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# Information Technology In Innovation Activity Of The Firm: Theory And Synthesis

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## **INFORMATION TECHNOLOGY IN INNOVATION ACTIVITY OF THE FIRM: THEORY AND SYNTHESIS**

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### **Abstract**

*In light of information technology (IT) increasingly leading to enterprise transformation in contemporary firms, we aim to build a theory of IT-enabled capabilities in innovation activity of the firm. For so doing, we extensively review almost five hundred innovation studies in organization and IS literature and conduct a thematic analysis to identify theoretical underpinnings of innovation research. Based on a solid understanding of the literature, we then derive a typology of different perspectives on innovation activity to categorize the themes (theoretical underpinnings). From an angle of enterprise transformation, we view innovation as a form of organizational change aiming to improve certain organizational outcomes. Accordingly, innovation activity is characterized based on the theoretical underpinnings taking different perspectives about organizational change processes, such as resource lifecycle process, teleological search process, evolutionary adaptation process, and dialectical synthesis process. Corresponding to these perspectives, four IT-enabled capabilities are theorized: IT-enabled resource operation capability, IT-enabled objective management capability, IT-enabled knowledge absorption capability, and IT-enabled information transparency capability. We develop a theoretical framework with several propositions explaining how these IT-enabled capabilities facilitate innovation activity in different perspectives, and the mechanisms leading to certain organizational outcomes. Directions for future research are discussed.*

*Keywords: IT-enabled enterprise transformation, IT-enabled organizational change, IT-enabled capabilities, IT innovation, resource-based theory, behavioral theory of the firm, evolutionary theory, property rights theory, agency theory, transaction costs theory.*

## 1 Introduction

Information technology (IT), as a modern technological innovation, has been significantly changing the way of doing business and leading to enterprise transformation in contemporary firms (Sambamurthy et al. 2003). Beside the adoption of IT per se as a way of innovating with IT (Fichman 2004), IT innovation literature has been increasingly revealed that the use of IT by firms, especially IT-enabled capabilities built upon the use of IT, can facilitate various other forms of innovation activity such as patent invention (Joshi et al. 2010, Kleis et al. 2012), new product development (Pavlou and El Sawy 2006, Tambe et al. 2012), and new process development (Tarafdar and Gordon 2007). In organization literature, innovation research has been broadly carried out and accumulates different perspectives to explain innovation of the firm (Fiol 1996). Yet, many of these theoretical underpinnings have not been introduced to IT innovation research. Therefore, a systematic understanding of IT-enabled capabilities in innovation activity from different perspectives has not been developed in IS literature. Particularly, we lack an overarching theoretical framework that synthesizes multiple theoretical underpinnings and guide research on IT innovation and IT-enabled business transformation.

Thus, there is an urgent need for us to introduce and synthesize different perspectives under a unified framework and theorize IT-enabled capabilities facilitating innovation activity from different perspectives, in order to deepen our knowledge of IT-enabled enterprise/business transformation. **To fill above gap, we aim to develop a theory of IT-enabled capabilities in innovation activity of the firm.** *From an angle of enterprise transformation, we define innovation broadly as the organizational change aiming to improve certain organizational outcomes* (Cyert and March 1963, Nelson and Winter 1982, Penrose 1959, Poole et al. 2000). Besides innovation, there are other forms of organizational change, such as organizational decline and market exit (Van de Ven and Poole 1995). *According to our definition of innovation, innovation activity refers to the activity carried out by a focal firm, independently or jointly with other parties, directed toward developing and introducing innovation to the focal firm* (Poole et al. 2000).

The first step of our study is to identify prominent theoretical underpinnings in innovation research. We conduct an extensive literature review on innovation research based on almost 500 studies from nine leading academic journals in organization and IS literature. The methodology, procedures, and results of our literature review are introduced in Section 2. Based on a solid understanding of the literature, we then develop a typology for different perspectives on innovation activity. This typology characterizes the innovation activity from four different perspectives of innovation research. We articulate each perspective and our typology in Section 3. Finally, we theorize four IT-enabled capabilities in innovation activity from different perspectives, and develop a theoretical framework with several important propositions in Section 4. We conclude this paper by discussing directions for future research in Section 5.

## 2 Literature Review on Innovation Research

Innovation has largely attracted the attention of organizational researchers for its relevance to a variety of organizational phenomenon, such as resource accumulation and deployment (Penrose 1959), knowledge creation and transfer (Cohen and Levinthal 1990), organizational learning and adaptation (Cyert and March 1963, Nelson and Winter 1982), competitive advantage and firm performance (Barney 1991, Teece et al. 1997), among others. In order to systematically understand the theoretical underpinnings of innovation research, we conduct an extensive literature review on innovation research consisting of 477 studies published in nine leading organization and IS journals. *Our aim of literature review is to group the theoretical underpinnings of innovation studies in the literature, in order to identify the fundamental theories that are used in innovation research.*

Thematic analysis is a systematic approach for literature review, which has been frequently used in prior review studies (e.g., Roberts et al. 2012). In this study, we apply thematic analysis to analyze and code literature for two reasons: 1) thematic analysis is particularly useful for systematic categorizing content of qualitative information; and 2) it is valuable for making sense of a large domain of literature, facilitating further theory building (Boyatzis 1998). Thematic analysis starts from deciding sampling strategy, followed by generating themes, and ends with validating themes (Boyatzis 1998). Our thematic analysis was carried out in three sequential steps.

