (1978) typology, this essay plans to demonstrate that in the context of innovation management, different capabilities are more beneficial for a specific type of firm, depending on their underlying strategy.

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ESSAY 3: EXTERNAL DYNAMICS

Innovation is a key factor that plays an important role in continuously providing competitive advantages and survival of firms of all sizes and in every industry in an ever-changing environment (Tushman and O'Reilly 1996; Utterback 1994). While for some researchers, innovation outcome is the endpoint of their quest chain, establishing the link between such innovation outcomes and organizational performance is also crucial as it reveals how innovation creates business value. Prior literature has proposed that firms need to require the right set of organizational factors that include strategy arrangement and planning, resources, and skills to successfully exploit entrepreneurial spirit to improve innovation performance (Ireland et al. 2009). One of those major managerial levers that enable innovation is governance management (Crossan and Apaydin 2010), or in particular, IT governance management. In addition, innovation has become much more open, global, and collaborative in nature (Nambisan 2013; Nambisan et al. 2017), and that investigations on the external market environment are warranted. In addition, literature has suggested that environmental uncertainty is often intertwined with the management of IT governance (e.g., Brown and Magill 1994; Xue et al. 2011). As innovation is becoming increasingly digitized and less well-bounded (Nambisan 2013; Nambisan et al. 2017), managers are constantly facing the challenge of applying the most effective IT governance mode in uncertain market environments to facilitate innovation creation. Thus, Essay 3 argues that both IT governance and environmental uncertainty serve as potential moderators of the relationship between innovation and firm performance, and a curvilinear relationship will be present to influence such relationship.

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REFERENCES

Brown, C. V., and Magill, S. L. 1994. "Alignment of the IS Functions with the Enterprise: Toward a Model of Antecedents," *MIS Quarterly* (18:4), pp. 371-403.

Chan, T., Nickerson, J. A., and Owan, H. 2007. "Strategic Management of R&D Pipelines with Cospecialized Investments and Technology Markets," *Management Science* (53:4), pp. 667-682.

Crossan, M. M., and Apaydin, M. 2010. "A Multi-Dimensional Framework of Organizational Innovation: A Systematic Review of the Literature," *Journal of Management Studies* (47:6), pp. 1154-1191.

Gao, G., Gopal, A., and Agarwal, R. 2010. "Contingent Effects of Quality Signaling: Evidence from the Indian Offshore It Services Industry," *Management Science* (56:6), pp. 1012-1029.

Ghoshal, S. 1987. "Global Strategy: An Organizing Framework," *Strategic Management Journal* (8:5), pp. 425-440.

Granstrand, O., Patel, P., and Pavitt, K. 1997. "Multi-Technology Corporations: Why They Have Distributed Rather Than Distinctive Core Competencies," *California Management Review* (39:4), pp. 8-25.

Han, K., Oh, W., Im, K. S., Oh, H., Pinsonneault, A., and Chang, R. M. 2012. "Value Cocreation and Wealth Spillover in Open Innovation Alliances," *MIS Quarterly* (36:1), pp. 291-315.

Hitt, M. A., Hoskisson, R. E., and Ireland, R. D. 1994. "A Mid-Range Theory of the Interactive Effects of International and Product Diversification on Innovation and Performance," *Journal of Management* (20:2), pp. 297-326.

Ireland, R. D., Covin, J. G., and Kuratko, D. F. 2009. "Conceptualizing Corporate Entrepreneurship Strategy," *Entrepreneurship Theory and Practice* (33:1), pp. 19-46.

Jeffery, M., and Leliveld, I. 2004. "Best Practices in IT Portfolio Management," *MIT Sloan Management Review* (45:3), pp. 41-49.

Kleis, L., Chwelos, P., Ramirez, R. V., and Cockburn, I. 2012. "Information Technology and Intangible Output: The Impact of It Investment on Innovation Productivity," *Information Systems Research* (23:1), pp. 42-59.

Miles, R. E., and Snow, C. C. 1978. Organizational Strategy, Structure and Process. New York: McGraw-Hill Book Company.

Nambisan, S. 2013. "Information Technology and Product/Service Innovation: A Brief Assessment and Some Suggestions for Future Research," *Journal of the Association for Information Systems* (14:4), pp. 215.

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www.manaraa.com

Nambisan, S., Lyytinen, K., Majchrzak, A., and Song, M. 2017. "Digital Innovation Management: Reinventing Innovation Management Research in a Digital World," *MIS Quarterly* (41:1), pp. 223-238.

Saldanha, T. J., Mithas, S., and Krishnan, M. S. 2017. "Leveraging Customer Involvement for Fueling Innovation: The Role of Relational and Analytical Information Processing Capabilities," *MIS Quarterly* (41:1), pp. 276-A11.

Stern, I., and Henderson, A. D. 2004. "Within-Business Diversification in Technology-Intensive Industries," *Strategic Management Journal* (25:5), pp. 487-505.

Sudarsan, R., Fenves, S. J., Sriram, R. D., and Wang, F. 2005. "A Product Information Modeling Framework for Product Lifecycle Management," *Computer-Aided Design* (37:13), pp. 1399-1411.

Tanriverdi, H., and Lee, C.-H. 2008. "Within-Industry Diversification and Firm Performance in the Presence of Network Externalities: Evidence from the Software Industry," *Academy of Management Journal* (51:2), pp. 381-397.

Thomke, S. H. 2006. "Capturing the Real Value of Innovation Tools," *MIT Sloan Management Review* (47:2), pp. 24.

Tushman, M. L., and O'Reilly, C. A. 1996. "Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change," *California Management Review* (38:4), pp. 8-29.

Utterback, J. 1994. Mastering the Dynamics of Innovation: How Companies Can Seize Opportunities in the Face of Technological Change. Cambridge, MA: Harvard Business School Press.

Xue, L., Ray, G., and Gu, B. 2011. "Environmental Uncertainty and It Infrastructure Governance: A Curvilinear Relationship," *Information Systems Research* (22:2), pp. 389-399.

Yoo, Y., Henfridsson, O., and Lyytinen, K. 2010. "Research Commentary—the New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research," *Information Systems Research* (21:4), pp. 724-735.

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IT PORTFOLIO DIVERSIFICATION, BUSINESS DIVERSIFICATION, AND INNOVATION

INTRODUCTION

Contemporary organizations are using many and different information technologies (ITs), aiming to improve business outcomes, maintain ongoing projects, and support transformation initiatives. IT investment has been a significant portion of capital budgets. However, some researchers question the business value of IT (Carr 2003), and that the contributing role of IT on organizational performance is an enduring subject of research (e.g., Chae et al. 2014; Devaraj and Kohli 2003). Hence, there has been significant interest in unraveling ways for effective management of information technology investments (e.g., Leliveld and Jeffrey 2004). Firms are keen to know how to manage a portfolio of ITs for maximum performance (e.g., innovation) to avoid over investments in a more diverse portfolios of IT assets (e.g., applications, projects, and infrastructure).

For multi-unit firms, limited IT resources may be distributed based on a given business unit's strategic needs. As a result, the variance across business units' IT portfolio collectively reflects a firm's diversification in managing its IT infrastructure and application investment. However, firms are struggling with developing proper IT portfolios that allow them to get better business outcomes, such as improved innovativeness. Despite the enduring discussion on IT impacts, there is a lack of deep understanding on what portfolio of ITs an organization should implement.

While answering this question, IS scholars face the challenge that technology-driven innovation in organizations is a highly complex phenomenon. Innovation is a key contributor to a firm's competitive success. Benefits brought by both product innovations, such as earning

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abnormal profits that could afford entering into new market segments (Agarwal and Bayus 2002), and process innovations, such as creating new cost-efficient methods of performing business routines (Baily and Chakrabarti 1988; Dougherty and Hardy 1996), may motivate firms to invest more into the innovation process. Meanwhile, IT has been identified as an enabler as well as a trigger of innovations (Nambisan and Baron 2013). Prior research has identified information technology as a potential key contributor to firm innovation efforts. For example, Han and Ravichandran (2006) show evidence of an indirect IT-innovation relationship through the interaction of R&D and IT while Kleis et al. (2012) empirically report that IT capital has a positive and significant effect on innovation knowledge output. Together with other studies (e.g., Dodgson et al. 2006; Thomke 2006), the collective evidence suggests that through the management of knowledge assets, production support, and inter-organizational coordination, ITs have improved the speed and efficiency of firm innovation. Despite all supporting evidence of IT's capability to facilitate innovativeness, innovation remains a costly and risky endeavor. One estimate puts the failure rate of new product at as high as 40% (Castellion and Markham 2013). Does it suggest, then, information technology has minimum influence on boosting firm innovations, or should firms stop investing on related ITs?

Focusing on multiunit firms, I argue that IT portfolio management at the business level matters for managing innovation efforts. More specifically, I argue that the firm's IT portfolio diversification reflected in the variance of IT infrastructure and application investment across business units facilitates innovation. With the increasing complexity of the competitive market, firms need to expand to include more functionally, sometimes even geographically diverse business units. Former studies on the relationship between IT and innovation tend to treat organizational IT as a whole (e.g., Kleis et al. 2012; Han and Ravichandran 2006; Ravichandran

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et al. 2017), but failed to consider the diversification of IT resource allocation within a given organization. In this study, I define information technology portfolio diversification at the organizational level as a degree of heterogeneity in business units' portfolio of IT infrastructure and application investment. Since the role and relevance of IT in any innovation are thereby expanding (Nambisan 2013), it remains instrumental for information systems (IS) researchers as well as practitioners to address the question: whether the diversification of a firm's overall IT portfolio would facilitate its innovation outcomes?

Prior diversification literature has focused only on product diversification (e.g., Hitt et al. 1994; Stern and Henderson 2004; Tanriverdi and Lee 2008) and general technological diversification (e.g., Garcia-Vega 2006; Quintana-García and Benavides-Velasco 2008). Both literature streams emphasize the notion of expansion: expansion of business lines and expansion of technology base, respectively. Subsequently, the resulted diversification can be managed as an effective innovation strategy, often realized through R&D advancement and acquisition. In IS literature, although this concept has been extensively situated in workgroups and general corporate management contexts (e.g., Garcia-Vega 2006; Ghoshal 1987; Harrison and Klein 2007; Hitt et al. 1994; Horwitz and Horwitz 2007; Quintana-García and Benavides-Velasco 2008; Stern and Henderson 2004; Tanriverdi and Lee 2008; Van Knippenberg and Schippers 2007), I am specifically interested in revealing the impact of information technology, rather than business product or service, diversification on firms. However, little systematic examination of information technology (IT) related diversification, rather than general business or technological diversification, and its impact on innovation has emerged. For example, Carlo et al. (2012) revealed the positive indirect impact of IT knowledge diversity on innovation level through technology sensing and experimentation. To advance our understanding of IT portfolio

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diversification, I aim to examine its direct impact on a firm's innovation capability by considering business unit level variance of IT resource allocation.

As aforementioned, business diversification as a firm-level strategy has been studied to some extent in the broad management literature as a source of competitive advantage. Researchers are especially interested in investigating the link between corporate diversification and firm performance (e.g., Gao et al. 2010; Ghoshal 1987; Hitt et al. 1994; Stern and Henderson 2004; Tanriverdi and Lee 2008). What's more, prior literature has shown a correlation between business diversification and innovation outcomes and seemed to suggest that business concentration, rather than diversification, enhances innovation (e.g., Grabowski 1968; Teece 1980; Gort 1962; Scherer 1984). Since business diversification may also influence innovation, I also consider its combined effect with IT portfolio diversification on firm innovation outcome.

The remainder of the paper is organized as follows. First, research on diversification and innovation is reviewed. Next, I formulate a moderation model for innovation with associated hypotheses. The model is then validated by a three-year panel analysis on 1,137 unique firms. Finally, the paper concludes with a discussion of main findings, limitations, and potential contributions and implications for future research.

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LITERATURE REVIEW

Diversification

Diversity, or diversification, has been studied in various disciplines including sociology, psychology, organizational behavior, and IS strategy from both theoretical and empirical perspectives (Van Knippenberg and Schippers 2007). Within the IS literature, the concept of diversity has been mostly situated in groups as well as business firms. Therefore, we provide a broad review of these two contexts.

Diversification in Groups

Although being defined and operationalized in various ways, researchers agree that in essence, diversification in groups emphasizes members' differences (Harrison and Klein 2007). In the past few decades, empirical literature has focused on the top of workgroup diversity, i.e., to understand differences among a predefined and bounded collection of individuals with specific goals and tasks (Van Knippenberg and Schippers 2007). Interesting conclusions have emerged from the literature. First, both positive and negative outcomes have been yielded because of the examined heterogeneity among members (Williams and O'Reilly III 1998) as such heterogeneity could bring both greater creativity and yet conflict (e.g., Peters and Karren 2009; Kankanhalli et al. 2006). Second, the literature has shown results in different aspects of diversity. Studies have documented inconsistent results, i.e., the same diversity aspect may lead to positive effects in one study, but negative effects in another (Harrison and Klein 2007). Also, task-related diversity and demographic diversity tend to have impacts on a different set of outcomes (Horwitz and Horwitz 2007). Last, the conceptualization of diversity encompasses many attributes and dimensions of a group.

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Diversification in Firms

Diversification, as a firm-level strategy, has been studied to some extent in the literature as a source of competitive advantage. Researchers are especially interested in investigating the link between corporate diversification and firm performance. More specifically, the literature has documented the impact of various types of diversification, such as international diversification (e.g., Ghoshal 1987; Hitt et al. 1994), production diversification (e.g., Hitt et al. 1994; Stern and Henderson 2004; Tanriverdi and Lee 2008), and service diversification (e.g., Gao et al. 2010). In essence, diversification heavily emphasizes expansions. Firms may expand across country boundaries as well as into new product and service markets.

Similar to the context of workgroups, in general, the findings of the impact of diversification on businesses are also equivocal. Wernerfelt and Montgomery (1988) find that focused firms outperform diversified firms while Villalonga (2004) show that diversification indeed could contribute to better firm performance. Later, more nuanced results on the effects of related diversification and unrelated diversification emerged. Related diversification is argued to be more desirable as it allows resource sharing across different functional areas as well as distinct businesses. For example, Stern and Henderson (2004) extend this argument by articulating that the relationship between within-business diversity and survival is contingent on some environmental changes caused by a firm's competitors. Firms that invested in product lines and markets that are similar to the focal firm's current strategy portfolio achieved higher profits. Tanriverdi and Lee (2008) show that market-related diversification and platform-related diversification in the context of software industry were compliments in enhancing the firm's sales and market share.

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Despite the direct impact on firm performance, several researchers also noted that diversification achieved by introducing new products is also a primary vehicle for innovation, particularly in technology-intensive settings (e.g., Eisenhardt and Tabrizi 1995; Tushman and Anderson 1986). For example, Hitt and his colleagues (1994) report that, by entering new international markets as well as investing in diverse products, firms may experience a higher level of innovativeness, so that they achieve a potential sustained competitive advantage, besides gaining profits. In the current study, we define business diversification as a degree of heterogeneity that reflects the variety of product lines in a firm's business product portfolio.

Information Technology Diversification

Although the concept of diversification, or diversity, has been extensively studied in workgroups and general corporate management contexts, we are specifically interested in revealing the impact of information technology, rather than business product or service, diversification in firms, which is understudied especially in IS literature. However, a similar concept, i.e., technological diversification, has also emerged and is worth mentioning first.

Technology diversification, in contrast to general business product diversification, has attracted interest among research since the 1990s. Over the last few decades, both researchers and practitioners have witnessed technology-related diversification due to increases in the complexity of products (e.g., Breschi et al. 2003). It is related to a corporation's expansion of its technological competence into a broader range of technical and discipline areas (Granstrand and Oskarsson 1994), although such expansion does not necessarily have to be associated with product diversification (Granstrand et al. 1997). Examining at the firm level, some researchers report insights into the relationship between technological diversification and some organizational dimensions, such as size, product diversification or corporate internationalization

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(Cantwell and Piscitello 2000; Piscitello 2000, 2004). On the theoretical grounds, technology diversification proceeding coherently at the firm level leads to increased sales, so that boosts firm performance (e.g., Granstrand 1998). Because of that, the notion of "multi-technology corporation" has emerged, articulating the strategy of operating in three or more broad technologies (e.g., Granstrand and Oskarsson 1994). Some studies have shed light on the correlation between technological diversification and organization innovation (e.g., Garcia-Vega 2006; Quintana-García and Benavides-Velasco 2008). Among these studies, the central theme is that diversification of the technology base enhances R&D intensity and the number of patents. For example, Quintana-García and Benavides-Velasco (2008) provide strong support for the premise that a diversified technology portfolio positively and significantly affects a firm's competence to innovate. Moreover, by examining registered patents, they took a step further to demonstrate that introducing new technologies into the firm's technology system favors the search for complementarities and novel solutions that increase the rate of invention.

Although with similarities, IT diversification is distinct from general technological diversification. First, the former does not emphasize the notion of expansion but instead, concentrating on the range of knowledge of endowment and the variance of IT resource use. Second, while technological diversification examines the complementarity of different technological competencies, IT diversification unravels the homogeneity/heterogeneity of IT infrastructure and applications domains only. Despite being a unique stream, little attention has been paid to IT-focused diversification and its impact on organizational performance, such as innovation, in IS literature. Some attempts have been made, however, to touch upon this topic. For example, Carlo et al. (2012) adopt the lens of absorptive capability to explain how a software firm's knowledge endowments influence its level of radical information technology innovation

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by examining key IT knowledge dimensions, such as knowledge diversity. They conclude that knowledge diversity positively influences the level of sensing and experimentation, which positively influences the level of base innovation while knowledge diversity does not directly influence base innovation. Also, Tanriverdi (2005) proposed the notion of IT relatedness, defined as the use of common IT infrastructure and common IT management processes across business units. They conclude that mediated by knowledge management capability, the relationship between IT relatedness and firm performance is positive and significant, after controlling for relatedness business diversification. Extending the existing literature, we aim to examine a corporate level IT portfolio diversification by collectively considering its business units' IT resource arrangement and how such diversification, both independently and jointly with business diversification, would influence the level of innovation. Table 1 summaries representative studies that investigate diversification at the organization level.

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Table 1. Organization Level Diversification Constructs[1]

Variable	Definition	Example Study
Business Diversification		
Product diversification • Related diversification • Unrelated diversification	The expansion into product markets new to the firm	Hitt et al. 1994 Wernerfelt and Montgomery 1988 Stern and Henderson 2004 Tanriverdi and Lee 2008 Villalonga 2004
International diversification	The expansion into international product markets new to the firm.	Ghoshal 1987 Hitt et al. 1997
Service diversification	The IT specializations that the vendor firm offers	Gao et al. 2010
R & D diversification	Firm-level investment in different technical fields	Argyres 1996
Technical Diversification		
Technological diversification	The corporation's expansion of its technological competence into a broader range of technological areas	Breschi et al. 2003 Cantwell and Piscitello 2000 Garcia-Vega 2006 Granstrand 1998 Granstrand et al. 1997 Granstrand and Oskarsson 1994 Piscitello 2000 Piscitello 2004 Quintana-García and Benavides-Velasco 2008
IT knowledge diversification	The degree of heterogeneity of knowledge related to the base and IT services	Carlo et al. 2012

[1] This table is not exhaustive and lists only new representative empirical studies on IT-innovation relationship to show the relevance and novelty of the current study.

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Innovation and Information Technology

Innovation cannot separate from technology. By definition, digital innovation is the use of digital technology during the process of innovating. In the last decade, the nature of innovation has undergone considerable change in most industries. Innovation has become much more open and collaborative in nature to involve a diverse network of partners (Chesbrough 2003; Sawhney and Nambisan 2007). Information technologies are becoming increasingly instrumental as they are being embedded in a wide range of new products and services. Nambisan (2013) provided a brief assessment of the pivotal role of IT in creating innovation. Being used as either an operand or operant resource, IT serves as key enabler or trigger, respectively. Further, it is evident that the extant studies on IT and product/service innovation have largely focused on the role of IT as an operand resource (Nambisan 2013). Also, it is imperative to differentiate IT's impact on innovation processes and that on innovation outcomes. Innovation processes examine tasks and activities related to product/service development while innovation outcomes focus on the functionalities associated with a new product or service. Therefore, in the current study, IT is treated as a tangible and static resource that an actor acts on to obtain support for executing a task. We focus only on product innovation outcomes and define innovations as novel knowledge representations embedded in a firm's inventions, discoveries, and other forms of developed ideas that precede actual commercialization (Joshi et al. 2010).

In the context of a multi-unit/multi-business firm, it is critical to note the importance of cross-unit management as within-unit management does not suffice to justify why individually well-performed business units should exist under the governance of a corporate parent rather than as separate firms in the market. Cross-unit management seeks to create cross-unit knowledge synergies and make the joint value of the corporation greater than the sum of the

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values of the individual businesses (Tanriverdi and Venkatraman 2005). As information technology contributes to the knowledge management and enables cross-unit coordination between the headquarter and other business units in innovation production, it is worth investigating each business unit level IT portfolio and the variance across such IT arrangements. Table 2 presents key constructs and their respective definition.

Table 2. Key Constructs

Construct	Definition
IT portfolio diversification	A degree of heterogeneity in business units' portfolio of IT infrastructure and application investment.
Business diversification	A degree of heterogeneity that reflects the variety of product lines in a firm's business product portfolio.
Innovation	Novel knowledge representations embedded in a firm's inventions, discoveries, and other forms of developed ideas that precede actual commercialization (Joshi et al. 2010).

