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RESEARCH PAPER

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Impact of the Information Technology Unit on Information Technology-Embedded Product Innovation

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Abstract

Organizations increasingly embed IT into physical products to develop new product innovations. However, there is wide variance in the outcomes of the IT-embedded product (ITEP) innovation process. In this paper, we posit that the IT unit's involvement in the ITEP innovation process could positively influence the outcomes. ITEP innovations become part of complex ecosystems in which they interact with their developers, customers, and other ITEPs. These developments suggest new roles for IT units of organizations. Yet, there is dearth of theory explaining how the IT unit of a firm could contribute to the firm's development of ITEP innovations in ways to create customer value and improve firm performance. This paper seeks to address this gap. ITEP innovations present new challenges for organizations. This paper builds on complexity science to articulate the challenges and explain how the IT unit can increase an organization's capacity to cope with them. First, the paper adopts Wheeler's (2002) "net-enabled business innovation model" to structure the key stages of innovation that an organization goes through in developing new ITEPs. Second, the paper articulates IT-specific uncertainties and challenges entailed in each of the four stages. Third, the paper develops hypotheses explaining how the IT unit could increase the effectiveness of each stage by helping to address these uncertainties and challenges. Finally, the paper empirically tests and finds support for the hypotheses in a sample of 165 firms. The paper contributes to the literature on IT-enabled business innovations by developing and validating a new theoretical explanation of how IT units increase the effectiveness of the ITEP innovation process.

Keywords: IT-Embedded Product Innovation, IT Unit, Chief Information Officer (CIO), IT Human Resource, Complexity Science, Innovation

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1 Introduction

The purpose of this paper is to explain how and why the IT unit of a firm could affect the success of the firm's IT-embedded product (ITEP) innovations. By IT unit, we mean the IT function that houses the IT employees of the firm and has decision rights and responsibility over its IT resources. ITEP innovations have become pervasive. Organizations reengineer physical products to embed IT hardware and software in them, and develop new product features and functionality (Konana & Ray, 2007; Porter & Heppelman, 2014). For example, large purchase items such as homes and cars embed IT hardware and software to offer innovative new safety, convenience, energy efficiency, and entertainment features and functionality. Likewise, household items such as televisions and home appliances, and consumer products such as watches and other wearables now embed significant IT to offer innovative new features and functionality. Even disposable items such as diapers have started to embed IT. For example, Huggies introduced the "TweetPee," an embedded humidity sensor that detects wetness in the diaper and tweets parents that it is time to change it.

Despite the pervasiveness of the ITEP innovations, there is wide variance across organizations in terms of the outcomes of the ITEP innovation projects. For example, Wheeler (2002, p. 125) states: "[some] firms with outstanding brands in the physical world have net-enabled their products and services to the delight of their customers, while other great brands have suffered from tardy and dismal efforts at net-enablement." One source of this variance in the outcomes could be the extent to which firms involve their IT units in the ITEP innovation process.

In the past, the scope of the IT unit's involvement in the new product innovation process was typically limited to support roles. Due to the lack of embedded IT in products, there was little or no need for the IT unit to participate in early-stage product innovation activities such as generating new product ideas, matching the ideas to potential business opportunities, developing the proof of concept, or justifying the business case. These activities were primarily the responsibility of the non-IT business units such as R&D, engineering, and marketing. The IT unit supported the business units by providing them with computing, communication, and collaboration infrastructures, and project and knowledge management applications. It also implemented and maintained enterprise systems to support the logistics, manufacturing, sales, and after-sales service needs of the new products.

Today, the potential scope of the IT unit's involvement in the new product innovation process has started to cover the early stage product innovation activities as well. Since many new product innovations embed IT hardware and software, many of the uncertainties and challenges faced during the ideation and development stages of ITEP innovation process are now IT-specific. To address the IT-specific uncertainties and challenges, it has become important for organizations to involve their IT units from the very early stages of the ITEP innovation process.