The first step is a computer-aided sampling process. Given the large body of innovation studies in organization literature, we sampled published papers from the top five academic journals with greatest impact on organization research, including *Academy of Management Journal*, *Academy of Management Review*, *Administrative Science Quarterly*, *Organization Science*, and *Strategic Management Journal*. We took a triangulation strategy in

sampling and use multiple keywords for abstract search in ProQuest database from 1990 to 2011<sup>1</sup>. Specifically, we first used “innovation” as keyword and obtained the initial sample of articles. Since there are two major streams of innovation research in organization literature related to absorptive capacity and new product development (Fiol 1996), we further used “absorptive capacity” and “new product” as two additional keywords to expand our search. As expected, the search results using these two keywords were highly overlapping with our initial sample. We then merged the articles from three search processes, and sorted out those studies meeting two criteria based on the purposes of this study: 1) innovation is not as a minor mention or non-centric background in the paper; and 2) the paper is relevant to innovation of the firm. It results in a final sample of 369 papers from organization literature. We also surveyed IT innovation literature from the top three academic journals with big impact on IS research including *Information Systems Research*, *Journal of Management Information Systems*, and *MIS Quarterly*, as well as another leading interdisciplinary journal – *Management Science*. We again used the keyword “innovation” for abstract search in ProQuest database from 1990 to 2011<sup>2</sup>. It generated a total number of 108 papers on IT innovation from IS literature. Thus, our literature review covered a total number of 477 papers from organization and IS literature.

The second step is a manual grouping process. For each article, one of the authors coded the research topics, major concepts, and theoretical underpinnings in a summary file. Based on the detail information about each article, we grouped the theoretical underpinnings of articles (and meanwhile took into account their research topics and major concepts) to generate themes. Our grouping and categorizing of articles were guided by three criteria: 1) the recurrence of the same thread of meaning in different words, 2) the repetition of words, phrases, or sentences, and 3) the internal consistency among a set of papers (Boyatzis 1998).

All sampled articles are categorized into one or more theoretical underpinnings, namely themes of our analysis. A total number of 6 themes emerged in this process, including resource-based theory, behavioral theory of the firm, evolutionary theory, property rights theory, agency theory, and transaction costs theory (see Mahoney 2005 for a review). Compared to the richness of theoretical underpinnings applied in organization literature, there is a paucity of IS studies investigating IT innovation by the lenses of behavioral theory of the firm, property rights theory, agency theory, and transaction costs theory.

The final step is a theme validating process. We validated our themes by inviting another independent doctoral student with expertise in organization theory to code randomly selected 10% papers from our sample (N = 48). The coding results were then compared with our initial coding in terms of whether a study falls into specific themes. The interrater reliability was then calculated based on dichotomous data (Cohen’s Kappa  $k = 0.86$ ,  $p < 0.001$ )<sup>3</sup>, indicating good interrater agreement in theme generation (Cohen 1960).

### **3 Different Perspectives on Innovation Activity**

As innovation is viewed as a kind of organizational change, we adapt the seminal work by Van de Ven and Poole (1995) to develop a typology to categorize our themes. In so doing, we can synthesize different theoretical underpinnings under a unified typology and better understand the nature and differences of their views on innovation activity. Van de Ven and Poole (1995) is perhaps the most influential work about well-classified organizational change processes. They conducted an inductive examination of organization literature and found that most specific theories of organizational change fall into one or more of four process models, which are denoted as lifecycle process, teleological process, evolutionary process, and dialectical process. They suggested that these four processes reflect different primitive perspectives on organizational change process rooted in four basic schools of philosophy, each of which has a rich and long-standing intellectual tradition and has been widely applied to various disciplines (Van de Ven and Poole 1995).

While Van de Ven and Poole (1995) focused their attention on all kinds of organizational change in a process model and did not characterize innovation activity in organizational change process, our study is targeted at characterizing innovation activity in different perspectives. For the purpose of this study, we compare our themes generated in literature review and Van de Ven and Poole’s process models, and deductively examine the

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<sup>1</sup> We accessed ProQuest (<http://www.proquest.com>) on May 2012.

<sup>2</sup> Similar to Roberts et al. (2012), we focus on IS studies at *Management Science*.

<sup>3</sup> We use Cohen’s Kappa as the measure of interrater reliability for two reasons: 1) it is particularly suitable for dichotomous data from two raters; and 2) it is generally more robust than other measures as it takes into account the agreement occurring by chance (Cohen 1960).

philosophical and conceptual commonality between them. This procedure enables us to categorize the themes (theoretical underpinnings) of innovation research into different perspectives of organizational change process, and finally develop a typology as Figure 1 shows. And then we characterize innovation activity in each perspective of organizational change process based on the core arguments of theoretical underpinnings. Below we explain the commonality between theoretical underpinnings and perspectives of organizational change process and articulate innovation activity in each perspective.