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RESEARCH MODEL

IT Portfolio Diversification and Innovation

Firms diversify their technological base are likely to benefit from new technological possibilities (Nelson 1959). What's more, technologically diversified firms may invest more in R&D, because the diversification reflected in the portfolio tends to reduce the risks inherent in the R&D projects (e.g., Garcia-Vega 2006; Quintana-García and Benavides-Velasco 2008). Thus, a firm with more IT-diversified business units may be more inclined to participate in innovation projects as the perceived risk is reduced. Also, the literature suggests that maintaining positions in a diverse range of technologies is essential (e.g., Dosi 1982; Nelson and Winter 1982). Because most innovations tend to address unrelated issues, companies that have more diversification in business unit level IT portfolios may capture more opportunities and technical possibilities to benefit largely from their research activities (Nelson 1959). IT diversification may also enlarge a firm's knowledge base. The application of diversified information technologies provides the links necessary for effective information sharing and reduces transaction costs that arise when multiple innovation units work together (Brockhoff 1992; Dodgson et al. 2006; Thomke 2006). Also, access and exposure to a variety of new and alternative technological knowledge domains influence a firm's propensity to transform knowledge and find new ways in which existing problems can be solved. The resulting ability to search for complementarities and novel solutions accelerates the rate of invention.

On the contrary, the repeated application of a particular set of technologies eventually exhausts the set of potential combinations. As evidence, several scholars have suggested that achieving knowledge diversity catalyzes radical innovation (e.g., Carlo et al. 2012; Shenkar and Li 1999). It is also considered that innovative asset creation by developing competencies such as

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new technological fields promotes the capacity to produce a more radical product and process innovation (Christensen et al. 2000). In other words, adding new knowledge to the firm's repertoire is important for its continuity in innovation creation and the mitigation of path dependencies.

Compared with rooted in a narrower scope, research projects orginiated within a more diverse development effors and IT knowedge is significantly more likely to result in inventions. By analyzing U.S. biotechnology patents applied between 1990 and 1998, Nesta and Saviotti (2005) suggest that the scope of the knowledge base contribute positively to innovation performance. Enforcing standardized IT portfolio may result in technology rigidities, causing an oversupply in some technological categories, or undersupply that diminishes subsequent IT-enabled innovation capabilities. Thus, maintaining a diverse IT portfolio is easier to exploit cross-unit synergies and explore or share new technological competencies that are crucial for realizing innovations. Thus, I hypothesize

H1: IT portfolio diversification has a positive impact on a firm's innovation outcome.

IT Portfolio Diversification, Business Diversification and Innovation

Besides IT diversification, prior literature also reported business/product diversification as one of the driving forces of innovation. Prior empirical studies investigating the relationship between diversification and innovation at the organization level is mostly based on product diversification measures; some even use such measures as proxies to general technological diversification. These studies have shown some correlation between product diversification and different measures of innovation, such as R&D intensity (Grabowski 1968; Teece 1980), the number of technical workers (Gort 1962), or the number of patents (Scherer 1984). Some

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researchers have made a further attempt to discuss that multiple types of diversification may jointly affect innovation. As an example, Fai and Von Tunzelmann (2001) find that historically, product diversification and patent were more directly related than in recent times and that is possibly due to the growing complexity and interdependence of the technologies. In essence, product diversification and technological diversification, and also IT diversification, are not the same. This is because technical and product market knowledge are different since they are originated in different stages of a value chain (Heeley and Matusik 2004). Thus, it is evident that business and IT diversification have different impacts on firm performance.

As argued above, to archive a better innovation outcome, a higher IT portfolio diversification is more desirable for enabling capabilities to facilitate knowledge assimilation and transformation. The resulting IT knowledge stocks help mitigate competency trap (Augier and Vendelo 1999), and subsequently lead to a potential gained from a wider range of ITs that can support new invention ideas, new functionalities, and increased productivity (Granstrand 1998). However, it may not be the case with business diversification. A higher business diversification implies a low level of knowledge homogeneity at a firm level. The more distant the knowledge bases, the more organizational resources are needed to create synergies and attempts to integrate islands of knowledge (Augier and Vendelo 1999). Firms are also likely to encounter information process limits (Hitt et al. 1996). Increasing bureaucratic costs are also associated with competition between divisional management for resources. What's more, without a solid business coherence, a firm's innovative resources and competence are scattered in different unrelated technologies field that a required common knowledge base to promote coordination and joint effort is absent. Although its ability to foster knowledge assimilation and transformation is agreed upon, a higher IT diversification portfolio is not able to easily mitigate

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the drawback of knowledge heterogeneity, resulted from high business diversification. Thus, I hypothesize,

H2: Jointly, IT portfolio diversification and business diversification have a negative impact on innovation outcome.

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METHOD

Data and Sources

To empirical test the model, I collected and compiled secondary data from several sources. I obtained IT data from the Computer Intelligence Infocorp (CI) data between 2005 and 2007. CI collects business unit-level data annually on the quantity of IT infrastructure in firms using surveys, site visits, physical audits, and telephone interviews initially at the site-level. The CI data have been widely used by IS scholars (e.g., Brynjolfsson et al. 2002; Kleis et al. 2012; Melville et al. 2007; Xue et al. 2011). All business units belong to large, multi-divisional companies. Primary firm-level patent citation data was obtained from Kogan et al. (2017) between 2008 and 2010. Financial and industry control information was obtained from the Compustat database.

As the theoretical population for this study is firms that actively engage in patenting, I carefully examined the data to exclude firms from industries that do not have a history of systematic parenting practice. Consistent with the literature, I dropped firms from several industries such as utilities, wholesale, retail, entertainment and recreation, and other services (e.g., Joshi et al. 2010; Saldanha et al. 2017; Ravichandran et al. 2017). The original sample before screening and the sample retained after the selected industries do not appear to be significantly different regarding the key firm characteristics.

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Variables

Innovation[2]*:* Innovation is novel knowledge representations embedded in a firm's inventions, discoveries, and other forms of developed ideas that precede actual commercialization (Joshi et al. 2010). I measure firm innovation using citation-weighted patent count. In specific, forward citation measures the number of times a patent is cited by later patents and thus reflects the impact and quality of innovations (e.g., Hall et al. 2001) Compared with other measurements, such as patent counts and trademark counts, citation count method is better in distinguishing the variability in patent quality (Hall et al. 2002). However, this measurement may suffer from truncation and inflation bias because, at any point in time, the data only reflects citations received up to that point in time (Hall et al. 2005).

Inflation may be addressed by the fix-effects benchmarking to standardize the citations across both year and technical field (Hall et al. 2001). However, as suggested by Kleis et al. (2012), it is more desirable to retain a level of variations among technical fields. Therefore, following their suggestion, raw citations are adjusted by dividing a given patent's citation counts received and by the corresponding year-field mean. This converts the citation data from a count into a continuous measure. Despite that, the adjusted citation data still resembles a count variable because of the presence of many zeros (Ravichandran et al. 2017). As Hall et al. (2002) suggest that at least a two-year lag for patent application processing should be observed, I run the analyses using patent citations that had issue dates three years subsequent to the IT data (i.e., 2008-2010) to incorporate a lag from inputs to outputs (e.g., Kleis et al. 2012). The vintage effect is unlikely to cause bias because all patents only have at most three years of a period to accrue.

[2] Prior studies also used patent count as a major measurement of innovation (e.g., Joshi et al. 2010; Saldanha et al. 2017). To access robustness, I employed this measurement and obtained similar results.

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It is worth mentioning that theoretically, the innovation captured in this study is more inclined to ideated rather than commercialized innovation (Joshi et al. 2010). In other words, I did not further consider if a particular patent would be successfully converted into a commercial application any point in the future. Previous studies did agree that there is a positive relationship between the propensity of firms to apply for patents and their innovation activities (Mairesse and Mohnen 2004; Ramirez and Kleis 2010).

IT portfolio diversification. IT portfolio Diversification is defined as the degree of heterogeneity in business units' portfolio of IT infrastructure and application investment. IT data was obtained from CI annual survey from 2005 to 2007. I classified cite-level IT installations based on CI's five topic areas: 1) hardware; 2) software; 3) storage; 4) networking; and 5) telecom (see Appendix A for more details). Every firm's IT portfolio diversification value was calculated as follows. First, within site, for each subcategory, I counted the total amount of variations and calculated the diversification value as ratios, i.e., amount of present variations/number of variations possible. For each category, I calculated the average diversification value. I then averaged again to get a single diversification value for a specific site. Finally, I calculated the firm-level diversification value as a weighted average by site employee number. I used a formula of IT portfolio diversification as

$$IT\ portfolio\ diversification = \frac{1}{p} \cdot w_k \sum_{k=1}^{p} \left[\frac{1}{5} \cdot \sum_{j=1}^{5} \left(\frac{1}{n} \cdot \sum_{i=1}^{n} \frac{e_i}{T_i} \right) \right]$$

where e is the actual number of installed variations of a subcategory; T is the number of possible variations of a subcategory; n is the number of possible subcategories of a technology category;

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w is the ratio of site employee number to firm employee number; p is the number of sites of a firm[3].

Business portfolio diversification. This degree of diversification describes the aggregate number of products in a firm's primary business line. I utilized the entropy measure of product diversification as

$$\sum i\,[P_i \times \ln(1/P_i)]$$

where P_i is the sales attributed to segment i and $\ln(1/P_i)$ is the weight given to each segment (e.g., Hitt et al 1997). The measure considers both the number of segments in which a firm operates and the proportion of total sales each segment represents.

Control variables. Size, measured by a firm's total asset, was used to account for the scale of resources (Bharadwaj et al. 1999). I controlled a group of financial characteristics, such as R&D expense, controlling for research investment; Tobin's q, controlling for business growth opportunity; ROA (Return of assets), controlling for profitability; firm tenure, measured by the length of time, in years, CRSP database records the stock price data of a given firm; and organization liquidity. I also accounted for the environmental turbulence effect. Industry sector dummies are used to represent the industry sector to which the firm belongs.

After I matched firms across the data sets and dropped incomplete observations, the final sample consisted of 1,930 observations of 1,137 unique firms. About 11% appear once, 21% appear twice, and 68% appear three times. Table 3 shows more details of the sampled firms. Table 4 shows the descriptive statistics of and the correlation among the variables. Both IT

[3] I also measured IT portfolio diversification using four categories, excluding hardware. The results were statistically similar.

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diversification and business diversification have positively significant correlations with the adjusted patent counts. It is noted that the mean average adjusted patent citation counts per firm per year seem very low (0.33). There is a possible explanation. Based on statistics provided by USPTO, it usually takes 2-3 years for examiners to issue a patent. I observed the same pattern in the sampled dataset. Therefore, there are apparent lags between filing dates and issue dates. For example, a patent issued in 2010, which is the last year of the data coverage, would only have at most one year of future citations being recorded. Likewise, a patent issued in 2008 would only have at most three years of future citations being recorded by the dataset.

I took several additional steps to assess robustness. First, the variance inflation factors were well within acceptable limits, suggesting that multicollinearity is not a problem. Moreover, the correlations between variables are well below the threshold of 0.80, suggesting evidence of discriminant validity (Bagozzi et al. 1991; Mithas et al. 2008; Saldanha et al. 2017). Second, because the independent, dependent, and control variables are from different sources and the innovation variable is objective (not perceptual), this mitigates concerns of common method bias.

Table 3. Firm Descriptive Statistics

Variable	Mean	StdD	Median	Min	Max
Sales (Million $)	3,595.623	8,423.216	1,043.524	<1	157,333
Employee (log)	7.948	1.717	7.979	<1	13.050
Total Ssset (log)	7.054	1.937	7.082	1.687	14.598
Market Value Equity (log)	7.086	1.918	7.222	<1	12.160

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Table 4. Correlations and Descriptive Statistics

		1	2	3	4	5	6	7	8	9	10
1	Average adjusted patent citation counts per firm per year	-									
2	IT diversification	0.057	-								
3	Business diversification	0.068	0.095*	-							
4	Log of total asset	0.08*	0.03	0.27*	-						
5	Tobin's q	0.13*	-0.06*	-0.05	-0.06*	-					
6	Return on assets	0.01	-0.02	0.10*	0.18*	0.20*	-				
7	R&D expenditure to total assets	0.19*	0.04	-0.06*	-0.19*	0.28*	-0.28*	-			
8	Turbulence	0.01	0.03	0.02	0.03	0.01	0.01	0.01	-		
9	Liquidity	-0.001	-0.02	0.07	0.16*	0.12*	0.51*	-0.03		-	
10	Firm tenure	0.022	0.13*	0.20*	0.22*	-0.12*	0.07*	-0.11*	0.01	0.003	-
	Max	22.25	0.56	3.15	14.60	11.90	1.91	0.96	28.12	0.80	82
	Min	0	0	0	1.69	0.53	-2.20	0	0.01	-1.62	0
	Mean	0.33	0.18	1.49	7.05	1.87	0.04	0.03	3.80	0.07	24.31
	Standard Deviation	0.93	0.11	0.69	1.94	1.00	0.13	0.06	19.97	0.11	17.36

*Note: Correlation coefficients statistically significant at $p < .01$

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EMPIRICAL ANALYSIS AND RESULTS

The final sample is longitudinal. Data of IT portfolio diversification (ITP), business portfolio diversification (BP), and control variables are during the year of 2005-2007, while I use patent citation data at the firm-level three-year after the year of the IT data, i.e., from 2008-2010, for the main analysis. As mentioned, the dependent variable is measured as adjusted patent count to reflect firm innovation activities. Since the adjusted citation count resembles a count variable, I use a negative binomial model with industry and year fixed effects on an unbalanced panel of firms observed annually (e.g., Ravichandran et al. 2017).

$$Innovation_{it} = \beta_0 + \beta_1 ITP_{it} + +\beta_2 BP_{it} \cdot ITP_{it} + \beta_3 Control_{it} + \mu_i + T_t + \varepsilon_{it}$$

$$Innovation_{it} = \beta_0 + \beta_1 ITP_{it} + \beta_2 BP_{it} + \beta_3 BP_{it} \cdot ITP_{it} + \beta_4 Control_{it} + \mu_i + T_t + \varepsilon_{it}$$

Here, μ_i is a firm-specific fixed effect that gets differenced out in the estimation; T_t captures average changes over time; ITP_{it} and BP_{it} represent the particular IT or business diversification index firm i receives by time t, respectively. $Control_{it}$ are controls for firm characteristics that change over time. We assume that ε_{it} is a normal i.i.d. variable and calculate heteroscedasticity-robust standard errors that are clustered by firm.

Because I lagged IT data be three years compared to the outcome variable, the reverse casualty is not likely a serious concern. To confirm, I did additional endogeneity tests by regressing IT data at year t using adjusted citation count data at year t-3/t-2/t-1, respectively. Two of three were insignificant, indicating that reverse causality is not likely an issue.

Table 5 shows the results of the main analyses. The analyses are conducted in a stepwise fashion examining the controls, the main effect of IT diversification, and the two-way interaction

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effect of IT diversification*Business diversification. In the main model of H1 (column 3), independent variables include IT portfolio diversification, business diversification, and all of the control variables. The results show that IT portfolio diversification has a positive and statistically signification relation with adjusted patent citation ($p<0.05$). To test any potential multicollinearity issues, I repeated the analysis with a square term of the focal independent variable, IT portfolio diversification. Multicollinearity was not present as no significant term emerged. Thus, H1 is supported as hypothesized, suggesting IT portfolio diversification has a positive impact on a firm's innovation.

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Table 5. Main Analyses

VARIABLES	(1) Control	(2) IT Diversification	(3) H1 Main Model	(4) H2 Main Model
IT portfolio diversification (ITP)		**1.034****	**0.985****	2.434*
		(0.465)	**(0.465)**	(1.265)
Business portfolio diversification (BP)			0.232**	0.538***
			(0.0965)	(0.186)
ITP*BP				**-1.393****
				(0.712)
Log of total asset	0.318***	0.322***	0.298***	0.208***
	(0.035)	(0.035)	(0.036)	(0.038)
Tobin's q	0.0849*	0.0888*	0.0970*	0.189***
	(0.051)	(0.051)	(0.051)	(0.072)
Return on assets	-0.251	-0.244	-0.226	-0.254
	(0.494)	(0.494)	(0.490)	(0.488)
R&D expenditure to total assets	4.523***	4.588***	4.814***	1.342
	(0.925)	(0.927)	(0.938)	(1.221)
Turbulence	0.003	0.002	0.002	0.03
	(0.003)	(0.003)	(0.003)	(0.022)
Liquidity				-0.266
				(0.488)
Firm tenure	-0.001	-0.002	-0.003	-0.0003
	(0.0032)	(0.003)	(0.003)	(0.003)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5 also shows the results of the moderation effect of IT portfolio diversification and business diversification on adjusted patent citation count. In the model base (column 4), I found that the coefficient of ITP*BP is negative and statistically significant, suggesting that together, IT portfolio diversification and business diversification affect innovation outcome negatively ($p<0.05$).

I also conducted additional analyses and performed robustness checks. First, to any potential issues with the short panel, I reran the analyses with a subsample, including firms that appeared in every year. The results shown in Table 6 were consistent with the main results.

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Second, in addition to the one used in the main analysis, I measured IT portfolio diversification using mean difference and observed similar results. In Table 7, the coefficient of ITP is positive and statistically significant at $p<0.05$ (column 3). The coefficient of ITP*BP is negative and statistically significant at $p<0.05$ (column 4). To test H2, I ranked observations based on IT diversification and business diversification values and created dummies indicating top 33-percentile, respectively. HITP/HBP takes one if the IT/business diversification falls in upper 33-percentile and zero otherwise (i.e., falls in lower 67 percentile). I then repeated the same regression analysis using 33-percentile dummies. Similar to the results in the mean analysis, the coefficient of the moderation term is negative and statistically significant (Table 8, column 2), suggesting when a firm has both highly diversified IT and business capabilities, it is likely that the combination is detrimental to innovation activities.

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Table 6. Additional Analyses with Subsample

VARIABLES	(1) Control	(2) IT Diversification	(3) H1 Main Model	(4) H2 Main Model
IT portfolio diversification (ITP)		**1.115****	**1.046***	4.614**
		(0.544)	**(0.546)**	(1.849)
Business portfolio diversification (BP)			0.231*	0.689***
			(0.127)	(0.260)
ITP*BP				**-2.481****
				(1.849)
Log of total asset	0.318***	0.356***	0.334***	0.333***
	(0.035)	(0.043)	(0.045)	(0.049)
Tobin's q	0.085*	0.070	0.087	0.090
	(0.051)	(0.062)	(0.063)	(0.070)
Return on assets	-0.251	-0.346	-0.335	-0.336
	(0.494)	(0.551)	(0.546)	(0.515)
R&D expenditure to total assets	4.523***	4.307***	4.459***	4.581***
	(0.925)	(1.116)	(1.129)	(1.463)
Turbulence	0.003	-0.009	-0.008	-0.009
	(0.003)	(0.006)	(0.006)	(0.006)
Liquidity	0.328	0.058	-0.003	0.112
	(0.532)	(0.629)	(0.627)	(0.574)
Firm tenure	-0.001	-0.004	-0.005	
	(0.003)	(0.004)	(0.004)	
Observations	1,930	1,266	1,266	1,266

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

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Table 7. Additional Analyses: IT Diversification Measured Using Mean Difference

VARIABLES	(1) Control	(2) IT Diversification	(3) H1 Main Model	(4) H2 Main Model
IT portfolio diversification (ITP)		**1.034****	**0.985****	3.245**
		(0.465)	**(0.465)**	(1.393)
Business portfolio diversification (BP)			0.232**	0.150
			(0.097)	(0.112)
ITP*BP				**-1.736****
				(0.778)
Log of total asset	0.318***	0.322***	0.298***	0.245***
	(0.035)	(0.035)	(0.036)	(0.035)
Tobin's q	0.085*	0.089*	0.097*	0.115**
	(0.051)	(0.051)	(0.051)	(0.051)
Return on assets	-0.251	-0.244	-0.226	-0.371
	(0.494)	(0.494)	(0.490)	(0.424)
R&D expenditure to total assets	4.523***	4.588***	4.814***	2.078*
	(0.925)	(0.927)	(0.938)	(1.071)
Turbulence	0.003	0.003	0.002	0.062**
	(0.003)	(0.003)	(0.003)	(0.029)
Liquidity	0.328	0.372	0.332	0.304
	(0.532)	(0.533)	(0.531)	(0.497)
Firm tenure				-0.027
				(0.079)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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Table 8. Robustness Check of H2

VARIABLES	(1) Control	(2) H2 Main Model
High IT portfolio diversification (HITP)		0.202
		(0.126)
High business portfolio diversification (HBP)		0.164
		(0.139)
HITP*HBP		**-0.441****
		(0.200)
Log of total asset	0.318***	0.264***
	(0.035)	(0.036)
Tobin's q	0.085*	0.095*
	(0.051)	(0.050)
Return on assets	-0.251	-0.335
	(0.494)	(0.479)
R&D expenditure to total assets	4.523***	2.175**
	(0.925)	(0.968)
Turbulence	0.003	0.062*
	(0.003)	(0.033)
Liquidity	0.328	0.280
	(0.532)	(0.516)
Firm tenure	-0.001	-0.002
	(0.003)	(0.003)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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DISCUSSIONS

Main Findings

To sum up, the empirical results of the study show strong support for my main proposition that IT portfolio diversification plays a significant role in influencing firm innovation activities. Using archival data on citation-adjusted patent counts, IT portfolio diversification, and business diversification for 1,137 unique firms from 2005 to 2010, the analysis yields two main findings. First, I find that the level of IT portfolio diversification enhances a firm's innovation. The results show that a more diversified IT portfolio positively and significantly affects a firm's competence to innovate. The findings further demonstrate that including more information technologies into the existing knowledge systems may enable firms to increase the quality of inventions by searching for complementarities and novel solutions.