However, there is wide variance in the extent to which firms are able to involve their IT units in the ITEP innovation process. Some executives do recognize the focal role of the IT unit in rapid development of innovative new products (Roberts, Sarrazin, & Sikes, 2010). Yet, their IT units are often overwhelmed with conventional roles and responsibilities, such as building and running enterprise IT systems that support relatively more structured and standardized business processes in finance, accounting, HR, logistics, sales and other functions (Ross et al., 2006). Participating in the relatively less structured, more uncertain early stage activities of the ITEP innovation processes would put additional demands on the resources and skills of the IT unit. Thus, not all IT units are willing or able to participate in the early stages of the ITEP innovation process.

The wide variance in the extent to which IT units are involved in the ITEP innovation processes raises important questions for IS research and practice: e.g., How does the participation of the IT unit impact the effectiveness of the stages and outcomes of the ITEP innovation process? What kinds of support can the IT unit provide to help the firm develop ITEPs that create customer value and improve firm performance? The IS literature to date has addressed some related questions, but it has yet to address these new questions. For example, recent studies indicate that fundamental transformations can be anticipated in the organizational roles of the IT unit as ITEPs become nodes in the extended information-processing infrastructures of organizations (Guillemette & Pare, 2012). However, this literature has not yet addressed whether and how the participation of the IT unit could contribute to the stages and outcomes of the ITEP innovation process. Likewise, the literature on IT and new product development informs us that the effective use of IT tools can assist in R&D activities such as technology search, gate-keeping, R&D portfolio management, and new product development (Pavlou & El Sawy, 2006; Whelan, Teigland & Golden, 2010; Gordon & Tarafdar, 2010; Nambisan, 2010). However, it has yet to explain the specific activities of the IT unit that can increase the effectiveness of the stages and outcomes of the ITEP innovation process.

We develop and validate a new theoretical explanation of how the IT unit can contribute to different stages of the ITEP innovation process, how it can enhance the value delivered to customers, and ultimately, how it can increase the firm's performance. The proposed theory has three boundary conditions. First, it applies only to ITEP innovations. We exclude IT-enabled service and business model innovations, and IT-enabled industry transformations because they are different in scope and they might entail different kinds of innovation processes. Second, it applies only to organizations that have institutionalized product innovation processes that are relatively formalized, legitimated, and supported with resources. We exclude small start-up firms and entrepreneurs which typically follow ad hoc and serendipitous approaches to product innovations. Third, it applies to organizations that have established IT units because our theory focuses on the role of IT units in ITEP innovation. We exclude organizations that do not yet have formal IT units.

In Section 2, we provide the theoretical foundations of the study. We define ITEP innovation and explain why it is a complex innovation. We adopt the "net-enabled business innovation model" (Wheeler, 2002) to structure the key stages of innovation that an organization goes through in developing such complex ITEP innovations. We justify why complexity science is an appropriate theoretical foundation for analyzing IT-specific uncertainties and challenges entailed in these key stages. In Section 3, we develop hypotheses that explain how and why the involvement of the IT unit could increase the effectiveness of each stage of the innovation process. In Section 4, we provide the methodological details and results of the study. Finally, we conclude the paper in Section 5 with a discussion of the paper's contributions and implications.

2 Theoretical Background

2.1 Definition of ITEP Innovation

We define an ITEP innovation as "a conventional product that embeds IT hardware and software to produce product features and functions that are perceived to be new by customers." With the embedding of IT hardware and software components, products gain new features, such as improved product convenience, safety, quality, and performance. They also gain new functionalities, such as the ability to connect to the Internet, track customers' product usage behaviors, and remotely diagnose the product and deliver firmware and software updates (Wheeler, 2002; Porter & Heppelman, 2014). While the idea of ITEP innovation is not new, the recent surge in ITEP innovations can be attributed to emerging information technologies (EIT) that reduce the costs and enhance the functionalities of the IT used in ITEPs. Thus, in this study, we focus primarily on how firms identify and use EIT in ITEP innovations.

As an example, we consider the automobile. Many innovative features and capabilities in the automobile, including the self-driving features, are made possible by a variety of embedded microprocessors and software in the car (Kellmereit & Obodovski, 2013; Konana & Ray, 2007). While the substantive form of the car is physical, embedded IT operates major functions such as transmission, acceleration/braking, safety/airbag deployment, lane changing and parking. In a self-driving car, these functions take place without human intervention.