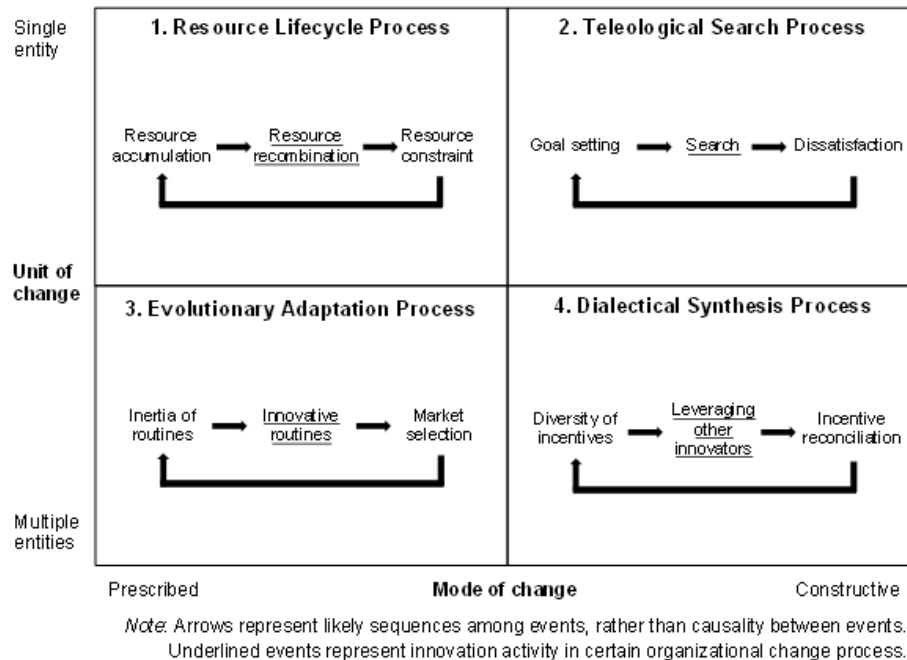


Figure 1. Different perspectives on innovation activity in organizational change process

Lifecycle process perspective is grounded in the biological metaphor of organic growth, which explains organizational change by immanent logic or program that regulates the process toward a subsequent end that can be prefigured in the previous state (Van de Ven and Poole 1995). Organizational change from lifecycle process perspective takes the forms of prescribed stages such as startup, growth, and termination. Resource-based theory can explain lifecycle process of organizational change by prescribed sequence of stages over time (Penrose 1959). A firm is started from accumulating resources for operation, which is recombined with other resources along with firm growth. Superior profit is earned if a firm can efficiently (more efficiently than its competitors) use various resources in operation, which is coordinated by managers. Since managerial experience and teamwork can be only internally developed over time, Penrose effect occurs after fast firm growth – managerial capacities become the binding constraint that limits the growth of the firm (Tan and Mahoney 2005). Therefore, the sequential cycle from accumulation, recombination, to constraint of resources maintained by resource-based theory naturally indicates lifecycle process of prescribed stages related to a firm’s internal operation based on resources. *We then use resource lifecycle process to describe a perspective of organizational change process about resource accumulation, recombination and constraint following lifecycle process (Quadrant 1, Figure 1).* Resource-based theory suggests that firms motivate innovation for using resources more efficiently through recombination, in order to capitalize on productive opportunities for growth (Penrose 1959). The sources of innovation emerge by introducing new combination of currently used and new or unused resources to the operation of a firm, yielding higher efficiency in resource utilization and leading to the growth of the firm. *Therefore, from the perspective of resource lifecycle process, innovation activity can be viewed as resource recombination.*

Teleological process perspective relies on the philosophical doctrine that purpose or goal is the cause for guiding organizational change of a single entity or a group of entities acting collectively as a unified unit (Van de Ven and Poole 1995). Teleological process perspective views organizational change as a repetitive sequence of goal setting, search, and dissatisfaction based on what was learned before. Behavioral theory well explains teleological process with respect to goal setting, search, and dissatisfaction (Cyert and March 1963, March and Simon 1958).

Quasi-resolution of goals can be formulated, enabling the firm to take goal-oriented actions collectively as a single entity (Cyert and March 1963). Once the performance is below managerial aspiration, dissatisfaction leads to problemistic search for alternative actions (March and Simon 1958). *We then use teleological search process to describe a perspective of organizational change process about goal setting, search and dissatisfaction following teleological process (Quadrant 2, Figure 1).* Behavioral theory suggests that problemistic search is motivated by dissatisfactory performance and directed toward innovative solutions to specific performance problems (Cyert and March 1963, Greve 2003). Also, slack search is introduced by excess resources and provides potential solutions to future problems (Cyert and March 1963, Greve 2003). *Therefore, from the perspective of teleological search process, innovation activity can be viewed as search.*