The evidence echoes the theoretical notion that it is desirable to create inventories of competencies to permit effective utilization of the new knowledge, and positively influence the accumulation of absorptive capability that allows the firm to predict the nature of the commercial potential of industrial advances while exploring and exploiting technological opportunities (e.g., Cohen and Levinthal 1990; Levinthal and March 1993). Firms with a more diversified IT portfolio have more strategic options gained through easier internal information sharing and coordination and more external technology and market exposure. Thus, a high level of IT portfolio diversification may be a necessary condition for firms to sustain their competitive advantage.

Second, I find that, interestingly, , a combination of high IT portfolio diversification and high business diversification do not jointly positively influence firm innovation. Instead, IT

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portfolio diversification has a negative impact on the relationship between business diversification and firm innovation outcome. Individually, IT portfolio diversification and business diversification are showed to have a significant positive influence on innovation competence. Arguably, different business units may have different product lines and perform different roles in developing innovations. Their respective functionalities may be enabled by a diverse range IT infrastructures and applications. Maintaining a diverse IT portfolio is easier to exploit cross-unit synergies and explore or share new technological competencies that are crucial for realizing innovations.

However, as shown by the results, it is not the case. Prior studies have provided interesting insights into the relationship between business, or product, diversification and other organizational level diversifications, such as general technological diversification (e.g., (Cantwell and Piscitello 2000; Cantwell and Santangelo 2000; Piscitello 2000; Le Bas and Patel 2004). The empirical works seem to support the hypothesis that business diversification and other types of diversification have a different impact on firm performance. Consistent with these results, the empirical analysis of this study shows that the positive impact of IT portfolio diversification on innovation outcome diminishes as the level of business diversification increases. What more, through additional exploratory tests, the findings suggest that firms are not able to utilize IT portfolio and business portfolio in a higher level simultaneously to generate quality innovative outcomes. Overall, the analysis yields that firm's innovation performance depends not only on its ability to diversify IT application and knowledge but also on the capability to maintain and exploit its business coherence over time.

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Limitations

Although the study shows interesting findings, I recognize several limitations of this study mainly due to data availability. First, this study uses secondary data on relatively large multi-units firms, which limits the generalizability of the findings when it comes to smaller firms. Second, whiling revealing the importance of a diversified IT portfolio throughout a firm's business units, more nuanced data on how specific IT applications and systems may influence innovation efforts are desirable to provide more insights in future research. Third, although adjusted patent citation count is a good measure for reflecting the actual output of firm innovation efforts, patents, in general, only represent only one type of outcome associated with innovation, especially considering not all inventions are patentable or can be patented in an equal magnitude (Griliches 1990). Thus, future studies may investigate the impact on other innovation-related outcomes, such as the innovation diffusion in organizations or industries, the actual industrial recognition of innovations, and inimitability of innovation (Leiponen and Helfat 2010,2011; Srivastava et al. 2013). Also, the role of IT portfolio diversification in the creation of incremental vs. radical innovations in various contexts can also be very interesting themes to examine in future research.

Contributions and Implications

Innovation is a key contributor to a firm's competitive success. Prior literature has witnessed the major impact of both product and general technological diversification on realized product and service innovations (e.g., Garcia-Vega 2006; Gort 1962; Grabowski 1968; Quintana-García and Benavides-Velasco 2008; Scherer 1984; Teece 1980). IS researchers have also examined diversification, however mostly in team/group settings with a few noticeable exceptions (e.g., Carlo et al. 2012). Thus, by defining and theorizing IT portfolio diversification,

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we advance the theoretical understanding of diversification. In particular, we were able to differentiate between general technological diversification and IT portfolio diversification and to highlight that the latter is a new stand-alone concept that is worth studying its organizational impact.

In recent decades, new information technologies and their widespread application have led to evolutionary changes in the innovation process, such as changes in the management of innovation knowledge and innovation collaboration. In this paper, we argue that focusing on aggregated IT resource investment does not suffice to justify the role of information technology in facilitating innovations, especially in the context of multi-unit or multi-business firms. Thus, by investigating IT diversification variance at the site-level, we also contribute to the innovation literature by showing that, through managing its diverse IT portfolio, a firm could maximize corporate innovation performance by seeking cross-unit IT synergies. We were able to show that IT portfolio diversification can serve as a source of cross-unit IT synergies and such synergies have a direct effect on organizational performance, i.e., the innovation capability in the current context. By studying this direct relationship, we advance our understanding of the true business value of IT portfolio diversification for multi-unit/multi-business firms, i.e., to balance resource demand for strategic innovation projects, firms need to pay close attention to managing and planning their information technology (IT) resources.

The conclusion that diversification is significantly correlated with innovation is not new. Some studies in this domain have shown some association between product diversification and different measures of innovation (Grabowski 1968; Gort 1962; Scherer 1984; Teece 1980). However, little attention has been paid to the complementary effect of business diversification and IT portfolio diversification on organization innovations. We contribute to the literature in

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this regard by showing that innovation creation may benefit from the knowledge gained through exploration and exploitation enabled by a more diversified IT portfolio, however, such positive effect is diminished by an over-diversified business focus. Heeley and Matusik (2004) argue that technical and product market knowledge are very different since they are originated in different stages of the value chain, and they are motivated for different reasons. What's more, IT portfolio diversification can be driven by the firm's necessity to produce more efficient products in a given market. Thus, the study also contributes to the literature by arguing and showing that the impact of IT diversification depends on the firm's product strategy that acts as a modulating factor in the relationship between diversification and innovation. Practically speaking, the results also inform managers that desirable innovation outcomes only appear when there is a fit between the variance of IT resources and the relatedness of products the firm develops. In other words, focusing on maintaining a broad range of IT applications and systems while compromising the business coherence may not be the best strategic decision regarding gaining quality innovation outcomes.

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CONCLUSION

Empirical researchers have accumulated significant evidence of the contribution of IT to firm innovation. Former studies tend to treat organizational IT as a whole (e.g., Kleis et al. 2012; Han and Ravichandran 2006; Ravichandran et al. 2017), but failed to consider the diversification of IT resource allocation within a given organization. Thus, we first shed new light on the direct impact of IT portfolio diversification on a firm's innovation capability by considering business unit level variance of IT resource allocation. I argued and found that IT portfolio diversification has a positive impact on a firm's innovation outcome. Besides IT diversification, prior literature also reported business/product diversification as one of the driving forces of innovation. I thus also examined the joint impact of IT portfolio diversification and business diversification on firm innovation. The results suggest that while seemingly reasonable, the two do not complement each other. More specifically, managing both types of diversification at a higher level is detrimental to firm innovation efforts. To the extent that innovation is one of the critical ingredients for survival and success in increasingly competitive markets, the results show that firms need to pay major attention to the management of level of IT variation and its jointly impact with business coherence to become more innovative.

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REFERENCES

Agarwal, R., and Bayus, B. L. 2002. "The Market Evolution and Sales Takeoff of Product Innovations," *Management Science* (48:8), pp. 1024-1041.

Argyres, N. 1996. "Evidence on the Role of Firm Capabilities in Vertical Integration Decisions," *Strategic Management Journal*), pp. 129-150.

Augier, M., and Thanning Vendelø, M. 1999. "Networks, Cognition And Management of Tacit Knowledge," J*ournal of Knowledge Management* (3:4), pp. 252-261.

Bagozzi, R. P., Yi, Y., and Phillips, L. W. 1991. "Assessing Construct Validity in Organizational Research," *Administrative Science Quarterly* (36:3), pp. 421-458.

Baily, M., and Chakrabarti, A. 1988. "Electronics and White-Collar Productivity," *Innovation and the Productivity Crisis*).

Bharadwaj, A. S., Bharadwaj, S. G., and Konsynski, B. R. 1999. "Information Technology Effects on Firm Performance as Measured by Tobin's Q," *Management Science* (45:7), pp. 1008-1024.

Breschi, S., Lissoni, F., and Malerba, F. 2003. "Knowledge-Relatedness in Firm Technological Diversification," *Research policy* (32:1), pp. 69-87.

Brockhoff, K. 1992. "R&D Cooperation between Firms—a Perceived Transaction Cost Perspective," *Management Science* (38:4), pp. 514-524.

Brynjolfsson, E., Hitt, L. M., and Yang, S. 2002. "Intangible Assets: Computers and Organizational Capital," *Brookings papers on economic activity* (2002:1), pp. 137-181.

Cantwell, J., and Piscitello, L. 2000. "Accumulating Technological Competence: Its Changing Impact on Corporate Diversification and Internationalization," *Industrial and corporate change* (9:1), pp. 21-51.

Carlo, J. L., Lyytinen, K., and Rose, G. M. 2012. "A Knowledge-Based Model of Radical Innovation in Small Software Firms," *MIS Quarterly* (36:3), pp. 865-895.

Carr, N. G. 2003. "It Doesn't Matter," *Educause Review* (38), pp. 24-38.

Castellion, G., and Markham, S. K. 2013. "Perspective: New Product Failure Rates: Influence of Argumentum Ad Populum and Self-Interest," *Journal of Product Innovation Management* (30:5), pp. 976-979.

Chae, H.-C., Koh, C. E., and Prybutok, V. R. 2014. "Information Technology Capability and Firm Performance: Contradictory Findings and Their Possible Causes," *Mis Quarterly* (38:1).

Chesbrough, H. 2003. "Open Innovation." Boston: Harvard Business School Press.

Christensen, J. F., Foss, N., and Robertson, P. 2000. "Building Innovative Assets and Dynamic Coherence in Multi-Technology Companies," *Resources, technology and strategy*), pp. 123-152.

Devaraj, S., and Kohli, R. 2003. "Performance Impacts of Information Technology: Is Actual Usage the Missing Link?," *Management Science* (49:3), pp. 273-289.

Dodgson, M., Gann, D., and Salter, A. 2006. "The Role of Technology in the Shift Towards Open Innovation: The Case of Procter & Gamble," *R&D Management* (36:3), pp. 333-346.

المنارة للاستشارات
www.manaraa.com

Dosi, G. 1982. "Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants and Directions of Technical Change," *Research policy* (11:3), pp. 147-162.

Dougherty, D., and Hardy, C. 1996. "Sustained Product Innovation in Large, Mature Organizations: Overcoming Innovation-to-Organization Problems," *Academy of management journal* (39:5), pp. 1120-1153.

Eisenhardt, K. M., and Tabrizi, B. N. 1995. "Accelerating Adaptive Processes: Product Innovation in the Global Computer Industry," *Administrative science quarterly*), pp. 84-110.

Fai, F., and Von Tunzelmann, N. 2001. "Industry-Specific Competencies and Converging Technological Systems: Evidence from Patents," *Structural change and economic dynamics* (12:2), pp. 141-170.

Gao, G., Gopal, A., and Agarwal, R. 2010. "Contingent Effects of Quality Signaling: Evidence from the Indian Offshore It Services Industry," *Management Science* (56:6), pp. 1012-1029.

Garcia-Vega, M. 2006. "Does Technological Diversification Promote Innovation?: An Empirical Analysis for European Firms," *Research policy* (35:2), pp. 230-246.

Ghoshal, S. 1987. "Global Strategy: An Organizing Framework," *Strategic management journal* (8:5), pp. 425-440.

Gort, M. 1962. "Front matter, diversification and integration in American industry," In *Diversification and integration in American Industry* (pp. 22-0). Greenwood Press.

Grabowski, H. G. 1968. "The Determinants of Industrial Research and Development: A Study of the Chemical, Drug, and Petroleum Industries," *Journal of political economy* (76:2), pp. 292-306.

Granstrand, O. 1998. "Towards a Theory of the Technology-Based Firm," *Research policy* (27:5), pp. 465-489.

Granstrand, O., and Oskarsson, C. 1994. "Technology Diversification in" Mul-Tech" Corporations," *IEEE Transactions on Engineering Management* (41:4), pp. 355-364.

Granstrand, O., Patel, P., and Pavitt, K. 1997. "Multi-Technology Corporations: Why They Have “Distributed” Rather Than “Distinctive Core” Competencies," *California management review* (39:4), pp. 8-25.

Griliches, Z. 1990. “Patent Statistics as Economic Indicators: A Survey,” *Journal of Economic Literature* (28:4), pp. 1661-1707.

Hall, B. H., Jaffe, A., and Trajtenberg, M. 2005. "Market value and Patent Citations," *RAND Journal of Economics*, pp. 16-38.

Han, S., and Ravichandran, T. 2006. "Does It Impact Firm Innovativeness: An Empirical Examination of Complementary and Direct Effects," *AMCIS 2006 Proceedings*), p. 91.

Harrison, D. A., and Klein, K. J. 2007. "What's the Difference? Diversity Constructs as Separation, Variety, or Disparity in Organizations," *Academy of management review* (32:4), pp. 1199-1228.

Hitt, M. A., Hoskisson, R. E., and Ireland, R. D. 1994. "A Mid-Range Theory of the Interactive Effects of International and Product Diversification on Innovation and Performance," *Journal of management* (20:2), pp. 297-326.

Hitt, M. A., Hoskisson, R. E., and Kim, H. 1997. "International Diversification: Effects on Innovation and Firm Performance in Product-Diversified Firms," *Academy of Management Journal* (40:4), pp. 767-798.

المنارة للاستشارات
www.manaraa.com

Horwitz, S. K., and Horwitz, I. B. 2007. "The Effects of Team Diversity on Team Outcomes: A Meta-Analytic Review of Team Demography," *Journal of management* (33:6), pp. 987-1015.

Joshi, K. D., Chi, L., Datta, A., and Han, S. 2010. "Changing the Competitive Landscape: Continuous Innovation through It-Enabled Knowledge Capabilities," *Information Systems Research* (21:3), pp. 472-495.

Kankanhalli, A., Tan, B. C., and Wei, K.-K. 2006. "Conflict and Performance in Global Virtual Teams," *Journal of management information systems* (23:3), pp. 237-274.

Kleis, L., Chwelos, P., Ramirez, R. V., and Cockburn, I. 2012. "Information Technology and Intangible Output: The Impact of It Investment on Innovation Productivity," *Information Systems Research* (23:1), pp. 42-59.

Kogan, L., Papanikolaou, D., Seru, A., and Stoffman, N. 2017. "Technological Innovation, Resource Allocation, and Growth," T*he Quarterly Journal of Economics* (132:2), pp. 665-712.

Leiponen, A. 2000. "Competencies, Innovation and Profitability of Firms," *Economics of Innovation and New Technology* (9:1), pp. 1-24.

Leliveld, I., and Jeffrey, M. 2004. "Best Practices in It Portfolio Management," *MIT Sloan Management Review*).

Levinthal, D. A., and March, J. G. 1993. "The Myopia of Learning," *Strategic Management Journal* (14:S2), pp. 95-112.

Mairesse, J., and Mohnen, P. 2004. "The Importance of R&D for Innovation: A Reassessment Using French Survey Data," *The Journal of Technology Transfer* (30:1-2), pp. 183-197.

Melville, N., Gurbaxani, V., and Kraemer, K. 2007. "The Productivity Impact of Information Technology across Competitive Regimes: The Role of Industry Concentration and Dynamism," *Decision support systems* (43:1), pp. 229-242.

Mithas, S., Jones, J. L., and Mitchell, W. 2008. "Buyer Intention to Use Internet-Enabled Reverse Auctions: The Role of Asset Specificity, Product Specialization, and Non-Contractibility," *MIS Quarterly* (32:4), pp. 705-724.

Nambisan, S. 2013. "Information Technology and Product/Service Innovation: A Brief Assessment and Some Suggestions for Future Research," *Journal of the Association for Information Systems* (14:4), p. 215.

Nambisan, S., and Baron, R. A. 2013. "Entrepreneurship in Innovation Ecosystems: Entrepreneurs' Self-Regulatory Processes and Their Implications for New Venture Success," *Entrepreneurship Theory and Practice* (37:5), pp. 1071-1097.

Nelson, R. R. 1959. "The Simple Economics of Basic Scientific Research," *Journal of political economy* (67:3), pp. 297-306.

Nelson, R. R., and Winter, S. G. 1982. "An Evolutionary Theory of Economic Change," *Harvard Business School Press, Cambridge*).

Nesta, L., and Saviotti, P. P. 2005. "Coherence of the Knowledge Base and the Firm's Innovative Performance: Evidence from the US Pharmaceutical Industry," *The Journal of Industrial Economics (*53:1), pp. 123-142.

المنارة للاستشارات
www.manaraa.com

Peters, L., and Karren, R. J. 2009. "An Examination of the Roles of Trust and Functional Diversity on Virtual Team Performance Ratings," *Group & Organization Management* (34:4), pp. 479-504.

Piscitello, L. 2000. "Relatedness and Coherence in Technological and Product Diversification of the World's Largest Firms," *Structural Change and Economic Dynamics* (11:3), pp. 295-315.

Piscitello, L. 2004. "Corporate Diversification, Coherence and Economic Performance," *Industrial and corporate change* (13:5), pp. 757-787.

Quintana-García, C., and Benavides-Velasco, C. A. 2008. "Innovative Competence, Exploration and Exploitation: The Influence of Technological Diversification," *Research Policy* (37:3), pp. 492-507.

Ravichandran, T., Han, S., and Mithas, S. 2017. "Mitigating diminishing returns to R&D: The role of information technology in innovation," *Information Systems Research (*28:4), pp. 812-827.

Saldanha, T. J., Mithas, S., and Krishnan, M. S. 2017. "Leveraging Customer Involvement for Fueling Innovation: The Role of Relational and Analytical Information Processing Capabilities," *MIS Quarterly* (41:1), pp. 276-A11.

Sawhney, M., and Nambisan, S. 2007. *The Global Brain: Your Roadmap for Innovating Faster and Smarter in a Networked World*. Pearson Prentice Hall.

Scherer, K. R. 1984. "On the Nature and Function of Emotion: A Component Process Approach," *Approaches to emotion* (2293), p. 317.

Shenkar, O., and Li, J. 1999. "Knowledge Search in International Cooperative Ventures," *Organization Science* (10:2), pp. 134-143.

Stern, I., and Henderson, A. D. 2004. "Within‐Business Diversification in Technology‐Intensive Industries," *Strategic Management Journal* (25:5), pp. 487-505.

Tanriverdi, H., and Lee, C.-H. 2008. "Within-Industry Diversification and Firm Performance in the Presence of Network Externalities: Evidence from the Software Industry," *Academy of Management Journal* (51:2), pp. 381-397.

Tanriverdi, H., and Venkatraman, N. 2005. "Knowledge Relatedness and the Performance of Multibusiness Firms," *Strategic Management Journal* (26:2), pp. 97-119.

Teece, D. J. 1980. "Economies of Scope and the Scope of the Enterprise," *Journal of economic behavior & organization* (1:3), pp. 223-247.

Thomke, S. H. 2006. "Capturing the Real Value of Innovation Tools," *MIT Sloan Management Review* (47:2), p. 24.

Tushman, M. L., and Anderson, P. 1986. "Technological Discontinuities and Organizational Environments," *Administrative science quarterly*), pp. 439-465.

Van Knippenberg, D., and Schippers, M. C. 2007. "Work Group Diversity," *Annu. Rev. Psychol.* (58), pp. 515-541.

Villalonga, B. 2004. "Diversification Discount or Premium? New Evidence from the Business Information Tracking Series," *The Journal of Finance* (59:2), pp. 479-506.

Wernerfelt, B., and Montgomery, C. A. 1988. "Tobin's Q and the Importance of Focus in Firm Performance," *The American Economic Review*), pp. 246-250.

www.manaraa.com

Williams, K. Y., and O'Reilly III, C. A. 1998. "Demography and Diversity in Organizations," *Research in organizational behavior* (20), pp. 77-140.

Xue, L., Ray, G., and Gu, B. 2011. "Environmental Uncertainty and It Infrastructure Governance: A Curvilinear Relationship," *Information Systems Research* (22:2), pp. 389-399.