2.2 Complexity of ITEP Innovation

ITEPs are complex products that are developed and used in complex sociotechnical ecosystems. Consider a new self-driving car feature that Toyota is currently researching. Steve Basra, General Manager of Engineering IT and Telematics at Toyota Motor Europe, described the idea as follows: The self-driving feature of the car requires the sensing of road markings to enable driving within road boundaries. If the car approaches an unmarked or poorly marked road, however, the control would have to be transferred to the human driver, which could reduce the value of the self-driving feature. An innovative idea to address this issue would be to dynamically discover the road boundaries and minimize the need to transfer control to a human driver. The proponents of the idea imagine all cars being connected to a Cloud-based system so that their GPS data and other sensory data about road conditions could be collected in real time. They further imagine combining the data with additional data sources, such as map data, department of transportation data, weather data, traffic data, etc. If analytics were applied to such data, it might be feasible to discover the road boundaries in real time, and send the information to all the cars approaching the unmarked road. While the first few cars hitting the unmarked road would have to switch to human drivers, subsequent cars could continue self-driving because of the dynamic discovery of the road boundaries in near real time.

In this example, the car is a complex system made up of many IT parts that interact with each other (Kellmereit & Obodovski, 2013). These diverse IT components have many functions. They acquire data from the car and the environment: e.g., sensors capturing the car's internal dynamics and its interaction with the road and other cars. They process data: e.g., microprocessors calculating speed, proximity, etc. They transfer data internally among different components of the car as well as externally to the Cloud: e.g., location data, speed data, proximity data. These IT components are also interdependent. A change in technologies and standards of any one of them could potentially create a domino effect on the other components. The car would also operate as part of a complex sociotechnical ecosystem made up of many other stakeholders, such as other manufacturers of self-driving cars, traffic control and signaling systems, weather service providers, Cloud system and application service providers, information content providers, regulators, customers, etc. These stakeholders would be "agentive," i.e., they could self-reflect, learn, change their behaviors, pursue their own interests, and self-regulate. They would interact with each other in the context of an innovative and rapidly changing IT landscape. The reactions of different agentive stakeholders to the changes in existing and emerging information technologies could trigger a series of cascading interactions whose outcomes would be infeasible to predict in advance. The inability to predict or forecast system-level outcomes in such complex ecosystems would be based on nonlinear interdependencies and the abilities of agentive stakeholders to learn and adapt without hierarchical control (Ferraro, Etzion, & Gehman, 2015; McDaniel, 2007). Thus, the nature and performance of a complex ITEP innovation such as the self-driving car are not only the function of what the focal firm decides to do with the product but also what the other stakeholders in the ecosystem decide to do.

2.3 An Institutionalized Process for Developing ITEP Innovation

The complexity of the ITEP and the sociotechnical ecosystem in which it is developed implies that the firm cannot simply rely on ad hoc, serendipitous approaches to innovation. Rather, it needs a systematic, institutionalized innovation process that is well defined, legitimated, and resourced. Prior studies use stage models to describe the general pattern of activity in such systematic, institutionalized organizational innovation processes. A stage model breaks down the entire innovation process into a series of logical groupings of steps, also known as stages, which unfold in sequence (e.g., McGrath, Tsai, Venkataraman, & MacMillan, 1996).

Wheeler (2002) synthesizes the IS and management literatures to propose a stage model for framing the key stages of an institutionalized innovation process that an organization can follow in developing "net-enabled business innovation." As an IT-focused theory of an institutionalized innovation process, Wheeler's model fits the purposes of this paper well. Figure 1 depicts Wheeler's (2002) model. We adapt the four stages to the specific context of ITEP innovations as follows: (1) scan the environment for identifying and choosing emerging information technologies (EIT) that could potentially be relevant and useful for new product innovations of the firm; (2) match the EIT to business opportunities that could be created by ITEP innovations; (3) implement the ITEP innovations; and (4) assess if and how the ITEP innovation creates customer value. We define and further elaborate on the four stages below. We also summarize their definitions and theoretical underpinnings in Table 1.