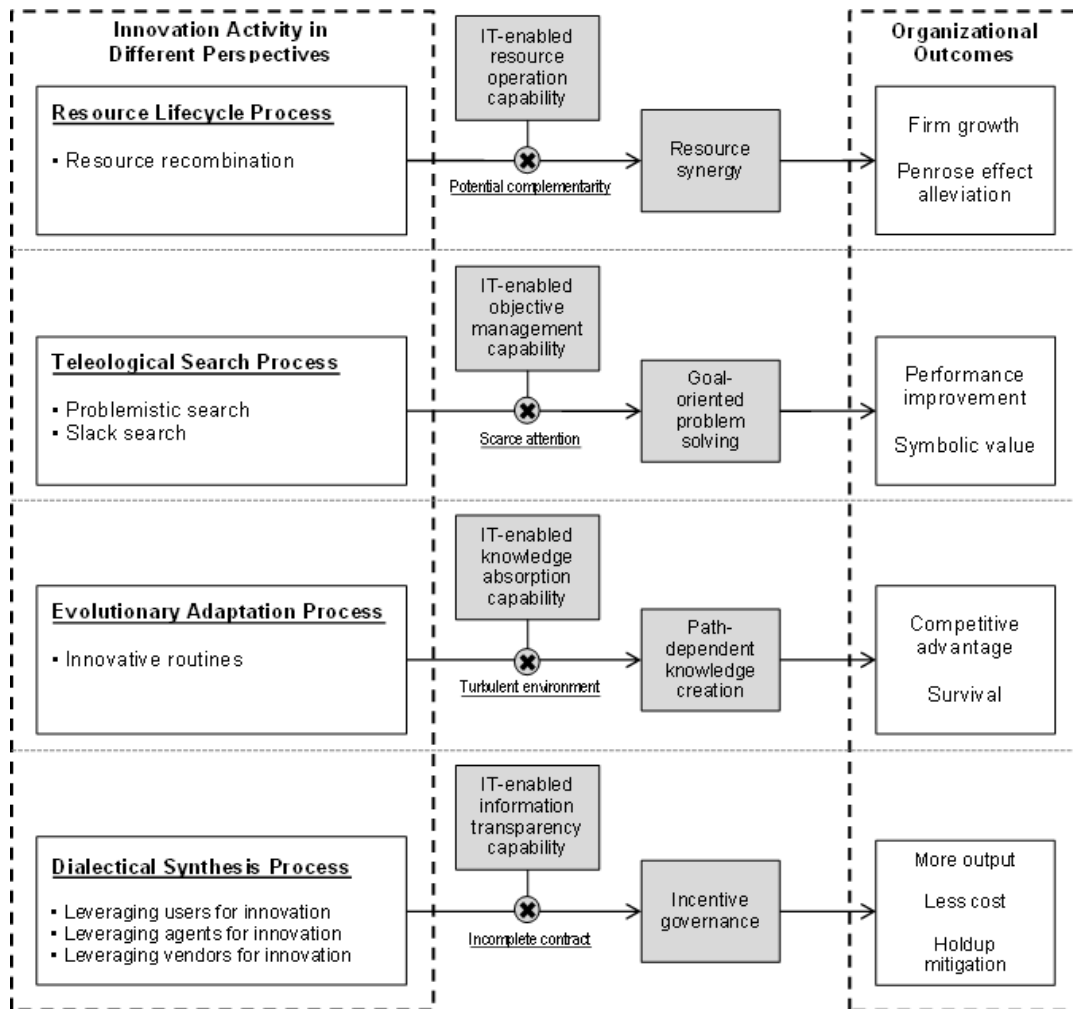
Evolutionary process perspective is also grounded in biology with a focus on the cumulative changes in structural forms of populations across communities and industries (Van de Ven and Poole 1995). Evolutionary process assumes biological evolution through continuous and prescribed process of variation, selection, and retention. Evolutionary theory is proposed by Nelson and Winter (1982), which explicitly assumes evolutionary process of economic change in its micro-foundations and macro-analysis (name as well). Nelson and Winter's (1982) general term for regular and predictable behavioral patterns of the firm is "routine". Routines are analogical to genes, as firms behave according to the routines they have employed in the past. Such behavioral continuity is a crucial assumption made by evolutionary theory (Nelson and Winter 2002). Firms vary by innovation through search for the change of routines, in order to adapt to the turbulent environment (Teece et al. 1997). Thus, the firm as an organism consisting of routines (genes) forms the micro-foundations for variation and retention in evolutionary process. In addition, evolutionary theory derives its major conclusions from the selection process of Schumpeterian competition (Nelson and Winter 1982). The focus of evolutionary theory is centered on market selection through competition among firms varying in their efforts and results in innovation. Market competition as a selection mechanism is essentially consistent with evolutionary process perspective in the macro-analysis of evolutionary theory. *We then use evolutionary adaptation process to describe a perspective of organizational change process about inertia and change of routines for market selection following evolutionary process (Quadrant 3, Figure 1).* Evolutionary theory suggests that firms regularly carry out innovative routines for changing ordinary routines and building competitive advantage (Nelson and Winter 1982). Since routines memorize and maintain organizational capabilities, innovative routines sometimes refer to dynamic capabilities leading to the change of ordinary capabilities (Teece et al. 1997). *Therefore, from the perspective of evolutionary adaptation process, innovation activity can be viewed as innovative routines.*