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APPENDIX A. The List of IT Components Available to Business Units

Hardware	
PC, 7	Total installed Apple Computers
	Percent Desktop PCs with Intel Chips
	Percent Desktop PCs with AMD Chips
	Percent Portable PCs with Intel Chips
	Percent Portable PCs with AMD Chips
	Total installed Thin Clients (0 in all observations)
	Total installed High-Performance Workstations
Servers, 6	Total installed IBM/PC Mainframe Servers
	Total installed IBM Midrange Servers
	Total installed Intel/AMD servers
	Total installed Unix/RISC Servers
	Total installed Proprietary Servers
	Percentage of Blade Servers
Printers, 7	Total installed Production printers
	Total installed color printers
	Total installed Laser printers
	Total installed Inkjet printers
	Total installed Dot Matrix printers
	Total installed wide format printers
	Total installed multifunction printers

Software, 14	
	Disaster recovery
	Open source software installed
	Application development software status
	Database management software status
	Workflow software status
	Enterprise & system management software status
	Security management software status
	Enterprise application software status
	Group software status
	Server computing software status
	Presence of ERP software suite at the site
	Business process management installed
	Data warehouse status
	Business intelligence software status

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Storage	
Storage devices, 4	Presence of direct attached storage
	Presence of network attached storage
	Presence of storage area network
	Presence of automated tape library
Associated management software, 1	Storage management software status

Network	
Network LAN equipment (Network Infrastructure), 11	Total installed LAN switches, 2005 Presence of a LAN switch, 2006-2009
	Total installed LAN routers, 2005 Presence of a LAN router, 2006-2009
	Wireless LAN status
	Usage of Single sign-on capability
	Presence of network directory software
	Network firewall
	Intrusion detection system
	Intrusion prevention system
Network service	Presence of audio/video conferencing service
	ATM status
	Frame relay status
	SONET status
	MPLS status
	Virtual Private Network status
	Voice over IP status
	Usage of class of service
	Total installed direct dial lines
	Total installed ISDN lines
	Total installed T1 lines
	Total installed T3 lines
	Total installed xDSL lines
	Total installed OCx lines

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Telecom	
Communication equipment, 9	PBX status for site (different variable/value in 2005)
	Centrex status for site (different variable/value in 2005)
	IP-PBX status for site
	Key system status for site (different variable/value in 2005)
	Single-line phone status for site (different variable/value in 2005)
	Remote phone status for site
	Unspecific phone system status for site (different variable/value in 2005)
	ACD status
	Presence of an IVR system

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IT-ENABLED CAPABILITIES AND BUSINESS STRATEGY IN ENHANCING INNOVATION

INTRODUCTION

Innovation management is an essential component of a firm's business strategy, and its importance will continue to grow, as the market environment becomes increasingly unpredictable and competitive. Information technologies and applications have led to noticeable changes in the innovation process (Quinn et al. 1997). By enabling and facilitating the management of innovation knowledge (Thomke 2006), innovation production (Sudarsan et al. 2005; Thomke 2006), and external innovation collaboration (Thomke 2006), it is evident that information technologies have improved the speed and efficiency of firm innovation. For example, by analyzing more than 1800 large U.S. firms between 1987 and 1997, Kleis et al. (2012) conclude that IT capital has a positive and significant effect on knowledge output, measured by innovation counts. Thus, IT has become essential to product development in firms.

Traditionally, innovation has been exercised under closed settings (Chesbrough 2003), focusing on a fixed, discrete set of boundaries and features. Information technologies (IT) are being embedded into an ever-increasing range of new products and services; such expansion testifies the significance and relevance of IT in any innovation. Because of the unique characteristics of enabling ITs, i.e., malleable, editable, open, transferable, etc. (Yoo et al. 2010), innovation has become a much less well-bounded phenomenon, often involving a diverse network of actors, such as customer, suppliers, and even rivals (Han et al. 2012; Nambisan et al. 2017). Thus, the traditional way of developing innovations within one focal organization has been challenged (Chesbrough 2003). Given that consumers' needs and the overall market environment are evolving rapidly, such traditional innovation creation paradigm does not suffice

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as generating new ideas internally through a slow and single path is far from efficient and flexible (West and Lakhani 2008).

Many contemporary business enterprises have embraced the trend of innovating on both knowledge inflows and outflows. For example, LEGO has exercised the concept of value co-creation with customers by creating an online community where members can discover cool creations by other fans and submit theirdesign for new sets. Projects with a considerable number of votes stand a chance to be sold as an official LEGO set (Milbrath 2016). Demonstrated by LEGO's strategic maneuver, the collaboration that facilitates the value co-creation through the joint design and development may reshape the competitive dynamics and alter the strategic positioning of the companies that operate within the ever-changing environment. Prior IS scholars have noted that firms seeking collaboration with external partners experience higher market returns from innovations (e.g., Han et al. 2012). Therefore, the existing literature seems to suggest that employing a more collaborative approach is quite promising in designing and development nuanced innovations. However, how could firms exercise this approach in a context that is highly digitized?

We argue that as ITs become essential, specific IT-enabled capabilities could facilitate innovation creation. Advances in certain information technologies, such as business intelligence and open source software, have magnified opportunities for firms to interact with customers and other external contributors and to link technology and business resources, such as customer competencies (Varadarajan and Yadav 2009). Prior literature has linked information technology capital with the organizational level intangible output (e.g., Kleis et al. 2012), concluding information technology is a significant driving force of knowledge production or innovation output. However, prior literature does not fully delineate which specific IT components, or

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related IT-enabled capabilities, that contribute to innovation creation. Thus, in the current study, we argue that triggered by specific IT use, specific information technology (IT) capabilities may facilitate innovation creating by enabling the focal firm to coordinate with other partners and customers. Since how well external knowledge is utilized depends on the firm's capabilities to absorb external information from partners and customers (Cohen and Levinthal 1990; Warren et al. 2011), we aim to examine how specific IT-enabled capabilities may influence innovation creation. Specifically, we identify two such specific IT-enabled capabilities: *analytical information processing capability* (AIPC), defined as "the extent to which a firm uses business analytical technologies or applications that analyze critical business data to better understand its business and make timely business decisions" (Saldanha et al. 2017, pp 269), and *external information integration capability* (EIIC), defined as the extent to which a firm use information exchange/sharing-related platforms or applications to support organizational work processes pertaining to managing and merging external information. *Firm innovation* is defined as novel knowledge representations embedded in a firm's inventions, discoveries, and other forms of developed ideas that precede actual commercialization (Joshi et al. 2010), and will be measured as registered innovation counts.

Besides IT-enabled innovation capabilities, other contextualizing variables, such as business strategy, may also aid successful product and process innovation. Business strategy determines the configuration of resources, products, processes, and systems that a firm needs to adapt to the external environment. While scholars have recognized that business strategy and innovation are intertwined in efforts to create a sustainable competitive advantage (e.g., Ettlie et al. 1984; Ireland et al. 2001), little attention has paid on how firms with different strategic orientations differ in innovative actions and outcomes. Also, as suggested by IT alignment

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research, organizational performance is contingent upon a fit between two or more factors such as strategy, structure, and technology (Burns and Stalker 1961). Given that strategy is the mediating force between the firm and its environment (Miles and Snow 1984), the organization's technology, and the subsequent capabilities enabled by such technology, must be compatible with the existing strategy if a significant competitive advantage is to be created (Raymond and Bergeron 2008). The issue of information technology's alignment with the firm's business strategy constitutes one main problem faced by IT managers in large enterprises (Luftman et al. 2006).

To examine the complementarity between business strategy and IT-enabled capability, we apply the Miles and Snow (1984) business strategy typology. In particular, the typology postulates three organization types—namely defender, analyzers, and prospectors—each with it own distinctive strategy. We argue that varying in defensiveness, risk aversion, aggressiveness, proactiveness, analysis, and futurity, defenders, prospectors, and analyzers may complement differently with the identified IT-enabled capabilities, i.e., analytical information processing capability and external information integration capability when firms are exercising a more collaborative approach to innovate. Therefore, the second goal of this essay is to advance our understanding on the impact of IT capability and business strategy alignment on innovation creation.

The remainder of the paper is organized as follows. First, we show the literature background and present a moderation model for IT-enabled capability, business strategy, and innovation with associated hypotheses. Then, a research design with data collection and analysis plan is proposed. Finally, the paper concludes with a discussion of potential contributions.

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LITERATURE BACKGROUND AND HYPOTHESES

IT Capability and External Innovation Involvement

Numerous theoretical and empirical studies have been conducted regarding the performance implications of gaining external resources in pursuit of knowledge exchange, sharing, or co-development of new products (Gulati 1998). Some studies have shown positive empirical relationships between inter-organizational partnering and the firms' financial performance (e.g., McConnell and Nantell 1985), other studies have found no statistically significant patterns (e.g., Finnerty et al. 1986), some even have identified impacts (e.g., Villalonga and McGahan 2005). Similarly, the literature on customer involvement and innovation produces mixed results. As suggested by some scholars, involving customers can improve outcomes such as innovation speed (Carbonell et al. 2009) and customer satisfaction (Bendapudi and Leone 2003). However, evidence also suggests that involving customer can cause challenges such as lower product innovativeness (Lawton and Parasuraman 1980), information overload from customer opinions (Hoyer et al. 2010), and process delays (Subramanyam et al. 2010). To sum up, the literature suggests that the overall external partner involvement may well be contingent on many factors.

We argue that IT may be one of the potential contributing factors. The application of IT contributes to the innovation processes through various mechanisms. Information technology contributes to the management of knowledge used in innovation production by creating an infrastructure for capturing and sharing knowledge across the enterprise (Lee and Choi 2003; Majchrzak et al. 2004; Tanriverdi 2005), and across valued networks (e.g., Han et al. 2012). Also, information technology enables supportive elements critical to the innovation product processes, such as opportunities identification, concept development, and innovation design.

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Also, as the production of innovations involves collaboration between internal and external participants, information technology enables the creation of an effective partnership by offering smooth communication channels. Thus, logic dictates that a collaborative innovation process aiming to create new value-added innovations in heavily enabled through IT. Although prior literature has suggested a significant positive relationship between IT capital and innovation output (e.g., Banker et al. 2006; Di Benedetto et al. 2008; Han and Ravichandran 2006; Kleis et al. 2012; Nambisan 2003, 2013), we still have little understanding in which specific IT-capabilities indeed have a significant impact on innovation creation, with some exceptions (e.g., Joshi et al. 2010; Saldanha et al. 2017) (also see Table 1). This study first aims to address this gap in the literature.

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Table 1. Illustrative Prior Empirical Studies Related to IT-Innovation Relationship[4]

Study	IT-related factor	Key finding
Banker et al. 2006	Collaborative product commerce (CPC) software	CPC implementation is associated with a significant reduction in product design cycle time and development cost as well as improvements in product design quality.
Barczak et al. 2007	IT infrastructure IT embeddedness The extent of IT usage	IT usage positively influences the performance of the new product in the marketplace.
Di Benedetto et al. 2008	Information technology capability	Information technology capability is positively related to radical innovation.
Durmusoglu et al. 2006	IT use	More IT use is better for new product development flexibility.
Han and Ravichandran 2006	IT investment	The interaction between IT investment and R&D expenditure significantly impacts firm innovation.
Joshi et al. 2010	IT-enabled knowledge capability	Knowledge capabilities that are enhanced through the use of IT contribute to firm innovation
Kleis et al. 2012	IT (capital)	A 10% increase in IT input is associated with a 1.7% increase in innovation output.
Saldanha et al. 2017	Relational information processing capability (RIPC) Analytical information processing capability (AIPC)	RIPC and AIPC complement product-focused customer involvement and information-intensive customer involvement practices, respectively, to enhance the amount of firm innovation

Business Strategy Types

While many definitions of business strategy can be found in the literature, Miles and Snow (1978) perspective is adopted here. This typology highlights three archetypal

[4] This table is not exhaustive and lists only new representative empirical studies on IT-innovation relationship to show the relevance and novelty of the current study.

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organizations. Defenders tend to pursue narrow product market domains, rarely make adjustments in their technology, structure, or methods of operation, and develop primary attention to improving efficiency. In contrast, prospectors almost continuously search for market opportunities, possess flexible technologies and are emphasizing on innovativeness. While prospectors and defenders reside at opposite ends, analyzers share some characteristics with each of the other two strategies and locate in between. Since analyzers normally behave similarly with defenders, we will not consider its sole impact in this essay but will include it in the analysis section.

Although limited, some scholars have shed light on the direct relationship between business strategy and firm innovation (e.g., Blumentritt and Danis 2006; Laforet 2008; Slater and Mohr 2006). For example, Blumentritt and Danis suggest that prospectors dedicate more attention to innovation than do defenders (and analyzers). Laforet offers more richness by considering additional factors, such as firm size and market orientation, and concludes that prospectors are more innovative, have a strong market orientation and larger in size than defenders.

In enabling firms to create value and sustain competitive advantage, different strategic capabilities, and IT-enabled capabilities, in particular, are related to different strategic types (DeSarbo et al. 2005; Raymond and Bergeron 2008). For example, in the context of e-business, Raymond and Bergeron attempt to link various e-business capability with Miles and Snow’s business strategic orientation typology and conclude that the ideal e-business capability profile varies in relation to the firms’ strategic orientation, whether it is of the defender, analyzer, or prospector type. Similarly, in the context of innovation, we argue that a firm’s IT-enabled capabilities should also be aligned and complemented by innovation strategy. Thus, besides the

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individual impact of the identified capabilities, we also aim to unravel the moderating role of business strategy in facilitating innovation creation.

Hypotheses Development

Consistent with the view that information technologies can shape innovation (Majchrzak and Malhotra 2013), we argue that the differential ability of firms to transform information, knowledge, and inputs from external partners into innovation development lies in their differential IT-enabled capabilities. Specifically, we focus on the involvement of customers and external knowledge contributors and define two specific IT-enabled capabilities that are argued to enable different types of involvement. First, we identify analytical information processing capability as "the extent to which a firm uses business analytical technologies or applications that analyze critical business data to better understand its business and make timely business decisions" (Saldanha et al. 2017, pp 269). Applications such as data warehousing and business intelligence packages enable firms to detect hidden insights from information obtained from customers. Such technologies facilitate the storage and retrieval of the history of events related to interactions with external partners and customers and can be used to leverage previously stored information to create innovation (Malhotra et al. 2005). Second, we define external information integration capability as the extent to which a firm uses information exchanging/sharing-related platforms or applications to manage and merge external information. Enterprise Resource Planning (ERP) software package and EDI (electronic data interchange) development platform are typical examples. This type of IT-enabled capability helps firms develop and manage relationships with external partners and contributors by effectively utilizing IT to acquire and manage external knowledge obtained from those outside participants.

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Analytical Capability

We propose that by using analytical applications, firms with analytical information processing capability may facilitate innovation creation. The management of knowledge is an activity critical to the creation of innovation. Firms utilize different kinds of knowledge, such as research knowledge, operation knowledge, etc., to develop and produce new products and services (Tanriverdi 2005). Each involved customer tends to have specific knowledge or an opinion that he or she contributes to the innovation process, either directly to indirectly. Information technology helps detect new patterns by enabling the collection of new knowledge assets through improved information searching and data mining techniques. For example, analytical information processing capability helps airlines to improve profitability and provide customers with better travel experiences. By leveraging business analytics applications, airlines are able to understand seat-assignment, legroom preferences, and other travel needs to be obtained from customers (Morgan 2016).

Besides influencing innovation knowledge management, analytical information processing capability may also impact innovation production in multiple stages. In the idea stage, business analytics software enables a firm to analyze its customers and to identify needs that are not being met by current products and services (Nambisan 2003). This helps organizations generate innovation ideas that come from the demand-side (e.g., Mithas et al. 2005). The analytical capability also contributes to the design stage of innovation production. With capability enabled by data warehousing and business intelligence software, firms may filter out poor designs based on preferences analyzed from historical customer interaction records much earlier in the process and improves overall innovation process efficiency (Thomke 2006; Rothwell 1994). Finally, the analytical capability is being used in the final production stage.

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With available detailed customer preferences, designers may identify the most efficient ordering of parts that should be used during the manufacturing of final innovation products. Together, we hypothesize that:

H1: Analytical information processing capability positively affects firm innovation.

Integration Capability

We propose that by using information integration applications, firms with analytical information processing capability may facilitate innovation creation. Complex technological change, global competition, and availability of remote innovation contributors have motivated the inclusion of external partners in innovation. As a result, firms open up their boundaries and start creating a diverse network of innovation contributors (Dodgson et al. 2006, Enkel et al. 2009). The literature suggests that such movement towards more collaborative innovation patterns have led to an increasing tendency to innovation (Dodgson et al. 2006, Enkel et al. 2009).

Information technology is a critical enabler of collaborative innovation by providing the necessary linkages and platforms for information sharing and exchanging with external knowledge contributors. Data integration applications, such as ERP software and EDI development platform, are instrumental in these collaborative efforts. Contemporary firms all face increased competition and dynamics markets. A viable response to potential disruption is constantly striving to serve customers better through sustained and continuous innovation (George 2016). Firms need to employ specific IT applications to acquire the ability to be collaborative.

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We argue that with external information integration capability, the focal firm may seamlessly develop collaborative relationship other partnering firms or knowledge contributors. For example, GE is known for actively participating in an innovation models that emphasize the significance of external contributors. They have been embracing the concept of open source, focusing on the collaboration between experts and entrepreneurs globally to share ideas and solve problems. As a result, GE has received total revenues of $232 billion over the last decade through innovative solutions (Elmansy 2016). Similarly, technologies such as EDI platforms also contribute to the collaborative efforts. Firms need relationship capabilities for developing long-term and close relationship with key partners and customers that drive product development, which is a pivotal competent of innovation. Research shows that inter-organizational technologies have a positive effect on external new product development relationship is disk drive manufacturing (Scott 2001). To ease the process of managing knowledge inflows and outflows for innovation creation, EDI platform enables the focal firm to be interoperable with external contributors. Thus, we hypothesize that:

H2: External information integration capability positively affects firm innovation.

The Role of Business Strategy

We argue that different capabilities are more beneficial for a specific type of firm, depending on their underlying strategy. Extensive business strategy literature has highlighted the distinction between a firm's emphasis on exploitation and exploration. Based on Miles et al. (1978) typology, defenders emphasize more on exploitation, stressing operational efficiency instead of innovativeness, while prospectors focus more on exploration, continuously seeking new opportunity and conducting environmental scanning. Thus, in terms of ways of management

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innovation creation, prospectors may be more focused on gathering external information from customers or other knowledge contributors and strengthen the culture of proactive external searching compared to defenders who may invest more on analyzing and refining their existing infrastructure, attempting to gather innovative ideas inside.

A defender firm is characterized as high in defensiveness, risk aversion, and futurity (Sabherwal and Chan 2001). As mentioned, analytical information processing capability is enabled by data warehousing and business intelligence packages and emphasizes data exploitation to help firms derive insights from large volumes of historical customer data. With such capability, a defender firm may effectively form an innovation strategy to protect its market position through chasing after current customers and carrying out minor changes to existing products. On the other hand, a prospector firm is characterized as high in aggressiveness and proactiveness (Sabherwal and Chan 2001). Such firm is better positioned to leverage upon external information integration capability (enabled by open source software and EDI platform) as this capability helps firms to effectively explore and manage external knowledge gained from customers and other contributors, and thus allocate their resources rapidly and accurately, through well-establish systems and platforms in a seamless manner. Thus, we hypothesize:

H3a: For defender firms, analytical information processing capability has a greater impact on firm innovation.

H3b: For prospector firms, external information integration capability has a greater impact on firm innovation.

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METHOD

Data and Sources

To empirical test the model, I collected and compiled secondary data from several sources. I obtained IT application information from the Harte Hanks Intelligence (CI) Data between 2006 and 2008. CI collects business unit-level data annually on the quantity of IT infrastructure in firms using surveys, site visits, physical audits, and telephone interviews initially at the site-level. IS scholars have widely used the CI data (e.g., Brynjolfsson et al. 2002; Kleis et al. 2012; Melville et al. 2007; Xue et al. 2011). All business units belong to large, multi-divisional companies. Firm-level patent count data was obtained from Kogan et al. (2017) between 2007 and 2009. Data on business strategy and controls were obtained from the Compustat database.

As the theoretical population for this study is firms that actively engage in patenting, I carefully examine the data to exclude firms from industries that do not have a history of systematic parenting practice. Consistent with the literature, I dropped firms from several industries such as utilities, wholesale, retail, entertainment and recreation, and other services (e.g., Joshi et al. 2010; Saldanha et al. 2017; Ravichandran et al. 2017). The original sample before screening and the sample retained after the selected industries do not appear to be significantly different regarding the key firm characteristics.

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Measurement

Innovation (Amount of filed patents)[5]. Consistent with the existing literature**,** patents count is used as the primary observable measure of innovation and use patent application data for the firm one year after the year of the IT data (i.e., 2007-2009), to incorporate a lag from inputs and outputs. Using the patent application date rather than the issue date is common practice in the literature because it is the earliest point at which we can identify new firm capabilities, and it represents the best measure of the time when patentable creation was actually fully developed and avoids methodological issues caused by the lag (Sampson 2007; Wadhwa and Kotha 2006). Also, measuring innovations in this way limits the possibility of reverse causality.

Analytical information processing capability (AIPC). I measured this capability as a formative construct that captures the deployment of data warehousing and business intelligence software in the firm. These ITs have been identified in prior research as critical for business analytics (Chen et al. 2012; Saldanha et al. 2017). First, for each of the two IT application usage, I computed the ratio of business sites that are equipped with data warehousing and business intelligence software. Next, I used the average ratio of the two IT usage as the measure of AIPC at the firm level.

External information integration capabilities (EIIC). I measured this capability as a formative construct that captures deployment of (1) ERP software and (2) EDI development platform in the firm. First, for each of the two IT application usage, I computed the ratio of

[5] Prior studies also used adjusted patent citation count as an alternative measurement of innovation (e.g., Kleis et al. 2012; Ravichandran et al. 2017). To access robustness, I employed this measurement and obtained similar results.

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business sites that are equipped with ERP and EDI software. Next, I used an average ratio of the two IT usage as the measure of EIIC at the firm level.

Business strategy. Business strategy is represented with a categorical measure, indicating which strategy the firm is currently pursuing. I include in this variable through two binary variables for Defender and Prospectors strategies, using Analyzer strategy as a benchmark. Consistent with existing literature (Delery and Doty 1996; Sabherwal and Chan 2001; Sabherwal and Sabherwal 2007), I utilize a profile deviation analysis, attempting to categorize each firm-year observation with pre-defined ideal profiles using Compustat data. Mainly based on the degree of business aggressiveness, the typology considers Prospectors as first-movers, regarding taking advantages of innovation, and risk-takers (Miles et al. 1978). Defenders, on the other hand, tend to focus on efficiency and follow more stable strategies. Analyzers tend to locate in the middle of the spectrum.