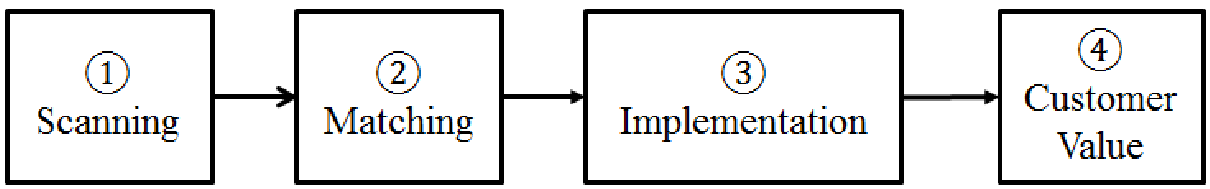

Figure 1. IT-Embedded Product Innovation Process (Adapted from Wheeler; 2002)

Table 1. Construct Definitions, Descriptions, and Theoretical Underpinnings

Constructs	Definitions and descriptions	Theoretical underpinnings
Scanning	The stage of the innovation process in which the organization identifies and chooses which of the emerging (EIT) in the environment could potentially be relevant and useful for product innovations.	Tornatzky & Fleischer (1990), Wheeler (2002), and Rush et. al. (2007)
Matching	The stage of the innovation process in which the organization analyz3s now the embedding of the EIT in products could create new economic opportunities.	D'Aveni (1994), Barua et al. (2001), and Wheeler (2002).
Implementation	The stage of the innovation process in which the organization develops the IT embedded product innovation.	Wheeler (2002) and Straub et al. (2004).
Customer Value	The stage of the innovation process in which the organization sells the product innovation and assesses customers' dynamically changing perceptions about the product in use, e.g., through their loyalty and referral behaviors.	Bolton & Drew (1991), Woodruff (1997), Wheeler (2002), and Chen & Dubinsky (2003).
Organizational Performance	Outcome based indicators that reflect the fulfillment of the organization's financial objectives: e.g., sales growth, market share, return on investment, and profitability.	Venkatraman & Ramanujam (1986, 1987)
IT Unit's Sensing	The extent to which the IT unit spots potentially relevant EIT and brings them to the attention of business units and executives. It captures the IT unit's role in addressing the challenges of the organization in sensing EIT.	Nilankanta & Scamell (1990), Rai (1995), Brown et al. (1997), Pawlowski & Robey (2004), and McDaniel (2007).
IT Unit's Sense-making	The extent to which the IT unit gives contextual meaning to EIT by interpreting and imagining what kinds of new product features and functionalities they can potentially enable, raising awareness of business units about such opportunities, and articulating new business partnerships the organization might need (e.g., with EIT vendors) if it embeds the EIT in its products. It captures the IT unit's role in addressing the organization's sensemaking challenges around EIT.	Weick (1993), Nambisan (1999), McDaniel (2007), Gordon & Tarafdar (2010), and Muhren & Van de Walle (2010).
IT Unit's Knowledge Sharing Support	The extent to which the IT unit builds IT hardware and applications to support electronic information and knowledge sharing (KS) across the organization. It captures the IT unit's KS support for improvisations challenges of the organization during the implementation of new product innovation ideas.	Duncan (1995), Barrett (1998), Earl & Khan (2001), Sambamurthy et al. (2003), McDaniel (2007), Kohli & Melville (2009), Pavlou & El Sawy (2010), and Moos et al. (2013)
IT Unit's Technology Standardization Support	The extent to which the IT unit identifies and maintains appropriate technology standards for the organization's EIT. It captures the IT Unit's Technology Standardization Support for improvisation challenges of the organization during the implementation of new product innovation ideas.	Duncan (1995), and Ross & Quadgrass (2009).
It Unit's Digitization Support	The extent to which a digital foundation is used to achieve enterprise-wide integration in the organization's customer-facing, supplier-facing, and internal process. It captures the IT Unit's Digitization Support for addressing the learning-on-the-fly challenges of the organization about changing customer value stage.	McDaniel (2007), McAfee & Brynjolfsson (2008.)