Dialectical process perspective assumes that organizations exist in a pluralistic world of collisions or oppositions, which compete with each other for domination (Van de Ven and Poole 1995). Thus, dialectical process requires at least two distinct entities that engage one another in conflict or embody oppositions to confront. When multiple entities that are not like-minded involve in organizational change, their diversity of incentives become a critical issue to be synthesized in dialectical process. We generally call property rights theory, agency theory, and transaction costs theory as contract theory because these theoretical underpinnings view the firm or the relationship between a firm and others as a nexus of incomplete contracts from distinct angles (Kim and Mahoney 2005). Unlike resource-based theory, behavioral theory of the firm, and evolutionary theory, contract theory does not explicitly theorize innovation activity. However, contract theory provides solid theoretical underpinnings to explain dialectical process of reconciling diverse incentives (Kim and Mahoney 2005). *We then use dialectical synthesis process to describe a perspective of organizational change process about diversity and reconciliation of incentives in leveraging other innovators following dialectical process.* By getting the property rights well defined and correctly allocated, property rights theory suggests that fundamental incentives can be guaranteed to yield higher output in production and application of properties (Hart and Moore 1990). Agency theory suggests that monitoring and incentive alignment can solve incentive problems and reduce agency costs caused by moral hazard and adverse selection (Fama 1980). Transaction costs theory suggests that appropriate governance mechanisms can provide incentives to contractual parties and mitigate holdup problems (Williamson 1975). Hence, property rights theory, agency theory, and transaction costs theory can explain how to reconcile diverse incentives in a firm's innovation activity involving other parties (e.g., users, agents, and vendors). *Therefore, from the perspective of dialectical synthesis process, innovation activity can be viewed as leveraging other innovators.*

#### **4 Toward a Theory: IT-Enabled Capabilities in Innovation Activity**

We develop rich conceptualizations of IT-enabled capabilities from different perspectives, based on a conceptual analysis about how IT can help to solve the problems in innovation activity. Figure 2 provides the theoretical framework as a result of our theory development. This multi-theoretic framework provides a holistic picture of

IT-enabled capabilities in innovation activity from different perspectives and explains the mechanisms through which they facilitate innovation activity toward certain organizational outcomes. Below we discuss each IT-enabled capability and associated propositions based on the theoretical framework.



Note: Underlined phrases denote problems to be solved by the focal firm in innovation activity.

Figure 2. Theoretical framework of IT-enabled capabilities in innovation activity

#### 4.1 IT-Enabled Resource Operation Capability (IT-ROC)

Penrose (1959) submitted that the firm could be viewed as a bundle of physical, labor, and intangible resources for operation and growth. From the perspective of resource lifecycle process, innovation activity is recombination between currently used resources and new or unused resources (Penrose 1959). To increase the efficiency of resource deployment in operation, innovative combination of resources is often targeted to derive resource synergy from multiple resources (Nevo and Wade 2010). To derive resource synergy from complimentary resources requires a firm to develop efficient coordination mechanisms in its operation with multiple resources (Bharadwaj et al. 2007). *In this study, we define IT-enabled resource operation capability (IT-ROC) as a firm's ability of using IT to increase the efficiency of resource coordination in internal operation.* In resource lifecycle process, IT-ROC can facilitate resource synergy arising from resource recombination through three mechanisms. First, IT-ROC helps to identify potential complementarity of resources in resource recombination. A firm can use IT for the purposes of automating, informing, and transforming internal operation based on various resources (Dedrick et al. 2003). The ability of using IT such as ERP systems is likely to reveal information about the complementarity across different types of resources in operation through better observing resource deployment, learning more about associated synchronization, and revising managers'

understanding of complementarity (Nevo and Wade 2010). Second, IT-ROC helps to realize potential complementarity of resources in resource recombination. A key role of IT is to serve as a coordination mechanism for a firm's operation in manufacturing and sales (Bharadwaj et al. 2007). The ability of using IT such as ERP systems can also facilitate managers to deploy and realize potential complementarity in a coordinative and just-in-time manner (Rai et al. 2006). Finally, IT-ROC helps to increase the agility of resource combination for new recombination. IT infrastructure and platform provide real option value to a firm for applying new resources whenever they are available (Fichman 2004). The ability of using IT can create digital option and increase operational agility, which supports competitive actions such as innovation activity (Sambamurthy et al. 2003). Therefore, we have the following proposition.

*P1: IT-ROC facilitates resource synergy arising from resource recombination through three mechanisms:*

*P1a: IT-ROC helps to identify potential complementarity of resources in resource recombination;*

*P1b: IT-ROC helps to realize potential complementarity of resources in resource recombination;*

*P1c: IT-ROC helps to increase the agility of resource combination for new recombination.*

Furthermore, Penrose (1959) maintained that the firm relies on managerial capacities to coordinate resources and capitalize on productive opportunities through innovation activity. However, the growth of the firm is naturally limited by the finite managerial capacities at least in the short run (Penrose 1959). This is because managerial capacities depend on the experience specific to a firm's internal operation and the teamwork of a firm's managers (Tan and Mahoney 2005). Thus, inelastic managerial capacities can be only developed internally over time and not available outside a firm. The complexity of resource coordination after a fast-growing period leads to increasing dynamic adjustment costs, which results in the decline of growth rate at which a firm can expand, namely the Penrose effect (Tan and Mahoney 2005). Since IT-ROC can facilitate resource synergy arising from resource recombination (as P1 states), a firm with strong IT-ROC can enlighten the burden of managerial capacities and reduce dynamic adjustment costs by increasing the efficiency of resource coordination and generate resource synergy. Therefore, stronger IT-ROC allows faster and longer firm growth and alleviates early occurrence of Penrose effect by strengthening the link between resource recombination and resource synergy in innovation activity. It leads to the following proposition.