Six strategic attributes, i.e., scope, liquidity, asset efficiency, fixed-asset intensity, long-range liability, and research and development (R&D) were used to capture the strategic profile of each firm. I classify each firm's business strategy per year into the typology of Defender, Analyzer, or Prospector ((Miles and Snow 1978; Miles et al. 1978; Sabherwal and Chan 2001; Sabherwal and Sabherwal 2007; McLaren et al. 2011). For every year, each strategic attribute is normalized with the sample mean and standard deviation. The classification is done based on the proximity of each firm's business strategy to the ideal profiles. High, medium, and low values for ideal business strategy attributes are operationalized as 0.5, 0.0, and -0,5, respectively (Sabherwal and Chan 2001). The root mean square distances each firm's business strategy and the three ideal business strategies are used to calculate the proximity values. The final sample

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contains 711 firm-year observation, classified into 286 Analyzers, 251 Defenders, and 174 Prospectors. Table 2 presents more details.

Table 2. Business Strategy Attributes

Attribute	**Measure**	**Ideal Analyzer**	**Ideal Defender**	**Ideal Prospector**
Scope	Natural log of number of four-digit SIC codes	High	Low	High
Liquidity	Current assets/Current liabilities	Medium	Low	High
Asset efficiency	Sales/Total assets	Medium	High	Low
Fixed-asset intensity	Fixed assets/Total assets	Medium	High	Low
Long-range financial liability	Debt to equity ratio	Low	Medium	High
R&D intensity	R&D expense/Net sales	Medium	Low	High

Control variables. Size, measured by a firm's total asset, was used to account for the scale of resources (Bharadwaj et al. 1999). I controlled a group of financial characteristics, such as R&D expense, controlling for research and innovation related investment, Tobin's q, controlling for growth opportunity, and ROA (Return of assets), controlling for profitability. I

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also controlled for IT portfolio diversification, business diversification, organization liquidity, and firm tenure. Industry dummies were included to control for variance in innovation propensity across industries. Industries were classified as high-tech, low-tech, or neither based on a classification scheme used in prior literature (e.g., Banker et al. 2011; Francis and Schipper 1999; Saldanha et al. 2017).

After I matched firms across the data sets and dropped incomplete observations, the final sample consisted of 711 observations of 354 unique firms. About 48.76% appear once, 33.06% appear twice, and 18.18% appear three times. Table 3 shows the descriptive statistics of and the correlation among the variables. Both IT diversification and business diversification have positively significant correlations with the adjusted patent counts.

I took several additional steps to assess robustness. First, the variance inflation factors were well within acceptable limits, suggesting that multicollinearity is not a problem. Moreover, the correlations between variables are well below the threshold of 0.80, suggesting evidence of discriminant validity (Bagozziet al. 1991; Mithas et al. 2008; Saldanha et al. 2017). Second, because the independent, dependent, and control variables are from different sources and the innovation variable is objective (not perceptual), this mitigates concerns of common method bias. Third, when I used principal components analysis, the measures that comprise AIPC and EIIC loaded positively and significantly onto their first principal components (see the screen plot of the eigenvalues in Appendix A). Forth, for each hypothesis, I used negative binomial models and generalized least squares (GLS) models, and I observed similar patterns, thus increasing confidence in the results (see Appendix B).

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Table 3. Correlations and Descriptive Statistics

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Patent Count	-												
2	AIPC	0.13*	-											
3	EIIC	0.15*	0.35*	-										
4	Defender	-0.02	0.20*	0.23*	-									
5	Prospector	-0.04	-0.22*	-0.20	-0.35*	-								
6	Log of total asset	0.38*	0.41*	0.31*	0.10	-0.08	-							
7	Tobin's q	0.09	-0.15*	-0.14*	-0.05*	-0.13*	-0.04	-						
8	Return on assets	0.12	0.13*	0.13*	0.03	-0.22*	0.20*	0.20*	-					
9	R&D expenditure to total assets	-0.01	-0.31*	-0.33*	-0.17*	0.09	-0.27*	0.38*	-0.32*	-				
10	IT portfolio diversification	-0.02	0.34*	-0.27*	-0.24*	0.17*	-0.01	0.15*	-0.11	0.41*	_			
11	Business diversification	0.21*	0.34*	0.07	0.10	-0.02	-0.02	-0.04	0.01	-0.14*	-0.24*	-		
12	Firm tenure	0.18*	0.44	-0.04	0.26*	-0.21*	0.40*	-0.12	0.12	-0.27	0.34*	0.15*	-	
13	Organization liquidity	0.08	0.09	0.03	0.12	-0.18*	0.19*	0.05	0.11	-0.30*	0.15*	0.02	0.07	-
	Mean	16.23	0.87	1.26	0.35	0.24	8.01	2.06	0.04	0.07	0.48	0.06	0.07	30.30
	Standard deviation	27.74	0.84	1.16	0.48	0.43	1.83	1.06	0.16	0.08	0.50	0.24	0.12	21.35

EMPIRICAL ANALYSIS AND RESULTS

The final sample is longitudinal. Data of IT capabilities, i.e., AIPC and EIIC, and business strategies, i.e., defender (D) and prospector (P) are during the year of 2006-2008, while I use patent count data for the firm one year subsequent to the year of the IT data, i.e., from 2007-2009, for the main analysis. As mentioned, the dependent variable is measured as a count

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of filed innovation. Consistent with prior recommendations (e.g.,Cameron and Trivedi 2013; Hausman et al. 1984; Saldanha et al. 2017), I use negative binomial regressions because of ovedispersion in our dependent variable (the standard deviation of patent count is larger than its mean).

$$Innovation_{it} = \beta_0 + \beta_1 AIPC_{it} + \beta_2 Control_{it} + \mu_i + T_t + \varepsilon_{it}$$

$$Innovation_{it} = \beta_0 + \beta_1 EIIC_{it} + \beta_2 Control_{it} + \mu_i + T_t + \varepsilon_{it}$$

$$Innovation_{it} = \beta_0 + \beta_1 AIPC_{it} + \beta_2 D_{it} + \beta_3 AIPC_{it} \cdot D_{it} + \beta_4 P_{it} + \beta_5 Control_{it} + \mu_i + T_t + \varepsilon_{it}$$

$$Innovation_{it} = \beta_0 + \beta_1 EIIC_{it} + \beta_2 P_{it} + \beta_3 EIIC_{it} \cdot P_{it} + \beta_4 D_{it} + \beta_5 Control_{it} + \mu_i + T_t + \varepsilon_{it}$$

Here, μ_i is a firm-specific fixed effect that gets differenced out in the estimation; T_t captures average changes over time; $AIPC_{it}$ and $EIIC_{it}$ represent each IT-enabled capability score received by firm i at time t, respectively; D_{it} and P_{it} represent whether a firm is classified as a Defender or Prospector, respectively. $Control_{it}$ are controls for firm characteristics that change over time: total assets, R&D expense, and industry dummy. We assume that ε_{it} is a normal i.i.d. variable and calculate heteroscedasticity-robust standard errors that are clustered by firm.

Table 4 shows the effect of AIPC and EIIC on the patent count. In the main model (column 2), I did not find supportive evidence of AIPC on the patent count, suggesting AIPC, i.e., analytical information processing capability, alone failed to positively enhance innovation outcome, echoing prior literature (e.g., Saldanha et al. 2017). The results also show that EIIC has a positive and statistically signification impact on patent count ($p<0.001$). Therefore, as hypothesized, I found that the coefficient of EIIC is positive and statistically significant,

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suggesting that, EIIC, i.e., external information integration capability, positively enhances innovation outcome.

Table 4. H1 and H2 Testing Results

VARIABLES	(1)	(2) Main Model
AIPC		**0.049**
		(0.081)
EIIC		**0.400*** **
		(0.089)
Firm Size		0.655***
		(0.031)
Tobin's q	0.059	0.017
	(0.0457)	(0.051)
Return on assets	0.540**	0.910***
	(0.263)	(0.300)
R&D expenditure to total assets	3.875***	2.691***
	(0.868)	(0.949)
Business diversification	0.029	0.234**
	(0.093)	(0.103)
IT portfolio diversification	0.127	-1.729***
	(0.472)	(0.618)
Firm tenure	0.0079***	0.007**
	(0.002)	(0.003)
Organization liquidity	-0.294	0.452
	(0.390)	(0.459)

Standard errors in parentheses
*** p<0.001, ** p<0.05, * p<0.1

Tables 5 shows results of H3a and H3b. As illustrated in Model 2, compared with external information processing capability, defender firms coupling with analytical information processing capability (AIPC) experience a positive boost on innovation outcome (p<0.001). As shown in Model 3, compared with external information processing capability, firms that are closer to a Prospector strategy, which characterized as high aggressiveness and proactiveness, did benefit from a capability that focuses on exploitation learning (p<0.05). Thus, H3b was

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supported[6]. Although analyzers were the reference group in creating the two dummy variables ("Defender," which is one for firms pursuing a Defender strategy, and zero otherwise, and "Prospector," which is one for firms pursuing a Prospector strategy, and zero otherwise), I ran additional analyses investigating whether analyzer firms are leaning toward one type of the IT-enabled capability, compared with Defender and Prospector, respectively. As shown in Table 6, I failed to observe any positively significant results. Compared with Defender firms, Analyzer firms did not seem to effectively utilize the benefit of analytical information technologies (the coefficient of AIPC*Analyzer is negatively significant, $p<0.05$). Similarly, compared with Prospector firms, Analyzer firms also were not able to enhance innovation outcome via external information processing capability (the coefficient of EIIC*Analyzer is negative and non-significant). Together, these results increase the confidence of the main results.

[6] Through probit models, I tested the reverse causality by regressing patent count on business strategy with one year lag. I found that patent count is not significant in predicting business strategy, suggesting that a firm's choice of business strategy is unlikely to be affected by the prior year's innovation outcome.

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Table 5. H3 Testing Results

VARIABLES	(1)	(2)	(3)
AIPC	-0.065	-0.242***	0.258**
	(0.074)	(0.094)	(0.106)
EIIC	-0.019	-0.072	0.274***
	(0.077)	(0.117)	(0.105)
Defender	0.101	-0.611***	-0.101
	(0.125)	(0.177)	(0.159)
Prospector	-0.121	-0.221*	0.611***
	(0.117)	(0.129)	(0.195)
AIPC*Defender		**0.580*** **	
		(0.156)	
EIIC*Defender		0.0500	
		(0.154)	
AIPC* Prospector			-0.439**
			(0.188)
EIIC* Prospector			**0.433** **
			(0.177)
Firm Size	0.684***	0.674***	0.671***
	(0.037)	(0.035)	(0.035)
Tobin's q	-0.010	0.001	-0.042
	(0.051)	(0.057)	(0.0634
Return on assets	0.434	0.421	1.060***
	(0.298)	(0.264)	(0.334)
R&D expenditure to total assets	4.665***	4.484***	4.126***
	(0.872)	(0.960)	(1.164)
Business diversification	0.063	0.088	0.293***
	(0.089)	(0.082)	(0.099)
IT portfolio diversification	-0.674	-0.322	-2.538***
	(0.523)	(0.618)	(0.711)
Firm tenure	0.003	0.002	0.005*
	(0.002)	(0.003)	(0.003)
Organization liquidity	0.059	0.096	1.129**
	(0.441)	(0.374)	(0.478)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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Table 6. H3 Testing Results: Analyzer

VARIABLES	(1)	(2)	(3)	(4)
AIPC	-0.065	0.071	-0.065	0.071
	(0.074)	(0.098)	(0.074)	(0.098)
Analyzer	-0.101	0.0630	0.121	0.219
	(0.125)	(0.176)	(0.117)	(0.139)
AIPC* Analyzer		**-0.275****		**-0.275****
		(0.132)		**(0.132)**
EIIC	-0.019	-0.089	-0.019	-0.089
	(0.077)	(0.100)	(0.0770)	(0.100)
EIIC* Analyzer		**0.135**		**0.135**
		(0.142)		**(0.142)**
Prospector	-0.222	-0.156		
	(0.135)	(0.144)		
Defender			0.222	0.156
			(0.135)	(0.144)
Firm Size	0.684***	0.691***	0.684***	0.691***
	(0.037)	(0.037)	(0.037)	(0.037)
Tobin's q	-0.010	-0.005	-0.010	-0.005
	(0.051)	(0.051)	(0.051)	(0.051)
Return on assets	0.434	0.399	0.434	0.399
	(0.298)	(0.298)	(0.298)	(0.298)
R&D expenditure to total assets	4.665***	4.576***	4.665***	4.576***
	(0.872)	(0.872)	(0.872)	(0.872)
Business diversification	0.063	0.054	0.063	0.054
	(0.089)	(0.088)	(0.089)	(0.088)
IT portfolio diversification	-0.674	-0.578	-0.674	-0.578
	(0.523)	(0.523)	(0.523)	(0.523)
Firm tenure	0.003	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
Organization liquidity	0.059	0.020	0.059	0.020
	(0.441)	(0.443)	(0.441)	(0.443)
Constant	-1.648*	-1.792*	-1.870*	-1.947**
	(0.959)	(0.962)	(0.969)	(0.968)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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DISCUSSIONS

Main Findings

Using archival data on the patent count, IT-enabled capabilities, and business strategy for 354 unique firms from 2006 to 2009, the analysis yields two main findings, consistent across a variety of estimation models. First, regarding the impact of IT-enabled capabilities, I find that only EIIC has positive impact on innovation outcome, measured as the amount of filed innovation. The positive and significant sign EIIC suggests that external information integration capabilities, rather than analytical information process capabilities, help firms better resources to generate more opportunities for innovation. Furthermore, as argued, the results echo the notion that firms' ability to transform information, knowledge, and inputs from external partners into innovation development lies in their differential IT-enabled capabilities. Specifically, being immersed in the information age, having the ability to collect, compile and, analyze information enables the firm to actively involve customers and other external knowledge contributors, which has shown to be a positive force for driving innovations (e.g., Saldanha et al. 2017).

Second, I find the complementary effect of IT capability and matching business strategy on firm innovation. Although with on direct effect, business strategy became a significant factor after coupling with differential IT-enabled capabilities. Specifically, I find that a prospector strategy complements the link between EIIC and the amount of firm innovation. This further suggests that for prospector firms, which characterized as high in aggressiveness, proactiveness and R&D intensity, is better positioned to use external information integration capability to explore actively and compile knowledge collected from customers and other contributors. I also find supportive evidence of the complementarity between AIPC and coupled defender strategy.

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Considered individually, this type of strategy also did not have a positive and significant impact on the amount of patent.

These results bridge the IS, strategy, and innovation literature to provide a deeper understanding of the role of differentiated IT-enabled capabilities in innovation by explicating the role of AIPC and EIIC in complementing specific kinds of business strategy from the perspective of external knowledge contributor involvement. In summary, I extend the limited but growing literature of IT and innovation by pointing to the salient role of IT in developing intangibles and its intermediate capabilities coupled with business strategy. I also contribute to the strategy literature by investigating its impact on innovation. The results suggest that compared with defenders, prospector firms is more likely to experience an increasing trend in materializing innovation outcome.

Limitations

Although the study shows interesting findings, I recognize several limitations of this study mainly due to data availability. First, this study uses secondary data on relatively large multi-units firms, which limits the generalizability of the findings when it comes to smaller firms. Thus, I call for additional studies to access causality and generalizability. Second, although adjusted patent count is a good measure for reflecting the actual output of firm innovation efforts, patents, in general, only represent only one type of outcome associated with innovation, especially considering not all inventions are patentable or can be patented in an equal magnitude (Griliches 1990). Thus, future studies may investigate the impact on other innovation-related outcomes, such as the innovation diffusion in organizations or in industries, the actual industrial recognition of innovations, speed, commercialization rate, and inimitability of innovation (Leiponen and Helfat 2010,2011; Srivastava et al. 2013). Also, future work could

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examine whether AIPC and EIIC play similar roles with these dimensions of innovation and whether there are any trade-offs in the effects of IT capabilities on various dimensions of innovation.

Contributions and Implications

The process of creating innovations has become a less well-bounded endeavor, involving a diverse network of contributors, such as customers, partners, and other external knowledge contributors (e.g., Han et al. 2012; Nambisan et al. 2017; Saldanha et al. 2017). Recognizing the importance of seeking external collaboration in innovation creation, in the current study, I aimed to unfold which specific IT-enabled capabilities could have direct impacts in this regard. Although prior literature has shed light on the links between IT and innovation (e.g., Kleis et al. 2003; Kleis et al. 2012; Joshi et al. 2010), there is little empirical examination to open the black box of IT, focusing on articulating which IT applications may have a more salient impact on innovation, especially in the context of external contributor involvement. This study contributes to the innovation literature by highlighting two key IT-enabled capabilities and their direct links to innovation. I intended to empirically demonstrate the roles of the importance of different information technologies in driving firms' competitive behavior as manifested in the forms of innovation outcomes. The results enhance the theoretical understanding of the nuanced role of specific types of IT-enabled capabilities. The study highlights the need to carefully consider the role of IT to help tease out the impact of differential capabilities on innovation. Thus, I fill in the gap where prior literature does not fully delineate which specific IT component, or related IT-enabled capabilities, that directly contribute to innovation outcome, materialized as the amount of filed patent. As innovation has become a collaborative endeavor, future research could study

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how specific IT capabilities may help firms leverage external knowledge contributor involvement at different levels in various phases of innovation development.

Also, strategic management is crucial for firms to achieve sustained competitive advantage. In the current essay, drawing on the notion of IT-strategy alignment, I aimed to demonstrate that to facilitate innovation creation, it is the combination of IT-enabled capability and appropriately matching business strategy that makes the difference. By leveraging upon this contextualizing factor, the analysis shows the significance of the moderating role of business strategy on the IT-enabled capability-innovation relationship and may help highlight the nuances of finding the right fit. In other words, although depending on a certain type of business strategy may not be sufficient, the results show that the complementarity between managerial practices and technology artifacts is able to fuel innovation through disciplined configurations. As I did not find a positive impact of the defender strategy, another research path would be to explore which IT-enabled capability or combination of capabilities could offset the negative impact, making creating innovation by gathering ideas inside a success.

For managers, the study points to specific types of capabilities that can help firms harness different information handling skills for innovation. In a hypercompetitive business climate which gathering information, especially from outside sources, is critical, firms need IT capabilities that help them usefully integrate and leverage all information sources. The results provide a justification of investing in specific types of ITs. Moreover, managers need to carefully evaluate their firm's strategy when forming innovation plans that supported by ITs. Merely focusing on pursuing a business strategy may not positively enhance innovation outcome as much as when those practices are accompanied by relevant IT applications that enable specific type of IT capabilities.

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CONCLUSION

Empirical studies in IS and innovation literature have suggested that employing a more collocative approach is increasingly promising in designing and developing nuanced innovations that stand out (e.g., Han et al. 2012; Nambisan et al. 2017). I argue that instead of general IT, specific IT-enabled capabilities facilitate innovation creation through actively analyzing and collecting information gathered from external knowledge contributors. I found that only one of the two capabilities, i.e., external information integration capability, has a positive and significant impact on the amount of filed patent. I further argue that tailored to organizational needs, differentiating business strategy may complement specific IT-enabled capability in innovation creation endeavors. Leveraged upon Miles and Snow's (1984) typology, I found that firms practicing a prospector strategy is more likely to enjoy desirable innovation outcomes when complemented by unitizing external information integration capability. While for Defender firms, they are in a better position when effectively utilizing analytical capabilities.

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REFERENCES

Banker, R. D., Bardhan, I. R., Chang, H., and Lin, S. 2006. "Plant Information Systems, Manufacturing Capabilities, and Plant Performance," MIS quarterly), pp. 315-337.

Barczak, G., Sultan, F., and Hultink, E. J. 2007. "Determinants of It Usage and New Product Performance," Journal of Product Innovation Management (24:6), pp. 600-613.

Bendapudi, N., and Leone, R. P. 2003. "Psychological Implications of Customer Participation in Co-Production," Journal of marketing (67:1), pp. 14-28.

Blumentritt, T., and Danis, W. M. 2006. "Business Strategy Types and Innovative Practices," Journal of Managerial Issues), pp. 274-291.

Brynjolfsson, E., Hitt, L. M., and Yang, S. 2002. "Intangible Assets: Computers and Organizational Capital," Brookings papers on economic activity (2002:1), pp. 137-181.

Burns, T. E., and Stalker, G. M. 1961. "The Management of Innovation,").

Cameron, A. C., and Trivedi, P. K. 2013. Regression Analysis of Count Data. Cambridge university press.

Carbonell, P., Rodríguez-Escudero, A. I., and Pujari, D. 2009. "Customer Involvement in New Service Development: An Examination of Antecedents and Outcomes," Journal of Product Innovation Management (26:5), pp. 536-550.

Chesbrough, H. 2003. "Open Innovation." Boston: Harvard Business School Press.

Cohen, W. M., and Levinthal, D. A. 1990. "Absorptive Capacity: A New Perspective on Learning and Innovation," Administrative science quarterly), pp. 128-152.

Delery, J. E., and Doty, D. H. 1996. "Modes of Theorizing in Strategic Human Resource Management: Tests of Universalistic, Contingency, and Configurational Performance Predictions," Academy of management Journal (39:4), pp. 802-835.

DeSarbo, W. S., Anthony Di Benedetto, C., and Sinha, I. 2005. "Revisiting the Miles and Snow Strategic Framework: Uncovering Interrelationships between Strategic Types, Capabilities, Environmental Uncertainty, and Firm Performance," Strategic Management Journal (26:1), pp. 47-74.