2.3.1 Scanning

At any given time, there is a multitude of EIT in the environment. Some of them can potentially be embedded in conventional products to enable new product innovations. Thus, the first stage of the organizational product innovation process is the Scanning stage. We define Scanning as "the stage in which the organization identifies and chooses which of the EIT in the environment could potentially be relevant and useful for product innovations." It involves an exploratory search of the environment to generate intelligence about EIT and dissemination of this information within the organization (e.g., Pavlou & El Sawy, 2011; Vandenbosch & Huff, 1997). The key challenge that the organization faces in the Scanning stage is that of continuously monitoring and sensing the IT landscape to identify which EIT could potentially be relevant and useful in its products. The sheer number of different EIT, their technical specifications, and their potential interdependencies and interactions within the product, increase the variety and complexity of technological possibilities. Organizational units traditionally involved in innovation do not have the internal variety of expertise to match such variety and complexity in the environment. Thus, they may not be able to effectively address the IT-specific challenges faced in the Scanning stage.

2.3.2 Matching

Once the relevant subset of EIT is identified by the organization, the next stage is to match the EIT to business and economic opportunities that the organization could create by embedding the EIT in its products. We define Matching as "the stage in which the firm analyzes how the embedding of the EIT in products could create new economic opportunities." The organization faces a number of questions in this stage: e.g., what technical functionality the EIT have; what new product features they can enable if embedded in the firm's products; whether those features would be valued by customers; whether they would meet regulatory requirements on safety, security, and privacy; which new ITEP innovations should be prioritized and pursued; etc. These questions are also interrelated. There is high variety and complexity in the possibilities for generating IT-embedded products. The key challenge the organization faces in this stage is that of making sense of these possibilities, and envisioning promising and likely ITEPs that could potentially provide new economic opportunities (D'Aveni, 1994, Barua, Konana, Whinston & Fang, 2001).

2.3.3 Implementation

Once the EIT are matched to potential economic opportunities, the next step is to realize the potential by implementing the ITEP innovations. We define Implementation as "the stage in which the organization develops the ITEP innovation." The organization faces significant uncertainty about the technical and economic feasibility of various configurations due to a wide variety of constraints such as technical compatibility, interoperability, and ease of use requirements; economic cost and affordability considerations; compliance with relevant safety, security, and privacy laws, regulations, and standards; etc. The key challenge in this stage is one of improvising, that is, spontaneously reconfiguring the firm's resources to quickly develop the ITEP innovation and deploy corresponding changes in workflows and technology infrastructures (Straub, 2004; Rush, Bessant, & Hobday, 2007; Pavlou & El Sawy, 2010). Given the variety and complexity of possible solution configurations and test-modification-retest options, addressing this challenge would require support for agility, flexibility, and adaptability, from the organization's technical platforms.

2.3.4 Customer Value

The final stage is to sell the innovation and ensure that it delivers value to customers. We define Customer Value as "the stage in which the organization assesses customers' perceptions about the innovation, through their referral, and loyalty behaviors." The success of technology-embedded products is assessed by the extent to which they generate value for the customer by enhancing the product's functionality and buying experience (Bolton & Drew, 1991; Wheeler, 2002; Woodruff, 1997; Chen & Dubinsky, 2003). ITEPs evolve continuously, for example, through software updates, patches, addition of new functionality and services, and connections to other services in the ecosystem. There is significant uncertainty not just about customers' initial purchase and usage behaviors and value perceptions, but also about their subsequent reactions to the ongoing changes in the product. The key challenge for the organization at this stage is one of continuously monitoring and learning about customers' evolving perceptions of the ITEP, and feeding the learning into further ongoing innovation. Given the variety and complexity of parameters to be monitored, addressing this challenge would require the ability to easily and continually track changes in ITEPs and customers' perceptions of them.

2.4 Complexity Science

We view the IT-specific uncertainties and challenges entailed in each of the four stages above as artifacts of complexity in the ITEP as well as the ecosystem in which it is developed and operated. Complexity is a property of a system that is made up of a large number of parts that interact with each other in nonlinear ways (Maguire, 2011). When some parts of a complex system are intelligent and agentive, they can observe and interpret stimuli from other parts and from the environment. They can learn, change behaviors, and develop adaptive responses (Casti, 1997; Holland, 1995). They also have connections and mutual dependencies with other parts. The actions of one part can affect those of others as well. These interactions cannot be controlled. They are unpredictable and emergent. They can lead to unexpected and surprising outcomes (McDaniel et al., 2003). Thus, there is fundamental, irreducible type of uncertainty in sociotechnical complex systems. Prior IS studies recognize the complexity of IT-related innovations, the surprising behaviors they can generate, and emphasize the need for "adaptive management of expectations in the context of the unexpected" (Swanson & Ramiller, 2004, p.555).