*P2: All else being equal, resource synergy as a result of resource recombination facilitated by IT-ROC supports firm growth and alleviates Penrose effect.*

#### **4.2 IT-Enabled Objective Management Capability (IT-OMC)**

As the decision makers of firms, managers suffer from bounded rationality in their decision making (Simon 1976). With limited managerial attention, it is impossible for a firm to process all available information and make the optimal choice (Simon 1976). From the perspective of teleological search process, innovation activity is problem-focused or slack-induced search (Cyert and March 1963). Dissatisfaction based on performance feedback motivates problemistic search directed toward innovative solutions to solve specific performance problems (Greve 2003). In order to overcome scarce attention and efficiently make decisions based on a cumulative solution stock from search, it is suggested that search should be conducted in a goal-oriented manner to minimize the amount of useless information being processed and enable managerial attention concentrating on a small number of important choices (Cyert and March 1963, Simon 1976). *In this study, we define IT-enabled objective management capability (IT-OMC) as a firm's ability of using IT to increase the efficiency of goal management in decision making.* In teleological search process, IT-OMC can facilitate goal-oriented problem solving arising from search through three mechanisms. First, IT-OMC helps to resolve goal inconsistency in search by supporting communication of managers and achieving converging aspiration. The ability of processing information by using IT such as groupware supports information exchange among the managers of a firm (Huber 1990). Standard protocols and interfaces of GDSS (i.e., group decision support systems) also help managers to interpret information in a similar way (Tippins and Sohi 2003). Moreover, knowledge repositories and communication technologies enhance connectivity among managers, facilitating them to reconcile inconsistent understanding (Kane and Alavi 2007). Second, IT-OMC helps to evaluate goal execution in search by providing real-time performance feedback to managers in the short run. Past studies supported that the ability of using IT such as SCM and CRM systems can provide real-time feedback to a firm, allowing it to quickly respond and correct deviation from objectives (Rai et al. 2006). Finally, IT-OMC helps to correct the bias of goal in search by enabling managers to quickly learn from performance feedback. It has been suggested that goal setting is partially biased and organizational learning from performance feedback can help to correct the bias of organizational goals (Cyert and March 1963, Greve 2003). The competence of IT has been found to accelerate a firm's organizational learning practices (Tippins and Sohi 2003), which supports organizational agility through



frequently adapting goals by providing systematic insight of past experience and strategic foresight of future opportunities (Sambamurthy et al. 2003). Search, if directed by organizational goals, will lead to goal-oriented problem solving as a result of efficient decision making. Therefore, we have the following proposition.

*P3: IT-OMC facilitates goal-oriented problem solving arising from search through three mechanisms:*

*P3a: IT-OMC helps to resolve goal inconsistency in search by supporting communication of managers and achieving converging aspiration;*

*P3b: IT-OMC helps to evaluate goal execution in search by providing real-time performance feedback to managers in the short run;*

*P3c: IT-OMC helps to correct the bias of goal in search by enabling managers to quickly learn from performance feedback.*

Goal-oriented problem solving as a result of search generates innovative solutions to performance problems (Cyert and March 1963). Eventually, the introduced innovative solutions will improve firm performance (Greve 2003). Grounded in a behavioral tradition, Feldman and March (1981) proposed a view of information as a symbol and used it to explain the reason why firms keep processing information regardless of costs. They suggested that justifying decision making in terms of information can create symbolic value to a firm, which leads to a social belief on the quality of decisions made (Feldman and March 1981). Thus, goal-oriented problem solving, which is essentially a result of decision making with efficient information processing facilitated by IT-OMC, can also create symbolic value (e.g., firm value in financial market). It leads to the following proposition.

*P4: All else being equal, goal-oriented problem solving as a result of search facilitated by IT-OMC improves firm performance and creates symbolic value.*

### **4.3 IT-Enabled Knowledge Absorption Capability (IT-KAC)**

Nelson and Winter (1982) submitted that the firm can be viewed as a collection of routines. In order to successfully adapt to the turbulent environment and survive in market selection, a firm needs to regularly carry out innovative routines aiming to change ordinary routines (Nelson and Winter 1982). From the perspective of evolutionary adaptation process, innovation activity is innovative routines (Nelson and Winter 1982). Since the turbulent environment keeps changing all the time, absorbing external information and creating new knowledge based on a firm's knowledge base to better understand the environment plays a critical role in path-dependent adaptation (Cohen and Levinthal 1990). *In this study, we define IT-enabled knowledge absorption capability (IT-KAC) as a firm's ability of using IT to increase the effectiveness in absorbing external knowledge.* In evolutionary adaptation process, IT-KAC can facilitate path-dependent knowledge creation arising from innovative routines through four mechanisms. First, IT-KAC helps to identify the value of external knowledge in innovative routines. Recent study found that the ability of using IT, if combined with an external focus, facilitates a firm to realize useful information from the environment in new product development (Tambe et al. 2012). In the supply chain context, the ability of using partner interface-directed information systems can facilitate absorptive capacity, and enable a firm to recognize valuable market knowledge from supply chain partners (Malhotra et al. 2005). Second, IT-KAC helps to acquire and assimilate valuable external knowledge in innovative routines. The ability of using IT such as SCM systems enables a supplier to acquire and assimilate domain-specific knowledge from customers (Subramani 2004). IS application capabilities were also found to support knowledge sharing between the focal firm and customers and channel partners (Saraf et al. 2007). Third, IT-KAC helps to interpret and apply valuable external knowledge in innovative routines. The ability of using IT such as KMS (i.e., knowledge management system) and BI (i.e., business intelligence) allows a firm to efficiently interpret and apply knowledge in new product development (Pavlou and El Sawy 2006) and new product commercialization (Joshi et al. 2010, Tambe et al. 2012). Finally, IT-KAC helps to enhance organizational memory and increases the path dependency of knowledge creation. Nelson and Winter (1982) suggested that routines can serve as the organizational memory, as firms are "remembering by doing". Beside such procedural memory of routines, there is also declarative memory of codified information (Moorman and Miner 1998). A firm is the most sensitive to external knowledge that is similar to its prior knowledge base (Cohen and Levinthal 1990). The ability of using IT such as OMS (i.e., organizational memory systems) can help to code, archive, store, and retrieve knowledge in organizational memory (Stein and Zwass 1995). A firm therefore will more extensively bring to bear past knowledge from strong organizational memory on present knowledge creation (Tippins and Sohi 2003). In sum, we have the following proposition.