Di Benedetto, C. A., DeSarbo, W. S., and Song, M. 2008. "Strategic Capabilities and Radical Innovation: An Empirical Study in Three Countries," IEEE Transactions on Engineering Management (55:3), pp. 420-433.

Dodgson, M., Gann, D., and Salter, A. 2006. "The Role of Technology in the Shift Towards Open Innovation: The Case of Procter & Gamble," R&D Management (36:3), pp. 333-346.

المنارة للاستشارات

www.manaraa.com

Durmusoglu, S. S., Calantone, R. J., and Sambamurthy, V. 2006. "Is More Information Technology Better for New Product Development?," Journal of Product & Brand Management (15:7), pp. 435-441.

Elmansy, R. 2016. "5 Successful Open Innovation Examples." from http://www.designorate.com/successful-open-innovation-examples/

Enkel, E., Gassmann, O., and Chesbrough, H. 2009. "Open R&D and Open Innovation: Exploring the Phenomenon," R&d Management (39:4), pp. 311-316.

Ettlie, J. E., Bridges, W. P., and O'keefe, R. D. 1984. "Organization Strategy and Structural Differences for Radical Versus Incremental Innovation," Management science (30:6), pp. 682-695.

Finnerty, J. E., Owers, J. E., and Rogers, R. C. 1986. "The Valuation Impact of Joint Ventures," Management International Review), pp. 14-26.

George, S. 2016. "Real Business Innovation Begins with Open Practices." from https://opensource.com/open-organization/16/9/lets-change-talk-innovation

Gulati, R. 1998. "Alliances and Networks," Strategic management journal (19:4), pp. 293-317.

Han, K., Oh, W., Im, K. S., Oh, H., Pinsonneault, A., and Chang, R. M. 2012. "Value Cocreation and Wealth Spillover in Open Innovation Alliances," MIS Quarterly (36:1).

Han, S., and Ravichandran, T. 2006. "Does It Impact Firm Innovativeness: An Empirical Examination of Complementary and Direct Effects," AMCIS 2006 Proceedings), p. 91.

Hausman, J. A., Hall, B. H., and Griliches, Z. 1984. "Econometric Models for Count Data with an Application to the Patents-R&D Relationship." national bureau of economic research Cambridge, Mass., USA.

Hoyer, W. D., Chandy, R., Dorotic, M., Krafft, M., and Singh, S. S. 2010. "Consumer Cocreation in New Product Development," Journal of service research (13:3), pp. 283-296.

Ireland, R. D., Hitt, M. A., Camp, S. M., and Sexton, D. L. 2001. "Integrating Entrepreneurship and Strategic Management Actions to Create Firm Wealth," The Academy of Management Executive (15:1), pp. 49-63.

Joshi, K. D., Chi, L., Datta, A., and Han, S. 2010. "Changing the Competitive Landscape: Continuous Innovation through It-Enabled Knowledge Capabilities," Information Systems Research (21:3), pp. 472-495.

Kleis, L., Chwelos, P., Ramirez, R. V., and Cockburn, I. 2012. "Information Technology and Intangible Output: The Impact of It Investment on Innovation Productivity," Information Systems Research (23:1), pp. 42-59.

Laforet, S. 2008. "Size, Strategic, and Market Orientation Affects on Innovation," Journal of business Research (61:7), pp. 753-764.

المنارة للاستشارات
www.manaraa.com

Lawton, L., and Parasuraman, A. 1980. "The Impact of the Marketing Concept on New Product Planning," The Journal of Marketing), pp. 19-25.

Lee, H., and Choi, B. 2003. "Knowledge Management Enablers, Processes, and Organizational Performance: An Integrative View and Empirical Examination," Journal of management information systems (20:1), pp. 179-228.

Luftman, J., Kempaiah, R., and Nash, E. 2006. "Key Issues for It Executives 2005," MIS quarterly Executive (5:2).

Majchrzak, A., Cooper, L. P., and Neece, O. E. 2004. "Knowledge Reuse for Innovation," Management science (50:2), pp. 174-188.

Majchrzak, A., and Malhotra, A. 2013. "Towards an Information Systems Perspective and Research Agenda on Crowdsourcing for Innovation," The Journal of Strategic Information Systems (22:4), pp. 257-268.

Malhotra, A., Gosain, S., and Sawy, O. A. E. 2005. "Absorptive Capacity Configurations in Supply Chains: Gearing for Partner-Enabled Market Knowledge Creation," MIS quarterly), pp. 145-187.

McConnell, J., and Nantell, T. 1985. "Common Stock Returns and Corporate Combinations: The Case of Joint Ventures," Journal of Finance (40:2), pp. 519-536.

Melville, N., Gurbaxani, V., and Kraemer, K. 2007. "The Productivity Impact of Information Technology across Competitive Regimes: The Role of Industry Concentration and Dynamism," Decision support systems (43:1), pp. 229-242.

Milbrath, S. 2016. "Co-Creation: 5 Examples of Brands Driving Customer-Driven Innovation," Vision Critical: Collective Wisdom Starts Here).

Miles, R. E., and Snow, C. C. 1978. Organizational Strategy, Structure and Process. New York: McGraw-Hill Book Company.

Miles, R. E., and Snow, C. C. 1984. "Designing Strategic Human Resources Systems," Organizational dynamics (13:1), pp. 36-52.

Miles, R. E., Snow, C. C., Meyer, A. D., and Coleman, H. J. 1978. "Organizational Strategy, Structure, and Process," Academy of management review (3:3), pp. 546-562.

Mithas, S., Krishnan, M. S., and Fornell, C. 2005. "Why Do Customer Relationship Management Applications Affect Customer Satisfaction?," Journal of Marketing (69:4), pp. 201-209.

Morgan, L. 2016. "10 Ways Predictive Analytics Improves Innovation." from http://www.informationweek.com/big-data/big-data-analytics/10-ways-predictive-analytics-improves-innovation/d/d-id/1324508

Nambisan, S. 2003. "Information Systems as a Reference Discipline for New Product Development," Mis Quarterly), pp. 1-18.

المنارة للاستشارات
www.manaraa.com

Nambisan, S. 2013. "Information Technology and Product/Service Innovation: A Brief Assessment and Some Suggestions for Future Research," Journal of the Association for Information Systems (14:4), p. 215.

Nambisan, S., Lyytinen, K., Majchrzak, A., and Song, M. 2017. "Digital Innovation Management: Reinventing Innovation Management Research in a Digital World," MIS Quarterly (41:1).

Quinn, J. B., Baruch, J. J., and Zien, K. A. 1997. Innovation Explosion: Using Intellect and Software to Revolutionize Growth Strategies. Simon & Schuster.

Raymond, L., and Bergeron, F. 2008. "Enabling the Business Strategy of Smes through E-Business Capabilities: A Strategic Alignment Perspective," Industrial Management & Data Systems (108:5), pp. 577-595.

Rothwell, R. 1994. "Towards the Fifth-Generation Innovation Process," International marketing review (11:1), pp. 7-31.

Sabherwal, R., and Chan, Y. E. 2001. "Alignment between Business and Is Strategies: A Study of Prospectors, Analyzers, and Defenders," Information systems research (12:1), pp. 11-33.

Sabherwal, R., and Sabherwal, S. 2007. "How Do Knowledge Management Announcements Affect Firm Value? A Study of Firms Pursuing Different Business Strategies," IEEE Transactions on Engineering Management (54:3), pp. 409-422.

Saldanha, T. J., Mithas, S., and Krishnan, M. S. 2017. "Leveraging Customer Involvement for Fueling Innovation: The Role of Relational and Analytical Information Processing Capabilities," MIS Quarterly (41:1).

Scott, W. R. 2001. Institutions and Organizations. SAGE Publications.

Slater, S. F., and Mohr, J. J. 2006. "Successful Development and Commercialization of Technological Innovation: Insights Based on Strategy Type," Journal of Product Innovation Management (23:1), pp. 26-33.

Subramanyam, R., Weisstein, F. L., and Krishnan, M. S. 2010. "User Participation in Software Development Projects," Communications of the ACM (53:3), pp. 137-141.

Sudarsan, R., Fenves, S. J., Sriram, R. D., and Wang, F. 2005. "A Product Information Modeling Framework for Product Lifecycle Management," Computer-aided design (37:13), pp. 1399-1411.

Tanriverdi, H. 2005. "Information Technology Relatedness, Knowledge Management Capability, and Performance of Multibusiness Firms," MIS quarterly), pp. 311-334.

Thomke, S. H. 2006. "Capturing the Real Value of Innovation Tools," MIT Sloan Management Review (47:2), p. 24.

Varadarajan, R., and Yadav, M. S. 2009. "Marketing Strategy in an Internet-Enabled Environment: A Retrospective on the First Ten Years of Jim and a Prospective on the Next Ten Years," Journal of Interactive Marketing (23:1), pp. 11-22.

المنارة للاستشارات
www.manaraa.com

Villalonga, B., and McGahan, A. M. 2005. "The Choice among Acquisitions, Alliances, and Divestitures," Strategic management journal (26:13), pp. 1183-1208.

Warren, Z., McPheeters, M. L., Sathe, N., Foss-Feig, J. H., Glasser, A., and Veenstra-VanderWeele, J. 2011. "A Systematic Review of Early Intensive Intervention for Autism Spectrum Disorders," Pediatrics (127:5), pp. e1303-e1311.

West, J., and Lakhani, K. R. 2008. "Getting Clear About Communities in Open Innovation," Industry and Innovation (15:2), pp. 223-231.

Xue, L., Ray, G., and Gu, B. 2011. "Environmental Uncertainty and It Infrastructure Governance: A Curvilinear Relationship," Information Systems Research (22:2), pp. 389-399.

Yoo, Y., Henfridsson, O., and Lyytinen, K. 2010. "Research Commentary—the New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research," Information systems research (21:4), pp. 724-735.

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APPENDIX A

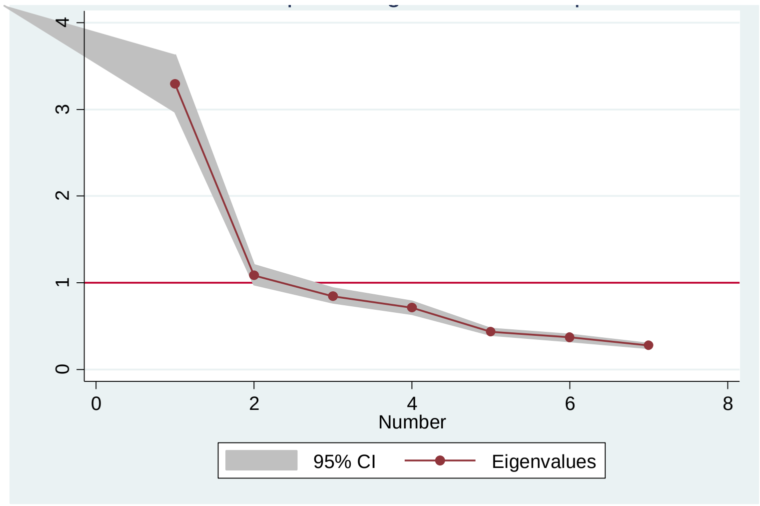

Figure A1. Screenplot of the Principle Component Analysis of AIPC and EIIC

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APPENDIX B

Table B1. Robustness Check with Generalized Least Squares Models

VARIABLES	(1) H1: Main Model	(2) H2	(3) H2: Main Model
AIPC	**0.110**	-0.088	-0.022
	(0.089)	(0.075)	(0.096)
EIIC	**0.258*** **	0.071	0.321***
	(0.065)	(0.055)	(0.070)
defender		0.238*	-0.546***
		(0.124)	(0.209)
prospector		-0.132	0.225
		(0.108)	(0.158)
AIPC*Defender			**0.531*** **
			(0.154)
EIIC*Prospector			**0.255** **
			(0.105)
Firm Size	0.572	0.591***	0.576
	(0.035)	(0.035)	(0.035)
Tobin's q	0.023	0.013	0.023
	(0.054)	(0.045)	(0.054)
Return on assets	0.981***	0.562**	0.936***
	(0.294)	(0.249)	(0.295)
R&D expenditure to total assets	2.575***	4.140***	2.519**
	(0.994)	(0.835)	(0.993)
Business diversification	0.440***	0.026	0.452***
	(0.110)	(0.095)	(0.109)
IT portfolio diversification	-2.047***	-0.434	-2.096***
	(0.640)	(0.540)	(0.631)
Firm tenure	0.017***	0.008***	0.016***
	(0.003)	(0.003)	(0.003)
Organization liquidity	0.754*	-0.279	0.816*
	(0.427)	(0.364)	(0.426)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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INNOVATION AND FIRM PERFORMANCE: THE ROLE OF IT INFRASTRUCTURE GOVERNANCE AND ENVIRONMENTAL UNCERTAINTY

INTRODUCTION

Innovation is a key factor that plays an important role in continuously providing competitive advantages and survival of firms of all sizes and in every industry in an ever-changing environment (Tushman and O'Reilly 1996; Utterback 1994). *Firm innovation* is defined as novel knowledge representations embedded in a firm's inventions, discoveries, and other forms of developed ideas that precede actual commercialization (Joshi et al. 2010). With numerous empirical studies concerning innovation at various levels of analysis (e.g., individual, group, firm, industry, region, and nation, etc.), still, notable gaps in this literature stream exist, especially at the organizational level. While for some researchers, innovation outcome is the endpoint of their quest chain, establishing the link between such innovation outcomes and organizational performance is also crucial as it reveals how innovation creates business value. To support, prior researchers have noted that innovation capability is the most important determinant of firm performance (Mone et al. 1998). Considering the impact of innovation on firm financial performance should not be in isolation. For example, some scholars proposed that firms need to acquire the right set of organizational factors that include strategy arrangement and planning, resources, and skills to successfully exploit entrepreneurial spirit to improve innovation performance (Ireland et al. 2009). Several studies have been carried out to understand the dynamics and processes of innovation in firms, including the influence of antecedents such as top management support and rewards on innovation performance (e.g., Morris et al. 2010; Goodale et al. 2011).

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One of the major managerial levers that enable innovation is governance management (Crossan and Apaydin 2010). Preliminary research has shed light on specialization and centralization (Damanpour 1991; Zaltman et al. 1973), formalization (Damanpour 1991), fit between organizational design and type of innovation (Burns and Stalker 1961). Although much is known about the effect of organizational governance on innovation outcomes, little is known about the potential direct or indirect impact of information technology (IT) governance and how it may moderate the relationship between innovation and firm performance. IT governance typically concerns the patterns of decision making for IT-related activities (Sambamurthy and Zmud 1999; Weill and Ross 2005). As IT investment has been a significant portion of capital budgets in modern organizations and that information technologies are being embedded in a wide range of new products and services, an understanding of how IT governance may influence innovation management and performance will be invaluable to both researchers as well as practitioners. Thus, the first goal of this research is to investigate the potential moderating impact of IT governance on innovation-firm performance relationship.

Traditionally, innovation has been created and marketed under closed settings, usually within one focal organization. Recently, as innovation has become much more open, global, and collaborative in nature and a new paradigm of open innovation has emerged, investigations on the external market environment are warranted. However, little attention has been paid to the environmental conditions, i.e., the level of environmental uncertainty, under which innovations are more likely to generate desirable business values, with a few exceptions focusing on its sole moderating effect on the relationship between innovation strategy execution and innovation performance (e.g., Oke et al. 2012). Also, literature has suggested that environmental uncertainty is often intertwined with the management of IT governance (e.g., Brown and Magill 1994; Xue

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et al. 2011). As innovation is becoming increasingly digitized and less well-bounded (Nambisan 2013; Nambisan et al. 2017), managers are constantly facing the challenge of applying the most effective IT governance mode in an uncertain market environment to facilitate innovation creation. Only considering the sole impact of environmental uncertainty does not suffice because IT governance mode is equally critical. Therefore, drawing upon the contingency theory, our second goal is to present that both IT governance and environmental uncertainty serve as potential moderators of the relationship between innovation and firm performance. In the current research, *IT infrastructure governance* is defined as the pattern of decision making for IT-related activities in general, and IT procurement in particular. *Environmental uncertainty* is manifested as industry clockspeed (Fine 1984).

The remainder of the paper is organized as follows. First, research on interconnections among IT governance, environmental uncertainty, and innovation are reviewed. Next, we formulate a dual-moderation model for innovation and firm performance with associated hypotheses. A research design with data collection and analysis plan is proposed. Finally, the paper concludes with a discussion of potential contributions.

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LITERATURE REVIEW

Environmental Uncertainty

Environmental uncertainty has been intensively studied in strategic management, organizational theory, as well as IS fields. Dess and Beard (1984) first proposed three dimensions that collectively explain the most variance: *munificence, dynamism, and complexity*. *Munificence* concerns the extent to which the environment can support sustained growth (Dess and Beard 1984). A munificent environment may enable organizational growth and stability, which in turn allows the generation of slack resources. *Dynamism* refers to the frequent turnover and industrial unpredictability (Dess and Beard 1984; Keats and Hitt 1988). In a dynamic market, patterns are absent, and changes in demands are hard to predict (Dess and Beard 1984; Xue et al. 2011). Last, *complexity* describes the heterogeneity and the number of an organization's activities that a firm need to face (Dess and Beard 1984; Xue et al. 2011). In a more dynamic industry, managers may perceive greater information-processing requirements as they need to deal with more diverse competitors. To sum up, these three dimensions reflect a rich history of theory and research on major environmental characteristics and provide the basis for our subsequent theorizing.

Early empirical studies have documented the importance of innovation as a competitive advantage to achieve superior performance in highly uncertain environments (Miller and Friesen 1982). Duncan (1972) reported that firms are inclined to continuously introduce revolutionary innovations that differentiate their products from the existing ones when environmental dynamism is high. Also, when experiencing high environmental complexity, by acquiring external knowledge from outside agencies, firm seek innovations to achieve superior performance (Utterback 1971). Kimberly and Evanisko (1981) further show that firms tend to

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become competitive through implementing innovative technological, organizational controls, and new processes to launch innovation product and services outperform competitors in a hostile environment.

IT Governance

Managing corporate IT infrastructure has been crucial to the viability and operations of modern organizations as those infrastructures provide the foundation of the IT resources shared throughout a firm (Broadbent et al. 1999). What's more, it is imperative to fully understand the role of IT governance as the significant impact of information technology investments and IT-related decision-making processes on organizational success is evident (Dean and Sharfman 1996; Devaraj and Kohli 2003). Despite the significance of understanding IT governance, according to Weill and Ross (2005), among 300 sampled enterprises, only one-third senior managers claimed knowing how IT is governed at his or her company. With no doubt, having a clear understanding of IT governance brings huge advantages. Companies that effectively govern IT resources generate profits that are 20% higher than those of other companies pursuing similar strategies. They also experience higher returns on equity and growth in market capitalization (Weill and Ross 2005).

As modern innovations become increasingly digitized, IT governance is also practically important to innovation management. In such a context, IT governance is associated with authority and communication patterns among innovators regarding who should be responsible for managing IT resource in innovation projects (Weil and Ross 2004). In multiunit/multibusiness firms, such IT governance concerns the tools and resources available to innovators, management of all organization units that are related to IT or research services, as well as the location of IT resources (Tarafdar and Gordon 2007). Some studies have been

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conducted to understand the impact of IT governance on facilitating organization innovations. For example, Tarafdar and Gordon (2007) identify IT governance as one of the key IS competencies that may influence innovation creation (Tarafdar and Gordon 2007). Through a case study at a U.S. hospital, they conclude that IT governance could enable the creation of structures and mechanisms for effectively managing technical resources and facilitate innovations through creating liaison positions, forming dedicated project teams, and standardizing IT infrastructure. Table 1 presents more prior studies on the impacts of environmental uncertainty and IT governance on innovation respectively.

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Table 1. Illustrative Prior Studies on Impacts of Environmental Uncertainty and IT governance on Innovation[7]

Study	Key finding
Environmental Uncertainty	
Covin and Slevin 1989	Firms in volatile and hostile environments had a higher innovation performance than those in stable environments.
Duncan 1972	Firms are inclined to continuously introduce revolutionary innovations that differentiate their products from the existing ones when environmental dynamism is high.
Eisenhardt and Tabrizi 1995	Innovation is harder to perform in firms in an uncertain environment.
Jansen et al. 2006	Creating new niches and targeting emerging markets is more effective in changing environments
Kimberly and Evanisko 1981	Firms become competitive through implementing innovative technological, organizational controls, and new processes to launch innovation product and services outperform competitors in a hostile environment.
Li and Atuahene-Gima 2001	Environmental turbulence is a factor that influences the effectiveness of new product innovation strategy in Chinese new technology ventures.
Miller and Friesen 1982	In highly uncertain environments, innovation is a competitive advantage to achieve superior performance.
Utterback 1971	When experiencing high environmental complexity, by acquiring external knowledge from outside agencies, firms seek innovations to achieve superior performance.
Vincent et al. 2004	In a turbulent environment, the effectiveness of a firm's effort in generating new opportunities and innovations increases.
Zahra et al. 1999	Environmental uncertainty is a key moderator to the relationship between technology strategy and new venture performance.
IT Governance	
Tarafdar and Gordon 2007	Effective IT governance enables the creation of structures and mechanisms for effectively managing technical resources and facilitating use buy-in of the innovations.
Peterson et al. 2000	Innovation-oriented firms adopt more integrated IT governance design.
Schwarz and Hirschheim 2003	IT governance heavily affects the practical IT capabilities, such as IT-enabled value innovation capability.
Weill and Ross 2005	The fast-growing companies that are focused on innovation tend to use a decentralized IT governance mode.

[7] This table is not exhaustive and lists only new representative empirical studies on IT-innovation relationship to show the relevance and novelty of the current study.

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IT Governance and External Environment

As aforementioned, both IT governance and environmental characteristics are equally relevant when managing organization innovations. Also, the complex market environment that a focal firm faces may ultimately influence how it governs IT resources (Ansoff 1965; Hitt and Tyler 1991). IS scholars already mark that changing external IT environment often influences IT-related management in organizations (e.g., Benamati and Lederer 2001; Benamati et al. 1997). Research shows that competition affects the allocation of IT decision rights within corporations (Brown 1997). For example, Eisenhardt and Bourgeois (1988) document that firms tend to follow a more centralized hierarchy in high velocity, competitive environments. Xue and other researchers also find that IT governance may be influenced by environmental factors including competitive pressures, institutional pressures, and access to external resources (Xue et al. 2008).

Besides these general comments regarding the relationship between IT governance and external environment, one study has specifically dived into this enduring topic. In particular, by investigating a sample of over 1000 business units, Xue et al. (2011) conclude that the relationship should be described in a curvilinear fashion, i.e., when environmental uncertainty increases from low to high, firms tend to decentralize their IT infrastructure decisions to the business units to enhance their responsiveness; and then centralize their IT infrastructure decisions to the headquarters as uncertainty increases. Based on prior studies, we thus expect that IT governance and external environment will jointly influence the relationship between organization innovation and firm performance.

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RESEARCH MODEL

Impact of IT Infrastructure Governance

Based on existing literature, decisions of IT investment can be triggered by various levels within organizations, ranging from senior executives, middle-level managers, to front-line specialists (Weill and Olson 1989). Recently, many fast-growing companies are focused on innovation and time to market. For them, effective governance should align IT investments with business priorities and determine who makes IT-related decisions and be responsible as such firms often rely on local accountability (Weill and Ross 2005). To better enhance revenue growth, these innovation-centric firms seek to maximize responsiveness to local customer needs and to minimize constraints on creativity and business unit autonomy by establishing less technology and business-process standardization. Subsequently, they require appropriate governance mechanisms to support unit-level autonomy. Therefore, we propose that, in general, a more decentralized IT governance may be more beneficial.

Scholars have noted that it is paramount for firms to innovate in a modern environment characterized by hypercompetition. Rapid competitive moves require firms to continuously innovate to create new advantages (Dess and Picken 2001; Tushman and O'Reilly 1996). Thus, with such a market environment, a key consideration in the choice of IT infrastructure governance is the need for in time responsiveness via local information processing. Since innovations have become more global and collaborative, firms are forced to react to a more diverse set of actors, i.e., customers, partners, and even competitors promptly. Although centralization of IT infrastructure brings the benefits of economies of scale, reducing the unit costs of IT infrastructure for each business unit, such governance structure may hinder the capability of providing fast responses when facing disruptions. For example, in one of their

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illustrative cases, Weill and Ross (2005) show that a more decentralized IT governance enables the firm to innovate and grow its business base achieved by focusing on rapid speed of delivery. According to Jensen and Meckling (1992) theory, to be efficient, decision rights should be co-located with the knowledge needed to make those decisions. In multiunit/multibusiness firms, the information needed to provide local responses tend to reside with business units. Thus, if employing a centralized governance mode, the resulting transmission may introduce information delays and misconceptions that subsequently hurt the quality and timeliness of innovation-related decision making (Jensen and Meckling 1992). As a result, business units are better positioned to make IT-related decisions, such as the procurement of IT infrastructure, to provide appropriate responses (Anand and Mendelson 1997). Also, a centralized IT infrastructure governance is always associated with technology and business process standardization (Weill and Ross 2005; Tarafdar and Gordon 2007). However, based on the Agency theory, agents, i.e., business units, may not share the same interest with its headquarter. In IT procurement context, business units may have specific needs tailored to their own technical demands to innovate. As a result, a firm may consist of business units with varied IT needs. Evidence suggests that a firm with more IT-diversified business units may be more inclined to participate in innovation projects as the perceived risk is reduced(e.g., Garcia-Vega 2006; Quintana-García and Benavides-Velasco 2008). Since many innovations are designed to solve unrelated problems, companies that have more variance in business unit level IT portfolios may capture more opportunities and technical possibilities to benefit largely from their own research activities (Nelson 1959). Thus, centralization and standardization of IT infrastructure may fail to meet the varying needs of different business units as well as of various innovation projects.

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H1: Decentralized IT infrastructure governance will positively moderate the influence of innovation outcomes on firm performance.

Joint Impact of IT Infrastructure Governance and Environmental Uncertainty

Existing literature has documented the importance of innovation as a competitive weapon to achieve superior performance in highly uncertain environments (Duncan 1972; Kimberly and Evanisko 1981; Miller and Friesen 1982; Utterback 1971), as well as the relationship between environmental uncertainty and IT governance (Brown and Magill 1994; Brown 1997; Xue et al. 2011). Leveraging upon the contingency theory, we thus aim to theorize the joint impact of IT infrastructure governance and environmental uncertainty on innovation. This particular view has been employed to understand potential contingency variables as moderators in innovation research (e.g., Covin and Slevin 1989; Boulding and Staelin 1995; Li and Atuahene-Gima 2001). The central proposition of the contingency theory is that the best way to organize a firm should depend on the nature of the environment (Burns and Stalker 1961; Lawrence and Lorsch 1967; Scott 2001). In other words, an organization will utilize the most appropriate governance mechanism that facilitates innovation creation and firm performance in varied environmental contexts. Thus, to take a step further from the last hypothesis, we present more comprehensive theorizing, considering both contextual factors.

There has been some evidence in the existing literature that shows that innovation (Covin and Slevin 1989; Levinthal and March 1993; Oke et al. 2012; Zahra et al. 1999) depends on environmental factors. For example, Covin and Slevin (1989) report that firms tend to experience higher innovation performance in volatile and hostile environments. Similarly, Oke et al. (2012)

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find that innovation strategy execution leads to better performance when environmental uncertainty is high compared to when it is low. When experiencing a less uncertain environment (i.e., less dynamic, munificent, and complex), firms may be willing to exert risky efforts, such as actively gaining access to a variety of new and alternative technological knowledge domains which may influence a firm's propensity to transform knowledge and find new ways to solve existing problems. The resulting ability to search for complementarities and novel solutions accelerates the rate of invention. For example, IS scholars have suggested that achieving knowledge diversity catalyzes radical innovation (e.g., Carlo et al. 2012; Shenkar and Li 1999). Thus, a decentralized IT infrastructure governance that supports business unit level technology diversification is more desirable to facilitate innovation creation in a less uncertain environment.

However, when uncertainty increases to a higher level, compared to centralization, a more decentralized governance mode may raise more issues of control. Agency theory notes that the interest of agents (i.e., business units) may not always align with corporate goals. Thus, a centralized governance mode may ensure that all resources are focusing on serving the most significant corporate innovation projects, instead of letting business units make their decisions which may not necessarily be in the overall innovation interest of the firm (Jensen and Meckling 1992; Holmstrom and Milgrom 1991). In addition, in a highly uncertain environment, firms normally need to deal with huge changes such as supply/demand disruptions caused by natural disaster. Under such circumstances, i.e., with the environment being more dynamics, more open to business opportunities, and more complex, an individual business unit may not have the capability to respond appropriately as that would require an overall firm-level consideration that satisfies the corporate's need.

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Further, firms with centralized governance can also benefit from coordination. Innovation has become much more collaborative and involves a diverse network of partners and emphasizing distributed innovation processes (Chesbrough 2003; Sawhney and Nambisan 2007). Participating in open innovation alliances has become an efficient strategy in pursuit of knowledge inflows and outflows to seek innovation creation. Thus, since innovations may span many processes involving multiple units or even multiple firms, IT infrastructure standardization enabled by centralization governance could ensure different parts of the systems would work seamlessly with one another, minimizing the problem of data integration. In other words, in highly uncertain environments, centralized governance reduces the cost of coordination across different units or firms (Tushman and Nadler 1978) and enable the exploitation of cross-unit or cross-firm synergies.

H2: Industry clock-speed and IT infrastructure governance will jointly moderate the influence of innovation outcomes on firm performance such that a) in low clock-speed industries, firms with more decentralized governance will observe a positive relationship between innovation outcomes and firm performance; and b) in fast clock-speed industries, firms with more centralized governance will observe a positive relationship between innovation outcomes and firm performance.

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METHOD

Data and Sources

To empirical test the model, I collected and compiled secondary data from several sources. I obtained IT application information from the Harte Hanks Intelligence (CI) Data between 2005 and 2008. CI collects business unit-level data annually on the quantity of IT infrastructure in firms using surveys, site visits, physical audits, and telephone interviews initially at the site-level. The CI data have been widely used by IS scholars (e.g., Brynjolfsson et al. 2002; Kleis et al. 2012; Melville et al. 2007; Xue et al. 2011). All business units belong to large, multi-divisional companies. Firm-level patent count data was obtained from Kogan et al. (2017) between 2006 and 2009. Data on controls were obtained from the Compustat database between 2007 and 2010.

As I intended to study the impact of innovation on firm performance, I carefully examined the sample. Consistent with the literature, I dropped firms from several industries such as utilities, wholesale, retail, entertainment and recreation, and other services, as firms from these industries do not have a history of systematic parenting practice (e.g., Joshi et al. 2010; Saldanha et al. 2017; Ravichandran et al. 2017). The original sample before screening and the sample retained after the selected industries do not appear to be significantly different regarding the key firm characteristics.

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Measurement

Innovation[8] *(Amount of filed patent):* Consistent with the existing literature**,** I used patents counts as the primary observable measure of innovation and use patent application data for the firm one year after the year of the IT data (i.e., 2006-2009), to incorporate a lag from inputs and outputs. Using the patent application date rather than the issue date is common practice in the literature because it is the earliest point at which we can identify new firm capabilities, and it represents the best measure of the time when patentable creation was actually fully developed and avoids methodological issues, such as citation accretion and truncation, caused by the lag (Sampson 2007; Wadhwa and Kotha 2006). Also, measuring innovations in this way limits the possibility of reverse causality.

IT infrastructure governance[9]. Each unit may be responsible for three IT infrastructure procurement decision (i.e., PC, server, and network) (Xue et al. 2011). First, for each site, I created a dummy that takes 0 if at least two procurement decision is made by business unit managers, and 1 otherwise. Next, for each firm, I took the average of the site level dummy weighted by site employee number as the firm level measurement for IT infrastructure governance.

Industry clockspeed. I chose Fine's (1998) classification to identify fast- and slow-clockspeed industries. Prior literature has established the convergent, discriminant, and nomological validity of Fine's measures (e.g., Mendelson and Pillai 1999; Nadkarni and

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[8] Prior studies also used adjusted patent citation count as an alternative measurement of innovation (e.g., Kleis et al. 2012; Ravichandran et al. 2017). To access robustness, I employed this measurement and obtained similar results.

[9] As a robustness check, I also considered that a firm has adopted a centralized governance mode when two-third or three-fourth of business units have adopted the same governance mode. The alternative measures produce consistent results.

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Narayanan 2007). In the framework, Fine identified seven fast clockspee industries (personal computers, compute aided software engineering, toys and games, athletic footwear, semiconductors, movie and cosmetics) and nine slow clockspeed industries (commercial aircraft, military aircraft, tobacco, steel, ship-building, petrochemicals, paper, electricity, and diamond mining). I identified these industries based on their four-digit Standard Industry Classification (SIC) codes. Table 1 shows the distinctions of these industries as well as their four-digit SIC codes.

Table 1. Description of Fast-clockspeed and Slow-clockspeed Industries

Industry (SIC)	Four-digit SIC code	The period of new product introduction	Average number of years of capital equipment being depreciated	The average time span between new corporate strategic actions introduced by all firms in each industry
Fast-clockspeed industries				
Personal computer	3571	<6 months	2-4 years	2-4 years
Computer-aided software engineering	7373	6 month	2-4 years	2-4 years
Semiconductor	3674	1-2 years	2-3 years	3-10 years
Movie industry	7812	<3 month	<1 year	2-4 years
Athletic footwear	3149	<1 year	5-15 years	5-15 years
Toys and games	3944	<1 year	5-10 years	5-15 years
Cosmetics	2844	2-3 year		10-20 years
Slow-clockspeed industries				
Aircraft	3721	10-20 years	5-30 years	20-30 years
Tobacco	2111, 2112	1-2 years	20-30 years	20-30 years
Steel	3324, 3325	20-40 years	10-20 years	50-100 years
Shipbuilding	3731	25-35 years	5-30 years	10-30 years
Petrochemicals	2911	10-20 years	20-40 years	20-40 years
Paper	2621	10-20 years	20-40 years	20-40 years
Diamond mining	1499	>100 years	20-30 years	50-100 years

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Firm performance. I used Tobin's q to measure firm performance as suggested by prior studies on IT impacts (e.g., (Hitt and Brynjolfsson 1996; Bharadwaj et al. 1999). Tobins'q represents a market-based measure of firm value, which is forward looking, risk-adjusted, and less vulnerable to changes in accounting practices. A Tobin's q value above one indicates that the long-run equilibrium market value of the firm is greater than the replacement value of its assets signifying an unmeasured source of value (Bharadwaj et al.1999). Tobin's q was calculated as the sum of the market value of equity (price per share at the end of the fiscal year before the announcement multiply by the number of shares outstanding), total liability, and the liquidating value of preferred stock, divided by the book value of the total assets.

Control variables. I used log values of the firm's total number of employee to control for the firm size. A group of financial characteristics, such as R&D expense, industry performance, industry capital intensity, organization liquidity, and firm tenure was included. To evaluate the moderating effect of industry change rate, I controlled for another facet of industry change, i.e., environmental turbulence measured as growth in industry sales (Dess an Beard 1984; Nadkarni and Narayanan 2007). This control was calculated using a two-step procedure. First, the natural logarithm of the total sales of four-digit NAICS industries was regressed against an index variable of years, over a period of five years. Then the antilog of the regression coefficient was used as the measure for munificence. Industry dummies are used to represent the industry sector of which the firm belongs.

After I matched firms across the data sets and dropped incomplete observations, the final sample consisted of 1,167 observations of 354 unique firms. About 48.76% appear once, 33.06% appear twice, and 18.18% appear three times. Table2 and 3 show more details.

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Table 2. Correlation Table

		1	2	3	4	5	6	7	8	9	10	11
1	Tobin's q	-										
2	IT governance	-0.16*	-									
3	Innovation	0.05	-0.08	-								
4	Industry fast-clockspeed	-0.03	0.09	0.06	-							
5	Environmental turbulence	0.03	-0.02	-0.01	-0.04	-						
6	Firm size	0.18*	-0.28*	0.32*	-0.23*	0.03	-					
7	R&D expenditure to total assets	-0.30*	0.19*	0.06	0.35*	-0.003	-0.02	-				
8	Industry performance	0.17*	-0.06	-0.01	0.20*	0.002	0.05	-0.07	-			
9	Industry capital intensity	-0.04	0.12*	0.03	0.05	-0.09	-0.04	-0.06	0.07	-		
10	Organization liquidity	-0.02	0.20*	-0.09	0.18*	-0.04	-0.02	-0.33*	0.23*	0.02	-	
11	Firm tenure	-0.13*	-0.04	-0.01	-0.13*	-0.02	0.01	0.19*	-0.05	0.001	0.10*	-

Table 3. Summary Statistics

Variable	Mean	Std. Dev.
Tobin's q	1.83	0.94
IT governance	0.07	0.25
Innovation	16.30	25.66
Industry fast-clockspeed	0.11	0.31
Environmental turbulence	4.88	18.69
Firm size	8.76	1.77
R&D expenditure to total assets	0.06	0.08
Industry performance	1.61	0.50
Industry capital intensity	1.28	0.66
Organization liquidity	2.52	1.84
Firm tenure	32.54	21.72

I took several additional steps to assess robustness. First, the variance inflation factors were well within acceptable limits, suggesting that multicollinearity is not a problem. Moreover, the correlations between variables are well below the threshold of 0.80, suggesting evidence of discriminant validity (Bagozziet al. 1991; Mithas et al. 2008; Saldanha et al. 2017). Second,

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because the independent, dependent, and control variables are from different sources and the innovation variable is objective (not perceptual), this mitigates concerns of common method bias.

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EMPIRICAL ANALYSIS AND RESULTS

The final sample is longitudinal in nature. IT governance data (GOV) was collected for the period 2005-2008, patent application data (IN) was collected a year after the year of the IT data, i.e., from 2006-2009. Firm performance and all control variables were measured during the years of 2007-2010, for the main analysis. I used panel analysis with industry and year fixed effects on an unbalanced panel of firms observed annually.

$$Firm\ Performance_{it} = \beta_0 + \beta_1 IN_{it} + \beta_2 GOV_{it} + \beta_3 IN_{it} \cdot GOV_{it} + \beta_4 Control_{it} + \mu_i + T_t + \varepsilon_{it}$$

$$Firm\ Performance_{it} = \beta_0 + \beta_1 IN_{it} + \beta_2 GOV_{it} + \beta_3 EN_{it} + \beta_4 IN_{it} \cdot GOV_{it} + \beta_5 IN_{it} \cdot EN_{it} + \beta_6 GOV_{it} \cdot EN_{it} + \beta_7 IN_{it} \cdot GOV_{it} \cdot EN_{it} + \mu_i + T_t + \varepsilon_{it}$$

Here, μ_i is a firm-specific fixed effect that gets differenced out in the estimation; T_t captures average changes over time $Control_{it}$ are controls for firm characteristics that change over time: size, R&D expense, industry performance, industry capital intensity, organizational slack and leverage. I assume that ε_{it} is a normal i.i.d. variable and calculate heteroscedasticity-robust standard errors that are clustered by firm.

Table 4 shows the results of the effect of IT governance on the innovation-performance relationship. In model 2, the coefficient of IT governance*Innovation is positively significant ($p<0.05$). Thus, H1 is supported as hypothesized, suggesting that decentralized IT infrastructure governance positively enhance the influence of innovation outcomes on firm performance.

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Table 4. H1 Testing Results

VARIABLES	(1)	(2) Main Model
IT governance	0.010	-0.106
	(0.109)	(0.121)
Innovation	0.003**	0.001
	(0.001)	(0.001)
IT governance* Innovation		**0.010****
		(0.003)
Firm size	-0.021	-0.023
	(0.023)	(0.023)
R&D expenditure to total assets	4.335***	4.343***
	(0.844)	(0.842)
Industry performance	2.002***	1.991***
	(0.746)	(0.740)
Industry capital intensity	0.002	0.002
	(0.001)	(0.001)
Organization liquidity	0.032	0.031
	(0.046)	(0.046)
Environmental turbulence	0.0004	0.0004
	(0.001)	(0.001)
Firm tenure	-0.002	-0.002
	(0.001)	(0.001)
R-squared	0.262	0.266

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Tables 5 and 6 shows the results of H2. In both tables, I first enter the controls and main effects of fast-/slow-clockspeed, IT governance, and innovation (Model 1). I then add the three-way interactions (Model 2). In Table 5, the coefficient of Innovation* Industry slow clock-speed is positively significant, suggesting in a less uncertain industry environment, there is a positive relationship between innovation and performance. The coefficient of the three-way interaction term, i.e., IT governance *Innovation* Industry slow clock-speed is negatively significant, suggesting in a less uncertain industry environment, a more centralized IT governance mode is

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detrimental to the innovation-performance relationship. In other words, a more decentralized IT governance is desired, supporting H2a.

In Table 6, the coefficient of Innovation* Industry fast clock-speed is negative, suggesting that a more uncertain industry environment has a negative, yet insignificant, impact on the innovation-performance relationship. The coefficient of the three-way interaction term, i.e., IT governance *Innovation* Industry fast clock-speed is positively significant ($p<0.05$), suggesting in a more uncertain industry environment, practicing a more centralized IT governance enhances the innovation-performance relationship, supporting H2b. Taken together, H2 is supported.

To further examine the significant three-way interactions, I median-split the sample based on the IT governance mode, producing two subsamples. I then conduct regressions similar to Model 2 in Tables 5 and 6. Results shown in Table 7 are similar to the main results. In the split-sample analysis for a sample with a more decentralized IT governance, the coefficient of Fast-clockspeed*Innovation is negatively significant, suggesting decentralization fits in an industry characterized as slow-moving. While in the split-sample analysis for a sample with a more centralized IT governance, the coefficient of Fast-clockspeed*Innocation is positively significant, suggesting centralization fits in an industry characterized as fast-moving.