*P5: IT-KAC facilitates path-dependent knowledge creation arising from innovative routines through four mechanisms:*

*P5a: IT-KAC helps to identify the value of external knowledge in innovative routines;*

*P5b: IT-KAC helps to acquire and assimilate valuable external knowledge in innovative routines;*  
*P5c: IT-KAC helps to interpret and apply valuable external knowledge in innovative routines;*  
*P5d: IT-KAC helps to enhance organizational memory and increases the path dependency of knowledge creation.*

Path-dependent knowledge creation brings innovation with competitive advantage to a firm (Cohen and Levinthal 1990), which increases the likelihood of the firm will survive in market selection (Nelson and Winter 1982). However, evolutionary adaptation process requires a consideration of competition. The competitive advantage may also be outcompeted by imitation. One of important barriers for imitation is the path dependency of knowledge creation, because the history-dependent knowledge can be only created with firm-specific knowledge base that is developed over time (Barney 1991). Given path-dependent knowledge creation is a function of a firm's prior knowledge, the competitive advantage it generates becomes more difficult to be imitated if the degree of path dependency enhanced by IT-KAC is high. It leads to the following proposition.

*P6: All else being equal, path-dependent knowledge creation as a result of innovative routines facilitated by IT-KAC generates competitive advantage and increases survival likelihood of a firm in market selection. The sustainability of competitive advantage depends on the degree to which knowledge creation is path-dependent.*

#### **4.4 IT-Enabled Information Transparency Capability (IT-ITC)**

Contemporary firms also leverage a variety of other innovators in their increasingly open innovation activity. When multiple parties are involved in innovation activity, incomplete contract under information asymmetry may cause several incentive problems. From the perspective of dialectical synthesis process, a critical task of the focal firm in innovation activity with other innovators is to effectively improve contract completeness and govern the diverse incentives of them under information asymmetry. *In this study, we define IT-enabled information transparency capability (IT-ITC) as a firm's ability of using IT to increase the effectiveness in making information transparent.* In dialectical synthesis process, IT-ITC can facilitate incentive governance of a firm in leveraging different types of innovators (e.g., users, agents, and vendors).

Well-defined and appropriately allocated property rights can guarantee the fundamental incentives in creating and applying properties (Hart and Moore 1990). Since contemporary firms increasingly leverage users in the production of intellectual properties and apply these properties for in their own innovation activity, the definition and allocation of intellectual property rights become an important issue. In leveraging users for innovation, we suggest that IT-ITC can facilitate incentive governance and increase innovation output through two mechanisms. First, IT-ITC increases the contractibility of intellectual property rights in leveraging users for innovation, which enables well-defined ownership providing better incentives in production of intellectual properties. The use of IT has been suggested to create numerous contractible information assets, which are easy to specify (Brynjolfsson 1994). For example, the new ideas generated in virtual customer environment have accurate and timely records about who create them and when they are created (Nambisan 2002). Without a worry of unclear ownership, users will invest more efforts in ideation. Second, IT-ITC increases the alienability of intellectual property rights in leveraging users for innovation, which makes reallocation of ownership feasible and provides better incentives in application of intellectual properties. Alienable intellectual properties make the change of their ownership feasible, if the original ownership is not allocated to the party that can efficiently apply them (Brynjolfsson 1994). By making intellectual properties alienable and transferable on a digital platform, the ability of using IT such as firm-hosted online community (e.g., MyStarbucksIdea) helps to provide sufficient incentives to the firm in efficiently applying intellectual properties for innovation. Therefore, firms are able to take advantage of social capital and use intellectual properties created by users.

*P7: IT-ITC facilitates incentive governance in leveraging users for innovation and thereby increases innovation output through two mechanisms:*

*P7a: IT-ITC increases the contractibility of intellectual property rights in leveraging users for innovation, which enables well-defined ownership providing better incentives in production of intellectual properties;*

*P7b: IT-ITC increases the alienability of intellectual property rights in leveraging users for innovation, which makes reallocation of ownership feasible and provides better incentives in application of intellectual properties.*