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Table 5. H2a Testing Results

VARIABLES	(1)	(2) Main Model
IT governance	0.008	0.174
	(0.109)	(0.139)
Innovation	0.0025**	0.002
	(0.001)	(0.002)
Industry fast-clockspeed	0.132	0.00358
	(0.141)	(0.005)
IT governance* Innovation		0.452
		(0.377)
IT governance* fast-clockspeed		-1.090**
		(0.441)
Innovation* fast-clockspeed		-0.010**
		(0.005)
IT governance *Innovation* fast-clockspeed		**0.018****
		(0.009)
Slow-clockspeed	0.198*	0.101
	(0.114)	(0.260)
Firm size	-0.021	-0.011
	(0.023)	(0.030)
R&D expenditure to total assets	0.002	0.003*
	(0.002)	(0.002)
Industry performance	0.033	-0.027
	(0.046)	(0.084)
Industry capital intensity	4.166***	4.339***
	(0.879)	(1.065)
Organization liquidity	1.967***	1.715**
	(0.750)	(0.792)
Environmental turbulence	0.006	-0.004
	(0.001)	(0.003)
Firm tenure	-0.002	-0.003
	(0.001)	(0.002)
R-squared	0.264	0.434

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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Table 6. H2b Testing Results

VARIABLES	(1)	(2) Main Model
IT governance	0.008	-0.091
	(0.109)	(0.105)
Innovation	0.003**	-0.0004
	(0.001)	(0.001)
Industry slow-clockspeed	0.198*	0.005
	(0.114)	(0.003)
IT governance* Innovation		0.202
		(0.149)
IT governance* Slow-clockspeed		-0.997*
		(0.527)
Innovation* Slow-clockspeed		0.010*
		(0.005)
IT governance *Innovation* Slow-clockspeed		**-0.022***
		(0.013)
Fast-clockspeed	0.132	0.329***
	(0.141)	(0.126)
Firm size	-0.021	0.0486**
	(0.023)	(0.024)
R&D expenditure to total assets	0.002	0.001
	(0.001)	(0.002)
Industry performance	0.033	-0.006
	(0.046)	(0.048)
Industry capital intensity	4.166***	2.989***
	(0.879)	(0.583)
Organization liquidity	1.967***	0.0285
	(0.750)	(0.024)
Environmental turbulence	0.001	0.0011
	(0.001)	(0.001)
Firm tenure	-0.002	-0.002*
	(0.001)	(0.001)
R-squared	0.264	0.216

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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Table 7. Split-Sample Analyses

VARIABLES	(1) IT Governance: More Decentralized	(2) IT Governance: More Centralized
Industry fast-clockspeed	0.370*	-0.526
	(0.223)	(0.766)
Innovation	0.003*	0.002
	(0.002)	(0.002)
Innovation* fast-clockspeed	**-0.008***	**0.008***
	(0.005)	**(0.004)**
slow-clockspeed	0.481***	-0.191
	(0.129)	(0.770)
Firm size	-0.044	-0.050
	(0.042)	(0.036)
R&D expenditure to total assets	0.002	0.077**
	(0.002)	(0.033)
Industry performance	0.043	-0.041
	(0.063)	(0.078)
Industry capital intensity	3.924***	3.657***
	(1.244)	(0.854)
Organizational slack	2.183*	0.803*
	(1.157)	(0.466)
Environmental turbulence	0.003	-0.001
	(0.003)	(0.005)
Firm tenure	-0.003	-0.003
	(0.003)	(0.002)
Observations	456	476
R-squared	0.309	0.456

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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DISCUSSIONS

Main Findings

While for some researchers, innovation outcome is the endpoint of their quest chain, establishing the link between such innovation outcomes and organizational performance is also crucial as it reveals how innovation creates business value. Prior literature has proposed that firms need to require the right set of organizational factors that include strategy arrangement and planning, resources, and skills to successfully exploit entrepreneurial spirit to improve innovation performance (Ireland et al. 2009). One of those major managerial levers that enable innovation is governance management (Crossan and Apaydin 2010), or in particular, IT governance management. Also, innovation has become much more open, global, and collaborative (Nambisan 2013; Nambisan et al. 2017), investigations on the external market environment are warranted. Also, literature has suggested that environmental uncertainty is often intertwined with the management of IT governance (e.g., Brown and Magill 1994; Xue et al. 2011). As innovation is becoming increasingly more digitized and less well-bounded (Nambisan 2013; Nambisan et al. 2017), managers are constantly facing the challenge of applying the most effective IT governance mode in uncertain market environments to facilitate innovation creation. Thus, this essay explored the impacts of IT governance and external environmental dynamics, specifically industry clockspeed, in conjunction with innovation on organizational performance.

Using archival data 354 unique firms from 2006 to 2010, the analysis yields two main findings, consistent across a variety of estimation models. First, regarding the impact of IT governance, I found a statistically significant moderation on the innovation-performance relationship. The negative sign of the interaction suggests that compared with a centralized IT infrastructure governance, a decentralized mode is more desired in helping firm materialize the

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advantages gained from ideated innovation outcomes. Second, I found evidence that environmental uncertainty and IT infrastructure governance will jointly moderate the influence of innovation outcomes on firm performance. In particular, \in a less uncertain environment, firms with more decentralized governance will observe a positive relationship between innovation outcomes and firm performance. While in a more uncertain environment, firms with more centralized governance will observe a positive relationship between innovation outcomes and firm performance.

Limitations

Although the study shows interesting findings, I recognize several limitations of this study mainly due to data availability. First, although adjusted patent count is a good measure for reflecting the actual output of firm innovation efforts, patents, in general, only represent only one type of outcome associated with innovation, especially considering not all inventions are patentable or can be patented in an equal magnitude (Griliches 1990). Thus, future studies may investigate the impact on other innovation-related outcomes, such as the innovation diffusion in organizations or industries, the actual industrial recognition of innovations, speed, commercialization rate, and inimitability of innovation (Leiponen and Helfat 2010,2011; Srivastava et al. 2013). Second, further research is needed to generalize the findings of this study to other areas of IT governance. The IT governance decision in this study is primarily about the hardware/platform. The decision-making about other aspects of IT, such as strategic planning, software development, and project management may have different features. Future studies may focus on application development and explore whether environmental factors have similar influences. Third, although I argue the conceptual benefits of decentralization, such as quicker local responsiveness, I did not observe or measure these constructs. More research is needed to

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reveal the micro-dynamics and shed more light on the underlying causes of the nonlinearity between IT governance and environment on the innovation-performance relationship.

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CONTRIBUTIONS

The nature of IT-enabled innovation has shifted considerably in most industries. Digitized innovations have been less well-bounded and more diversified in the sense that the resources, both knowledge workers, and IT tools, are distributed in multiple business units of the same firm or even across different strategically allied firms (Han et al. 2012; Nambisan 2013; Yoo et al. 2010). Under great pressure of realizing revenue growth through innovations, it is clear that firms need to pay close attention to both internal and external dynamics which may influence daily operations in innovation projects. Internally, it has been argued that different institutional frameworks have comparative advantages in solving the organizational problems of different innovation strategies (e.g., Miozzo and Dewick 2002) Further, given the critical impact that information technology investments have on organizational success (Dean and Sharfman 1996; Devaraj and Kohli 2003) and the fact that innovations have been much more digitized, it is imperative to fully understand that under which IT infrastructure governance can a focal firm strengthen the relationship between innovation and firm performance. However, most existing research has only shed light on the significant impact of corporate governance on innovation outcomes through the lens of the principal-agent framework and the economics of innovation (e.g., Miozzo and Dewick 2002). Thus, by explicitly focusing on IT infrastructure governance (mostly on hardware or platform decisions) using a dataset of business units, I first contribute to the broad literature on innovation management, in general, and on such management in multiunit/multibusiness context, in particular.

Externally, a new paradigm of open innovation has recently emerged, encouraging the use of external resources to accelerate internal innovation (Chesbrough et al. 2006). Collaborative maneuvers, such as forming open innovation alliances, has harnessed by high-

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technology industries and could potentially alter the strategic positions of the companies that operate within the fast-paced environment. To support, researchers have suggested that firms participating in such strategic alliances cocreate economic value through the joint development of IT innovations (e.g., Han et al. 2012). With the loose boundary of innovation development, researchers seem to pay less attention to environmental uncertainty and the fact that an external environment comprising customers, suppliers, competitors, and other social and economic forces may impact organizational governance and decision-making (Hitt and Tyler 1991; Xue et al. 2008). What's more, as the contingency theory posits, there is no best way to organize an organization (Burns and Stalker 1961; Lawrence and Lorsch 1967). In particular, IS researchers concluded IT governance in information technology investment processes is contingent upon the external environment (Xue et al. 2008; Xue et al. 2011). Therefore, by examining the joint impact of IT governance and environmental uncertainty, this study contributes to innovation literature by simultaneously incorporating key internal and external dynamics and help understand which combination could a firm experience a stronger positive relationship between innovation execution and firm performance.

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CONCLUSION

In summary, this study has provided initial insights into the organizational and environmental exogenous variables surrounding innovation-performance relationship through a panel data analysis. Specifically, this study has shown that while the innovation-performance is truly contingent upon effective IT governance mode, firms are also required to account for external environmental influences. In general, a decentralized is more desirable as it allows firms to insist on local accountability, seeking to maximize responsiveness to local customer needs and minimize constraints on creativity and business unit autonomy by establishing few enterprise-wide technology and business-process standards. On the other hand, a centralized IT governance strategy emphasizes efficient operations. This strategy also encourages a high degree of standardization in the pursuit of low business costs. The findings show that in a more uncertain industry environment, compared with a more decentralized IT governance strategy, centralized IT governance enforcing architecture and hierarchy compliance is more desirable regarding innovation value creation.

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REFERENCES

Anand, K. S., and Mendelson, H. 1997. "Information and Organization for Horizontal Multimarket Coordination," *Management Science* (43:12), pp. 1609-1627.

Ansoff, H. I. 1965. *Corporate Strategy: Business Policy for Growth and Expansion*. McGraw-Hill Book.

Banker, R. D., Bardhan, I. R., Chang, H., and Lin, S. 2006. "Plant Information Systems, Manufacturing Capabilities, and Plant Performance," *MIS quarterly*), pp. 315-337.

Barczak, G., Sultan, F., and Hultink, E. J. 2007. "Determinants of It Usage and New Product Performance," *Journal of Product Innovation Management* (24:6), pp. 600-613.

Bendapudi, N., and Leone, R. P. 2003. "Psychological Implications of Customer Participation in Co-Production," *Journal of marketing* (67:1), pp. 14-28.

Blumentritt, T., and Danis, W. M. 2006. "Business Strategy Types and Innovative Practices," *Journal of Managerial Issues*), pp. 274-291.

Brynjolfsson, E., Hitt, L. M., and Yang, S. 2002. "Intangible Assets: Computers and Organizational Capital," *Brookings papers on economic activity* (2002:1), pp. 137-181.

Carlo, J. L., Lyytinen, K., and Rose, G. M. 2012. "A Knowledge-Based Model of Radical Innovation in Small Software Firms," *MIS quarterly* (36:3), pp. 865-895.

Chesbrough, H. 2003. "Open Innovation." Boston: Harvard Business School Press.

Chesbrough, H., Vanhaverbeke, W., and West, J. 2006. *Open Innovation: Researching a New Paradigm*. Oxford University Press on Demand.

Covin, J. G., and Slevin, D. P. 1989. "Strategic Management of Small Firms in Hostile and Benign Environments," *Strategic management journal* (10:1), pp. 75-87.

Damanpour, F. 1991. "Organizational Innovation: A Meta-Analysis of Effects of Determinants and Moderators," *Academy of management journal* (34:3), pp. 555-590.

Dean, J. W., and Sharfman, M. P. 1996. "Does Decision Process Matter? A Study of Strategic Decision-Making Effectiveness," *Academy of management journal* (39:2), pp. 368-392.

Dess, G. G., and Beard, D. W. 1984. "Dimensions of Organizational Task Environments," *Administrative science quarterly*), pp. 52-73.

Devaraj, S., and Kohli, R. 2003. "Performance Impacts of Information Technology: Is Actual Usage the Missing Link?," *Management science* (49:3), pp. 273-289.

Duncan, R. B. 1972. "Characteristics of Organizational Environments and Perceived Environmental Uncertainty," *Administrative science quarterly*), pp. 313-327.

Eisenhardt, K. M., and Bourgeois, L. J. 1988. "Politics of Strategic Decision Making in High-Velocity Environments: Toward a Midrange Theory," *Academy of management journal* (31:4), pp. 737-770.

Eisenhardt, K. M., and Tabrizi, B. N. 1995. "Accelerating Adaptive Processes: Product Innovation in the Global Computer Industry," *Administrative science quarterly*), pp. 84-110.

Garcia-Vega, M. 2006. "Does Technological Diversification Promote Innovation?: An Empirical Analysis for European Firms," *Research policy* (35:2), pp. 230-246.

www.manaraa.com

George, S. 2016. "Real Business Innovation Begins with Open Practices." from https://opensource.com/open-organization/16/9/lets-change-talk-innovation

Gulati, R. 1998. "Alliances and Networks," *Strategic management journal* (19:4), pp. 293-317.

Han, K., Oh, W., Im, K. S., Oh, H., Pinsonneault, A., and Chang, R. M. 2012. "Value Cocreation and Wealth Spillover in Open Innovation Alliances," *MIS Quarterly* (36:1).

Han, S., and Ravichandran, T. 2006. "Does It Impact Firm Innovativeness: An Empirical Examination of Complementary and Direct Effects," *AMCIS 2006 Proceedings*), p. 91.

Hausman, J. A., Hall, B. H., and Griliches, Z. 1984. "Econometric Models for Count Data with an Application to the Patents-R&D Relationship." national bureau of economic research Cambridge, Mass., USA.

Hitt, L. M. 1999. "Information Technology and Firm Boundaries: Evidence from Panel Data," *Information Systems Research* (10:2), pp. 134-149.

Hitt, M. A., and Tyler, B. B. 1991. "Strategic Decision Models: Integrating Different Perspectives," *Strategic management journal* (12:5), pp. 327-351.

Hoyer, W. D., Chandy, R., Dorotic, M., Krafft, M., and Singh, S. S. 2010. "Consumer Cocreation in New Product Development," *Journal of service research* (13:3), pp. 283-296.

Ireland, R. D., Hitt, M. A., Camp, S. M., and Sexton, D. L. 2001. "Integrating Entrepreneurship and Strategic Management Actions to Create Firm Wealth," *The Academy of Management Executive* (15:1), pp. 49-63.

Jansen, J. J., Van Den Bosch, F. A., and Volberda, H. W. 2006. "Exploratory Innovation, Exploitative Innovation, and Performance: Effects of Organizational Antecedents and Environmental Moderators," *Management science* (52:11), pp. 1661-1674.

Jensen, M. C., and Meckling, W. H. 1992. "Specific and General Knowledge and Organizational Structure,").

Joshi, K. D., Chi, L., Datta, A., and Han, S. 2010. "Changing the Competitive Landscape: Continuous Innovation through It-Enabled Knowledge Capabilities," *Information Systems Research* (21:3), pp. 472-495.

Keats, B. W., and Hitt, M. A. 1988. "A Causal Model of Linkages among Environmental Dimensions, Macro Organizational Characteristics, and Performance," *Academy of management journal* (31:3), pp. 570-598.

Kimberly, J. R., and Evanisko, M. J. 1981. "Organizational Innovation: The Influence of Individual, Organizational, and Contextual Factors on Hospital Adoption of Technological and Administrative Innovations," *Academy of management journal* (24:4), pp. 689-713.

Kleis, L., Chwelos, P., Ramirez, R. V., and Cockburn, I. 2012. "Information Technology and Intangible Output: The Impact of It Investment on Innovation Productivity," *Information Systems Research* (23:1), pp. 42-59.

Laforet, S. 2008. "Size, Strategic, and Market Orientation Affects on Innovation," *Journal of business Research* (61:7), pp. 753-764.

Lawton, L., and Parasuraman, A. 1980. "The Impact of the Marketing Concept on New Product Planning," *The Journal of Marketing*), pp. 19-25.

Lee, H., and Choi, B. 2003. "Knowledge Management Enablers, Processes, and Organizational Performance: An Integrative View and Empirical Examination," *Journal of management information systems* (20:1), pp. 179-228.

المنارة للاستشارات
www.manaraa.com

Miles, R. E., and Snow, C. C. 1984. "Designing Strategic Human Resources Systems," *Organizational dynamics* (13:1), pp. 36-52.

Miles, R. E., Snow, C. C., Meyer, A. D., and Coleman, H. J. 1978. "Organizational Strategy, Structure, and Process," *Academy of management review* (3:3), pp. 546-562.

Nambisan, S. 2003. "Information Systems as a Reference Discipline for New Product Development," *Mis Quarterly*), pp. 1-18.

Nambisan, S. 2013. "Information Technology and Product/Service Innovation: A Brief Assessment and Some Suggestions for Future Research," *Journal of the Association for Information Systems* (14:4), p. 215.

Nambisan, S., Lyytinen, K., Majchrzak, A., and Song, M. 2017. "Digital Innovation Management: Reinventing Innovation Management Research in a Digital World," *MIS Quarterly* (41:1).

Quinn, J. B., Baruch, J. J., and Zien, K. A. 1997. *Innovation Explosion: Using Intellect and Software to Revolutionize Growth Strategies*. Simon & Schuster.

Raymond, L., and Bergeron, F. 2008. "Enabling the Business Strategy of Smes through E-Business Capabilities: A Strategic Alignment Perspective," *Industrial Management & Data Systems* (108:5), pp. 577-595.

Rothwell, R. 1994. "Towards the Fifth-Generation Innovation Process," *International marketing review* (11:1), pp. 7-31.

Sabherwal, R., and Chan, Y. E. 2001. "Alignment between Business and Is Strategies: A Study of Prospectors, Analyzers, and Defenders," *Information systems research* (12:1), pp. 11-33.

Sabherwal, R., and Sabherwal, S. 2007. "How Do Knowledge Management Announcements Affect Firm Value? A Study of Firms Pursuing Different Business Strategies," *IEEE Transactions on Engineering Management* (54:3), pp. 409-422.

Saldanha, T. J., Mithas, S., and Krishnan, M. S. 2017. "Leveraging Customer Involvement for Fueling Innovation: The Role of Relational and Analytical Information Processing Capabilities," *MIS Quarterly* (41:1).

Tanriverdi, H. 2005. "Information Technology Relatedness, Knowledge Management Capability, and Performance of Multibusiness Firms," *MIS quarterly*), pp. 311-334.

Thomke, S. H. 2006. "Capturing the Real Value of Innovation Tools," *MIT Sloan Management Review* (47:2), p. 24.

Tushman, M. L., and Nadler, D. A. 1978. "Information Processing as an Integrating Concept in Organizational Design," *Academy of management review* (3:3), pp. 613-624.

Tushman, M. L., and O'Reilly III, C. A. 1996. "Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change," *California management review* (38:4), pp. 8-29.

Utterback, J. 1994. "Mastering the Dynamics of Innovation: How Companies Can Seize Opportunities in the Face of Technological Change,").

Utterback, J. M. 1971. "The Process of Technological Innovation within the Firm," *Academy of management Journal* (14:1), pp. 75-88.

Varadarajan, R., and Yadav, M. S. 2009. "Marketing Strategy in an Internet-Enabled Environment: A Retrospective on the First Ten Years of Jim and a Prospective on the Next Ten Years," *Journal of Interactive Marketing* (23:1), pp. 11-22.

المنارة للاستشارات
www.manaraa.com

Villalonga, B., and McGahan, A. M. 2005. "The Choice among Acquisitions, Alliances, and Divestitures," *Strategic management journal* (26:13), pp. 1183-1208.

Warren, Z., McPheeters, M. L., Sathe, N., Foss-Feig, J. H., Glasser, A., and Veenstra-VanderWeele, J. 2011. "A Systematic Review of Early Intensive Intervention for Autism Spectrum Disorders," *Pediatrics* (127:5), pp. e1303-e1311.

West, J., and Lakhani, K. R. 2008. "Getting Clear About Communities in Open Innovation," *Industry and Innovation* (15:2), pp. 223-231.

Xue, L., Ray, G., and Gu, B. 2011. "Environmental Uncertainty and It Infrastructure Governance: A Curvilinear Relationship," *Information Systems Research* (22:2), pp. 389-399.

Yoo, Y., Henfridsson, O., and Lyytinen, K. 2010. "Research Commentary—the New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research," *Information systems research* (21:4), pp. 724-735.

Zahra, S. A., Nielsen, A. P., and Bogner, W. C. 1999. "Corporate Entrepreneurship, Knowledge, and Competence Development," *Entrepreneurship: Theory and Practice* (23:3), pp. 169-169.

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OVERALL CONCLUSION

Innovation management is an essential component of a firm's business strategy, and its importance will continue to grow, as the market environment becomes increasingly unpredictable and competitive. This dissertation takes a dual view of IT and business, aiming to investigate the antecedents and consequences of innovations. While Essays 1 and 2 focus more on internal dynamics, Essay 3 further sheds light on the relationship between innovation and firm performance, moderated by IT governance and industry clockspeed.

In Essay 1, I argued and found that IT portfolio diversification has a positive impact on a firm's innovation outcome. In addition, the results suggest that while seemingly reasonable, the two do not complement each other. More specifically, managing both types of diversification at a higher level is detrimental to firm innovation efforts. Essay 2 investigates the impacts of two specific types of IT capabilities and their joint influence with matching business strategies. In particular, I found that only one of the two capabilities , i.e., external information integration capability, has a positive and significant impact on the amount of filed patent. Regarding the moderating effect, firms practicing a prospector strategy is more likely to enjoy desirable innovation outcomes when complemented by unitizing external information integration capability. While for Defender firms, they are in a better position when effectively utilizing analytical capabilities. Essay 3 goes further to address the external dynamics of creating innovation outcomes. The results show that while the innovation-performance is truly contingent upon effective IT governance mode, firms are also required to account for external environmental influences. In general, a decentralized is more desirable as it allows firms to insist on local accountability, seeking to maximize responsiveness to local customer needs and minimize constraints on creativity and business unit autonomy by establishing few enterprise-

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wide technology and business-process standards, especially when firms practice in an industry characterized as slow-moving. Further, in a more uncertain industry environment, compared with a more decentralized IT governance strategy, centralized IT governance enforcing architecture and hierarchy compliance is more desirable regarding innovation value creation.

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