Fama (1980) suggested that principle-agent framework may have two types of incentive problems – moral hazard and adverse selection. Moral hazard occurs when the agents have more information than the principle, allowing them to underinvest their efforts for the interest of principle. Adverse selection happens if the principle is lack of sufficient information to select appropriate agents, which tend to hide information. Since contemporary firms increasingly leverage other agents in crowdsourcing of innovation (e.g., InnoCentive), agency costs need

to be carefully managed. In leveraging agents for innovation, we suggest that IT-ITC can facilitate incentive governance and reduce agency costs through two mechanisms. First, IT-ITC increases the contractibility of innovation tasks and allows better monitoring in leveraging agents for innovation, which reduces agency costs due to moral hazard. The use of IT has been suggested to increase the measurability and tractability of the information about tasks and thereby improve contract completeness (Brynjolfsson 1994). It allows a firm to better monitor its agents based on measurable and tractable information (Dedrick et al. 2008), which therefore mitigates inappropriate behavior of agents caused by moral hazard. Second, IT-ITC avoids the amount of hidden information in leveraging agents for innovation, which reduces agency costs due to adverse selection. IT-ITC increases the transparency of information, increasing the difficulty for agents to hide information. The ability of using IT such as social media can gather rich information about potential agents from the Internet (e.g., online review), which thereby avoids the risk of adverse selection (Li and Hitt 2008).

*P8: IT-ITC facilitates incentive governance in leveraging agents for innovation and thereby reduces agency costs through two mechanisms:*

*P8a: IT-ITC increases the contractibility of innovation tasks and allows better monitoring in leveraging agents for innovation, which reduces agency costs due to moral hazard;*

*P8b: IT-ITC reduces the amount of hidden information in leveraging agents for innovation, which reduces agency costs due to adverse selection.*

Williamson (1975) suggested several types of transaction costs occurring in markets, which are either *ex ante* (e.g., negotiation and contracting) or *ex post* (e.g., contract enforcement and opportunistic behavior) to the occurrence of transactions. From the perspective of dialectical synthesis process, we focus our attention on the diverse incentives between a focal firm and its vendors in outsourcing of innovation, which may cause holdup problems. Due to bounded rationality and opportunism of contractual parties, market transactions are often carried out based on incomplete contract making vendors very likely to underinvest in relationship-specific investment (Williamson 1975). This is because anticipating potential gains from relationship-specific investment to be dissipated by opportunistic behavior of the focal firm, vendors will avoid such investment which generates greatest value for outsourcing (Susarla et al. 2010). In leveraging vendors for innovation, we suggest that IT-ITC can facilitate incentive governance and reduce transaction costs due to holdup problems through two mechanisms. First, IT-ITC increases the contractibility of relationship-specific investment in leveraging vendors for innovation. The ability of using IT such as CAD (i.e., computer-aided design) and PLM (i.e., product lifecycle management) digitizes the data in innovation process and improves the measurability and tractability of relationship-specific investment in outsourcing of innovation (Gordon et al. 2008), which thereby mitigates vendors' holdup of such investment. Second, IT-ITC increases mutual commitment and integration level in leveraging vendors for innovation. The ability of using IT such as IOS for information exchange between the focal firm and its vendors can be viewed as a mutual commitment developed by both parties with huge sunk costs (Kim and Mahoney 2006). Thus, it enables the focal firm to work closely with a small number of vendors with a high level of trust and thereby mitigates vendors' holdup (Dedrick et al. 2008). Such ability of establishing electronic links with partners can also be viewed as a form of quasi-vertical integration and thereby solve holdup problems analogical to vertical integration (Mukhopadhyay and Kekre 2002).

*P9: IT-ITC facilitates incentive governance in leveraging vendors for innovation and thereby reduces transaction costs due to holdup problems through two mechanisms:*

*P9a: IT-ITC increases the contractibility of relationship-specific investment by vendors in leveraging vendors for innovation;*

*P9b: IT-ITC increases the mutual commitment and integration level in leveraging vendors for innovation.*

## **5 Conclusion**

Based on an extensive literature review on innovation research, we synthesize different theoretical underpinnings and contribute a multi-theoretic framework of IT-enabled capabilities in innovation activity. IT-enabled resource operation capability and IT-enabled objective management capability aim to increase the efficiency of internal operation and decision making, which are critical to the success of innovation activity from the perspectives of resource lifecycle process and teleological search process. IT-enabled knowledge absorption capability and IT-enabled information transparency capability target at improving the effectiveness of knowledge creation and incentive governance, which are essential to the success of innovation activity from the perspectives of evolutionary adaptation process and dialectical synthesis process. Thus, our multi-theoretic framework provides a holistic picture of the roles of IT in different perspectives on innovation activity and explains the mechanisms through which IT-enabled capabilities facilitate innovation activity to achieve certain organizational outcomes.

Several lacunas can be identified by comparing what has been done in prior IS literature with our theoretical framework. While IT-enabled strategic resources from the perspective of resource lifecycle process has been extensively studied, only until recently IS researchers started to investigate the role of IT in facilitating innovative routines from a perspective of evolutionary adaptation process. More importantly, a paucity of studies has been dedicated to understand IT innovation from the perspectives of teleological search process and dialectical synthesis process, suggesting largely open areas for future research. Our study also sheds light on IT innovation research by offering several testable propositions, which explain the mechanisms through which IT-enabled capabilities facilitate innovation activity and lead to certain organizational outcomes. They can serve as the basis for hypotheses development and testing in future study. These propositions also allow important managerial implications about how to implement IT-enabled capabilities to improve innovation activity and organizational outcomes. We hope that our effort of theory building will encourage and assist future research around IT, innovation, and enterprise transformation in contemporary firms.

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