Pavlou and El Sawy (2011) caution that even dynamic IT capabilities would have limitations in addressing such challenges. They argue that dynamic capabilities are well suited for environments characterized by *predictable* patterns of change, but they cannot address the *unexpected and unpredictable* changes generated by complex, turbulent environments. Pavlou and El Sawy (2011) recommend improvisation as a way of spontaneously reconfiguring existing resources to build new capabilities to address unpredictable and novel situations in complex systems. Complexity science goes a step further and recommends four interrelated activities for increasing an organization's capacity to address and tame the unpredictable behaviours and irreducible uncertainties of complex systems (McDaniel, 2007): (1) sensing, (2) sensemaking, (3) improvising, and (4) learning on the fly. We argue that these activities can increase an organization's capacity to address the IT-specific uncertainties and challenges faced in each stage of the ITEP innovation process.

The key challenge in the Scanning stage is to continuously monitor a complex and rapidly evolving IT landscape to identify which EIT could potentially be relevant and useful for the firm's product innovations. The Sensing activity spots the changes in emerging information technologies in the environment and brings them to the attention of decision makers in the organization. It can thus increase the organization's capacity to address the key challenges of the Scanning stage.

The key challenge in the Matching stage is to make sense of the plethora of EIT by imagining what new economic opportunities they could potentially create if they were to be embedded in the organization's products. Sensemaking focuses on human cognitions and social interactions that seek to interpret the changes in the environment, give meaning to them, and understand what they might imply for the organization; it can thus increase the organization's capacity to address the key challenge in the Matching stage.

The key challenge in the Implementation stage is to improvise—i.e., spontaneously and creatively develop a technically and economically feasible solution for the IT-embedded innovation by reconfiguring the firm's resources. The improvising activity focuses on inventing novel actions in response to the changes sensed in the environment; it can thus increase the organization's capacity to address the key challenges in the Implementation stage.

The key challenge in the Customer Value stage is to continuously learn about customers' perceptions of the evolving ITEP for further ongoing innovation. Learning on the fly focuses on understanding how customers and the environment react to improvisational actions of the firm on the product; it can thus help the organization address the key challenges in the Customer Value stage.

Complexity science informs us that organizations face "adaptive tension" when the variety and complexity in the external environment increases (McKelvey, 1999). That is, organizations are not able to effectively adapt to the changing environment because they lack sufficient variety in their internal resources and skills to match the increasing variety and complexity in the environment. Ashby's (1956) law of requisite variety suggests that organizations can address the adaptive tension by increasing their internal variety and complexity. Indeed, managers adjust internal structures of their firms based on the complexity and uncertainty levels in the external environment (Davis, Eisenhardt, & Bingham, 2009). In our context, we argue that organizational units such as R&D, engineering, marketing, etc. are not able to effectively address the increasing variety and complexity of IT-specific challenges they face in the four stages of ITEP innovation because they lack the required variety and depth of IT expertise. We argue that the involvement of the IT unit in all four stages of the innovation process could increase the organization's internal variety of expertise, enable it to adapt to the external variety, and hence, make it possible for it to better address the IT-specific uncertainties and challenges faced in the four stages of the ITEP innovation.

In the next section, we build on complexity science and the IS literature to develop hypotheses explaining how and why the involvement of the IT unit could increase the effectiveness of the four stages of the ITEP innovation process.

3 Hypotheses Development

As discussed above and shown in Figure 1, we adopt Wheeler's (2002) "net-enabled business innovation model" to structure the four key stages that an organization systematically goes through in developing an ITEP innovation. We superimpose the hypothesized roles of the IT unit on this framework and depict the proposed research model in Figure 2. We explain how the IT unit contributes to the organization's sensing activities in the Scanning stage, sensemaking activities in the Matching stage, improvisation activities in the Implementation stage, and learning activities in the Customer Value stage. We include Organizational Performance as an outcome of the ITEP innovation process. We summarize the definitions and theoretical underpinnings of the key constructs of the research model in Table 1.

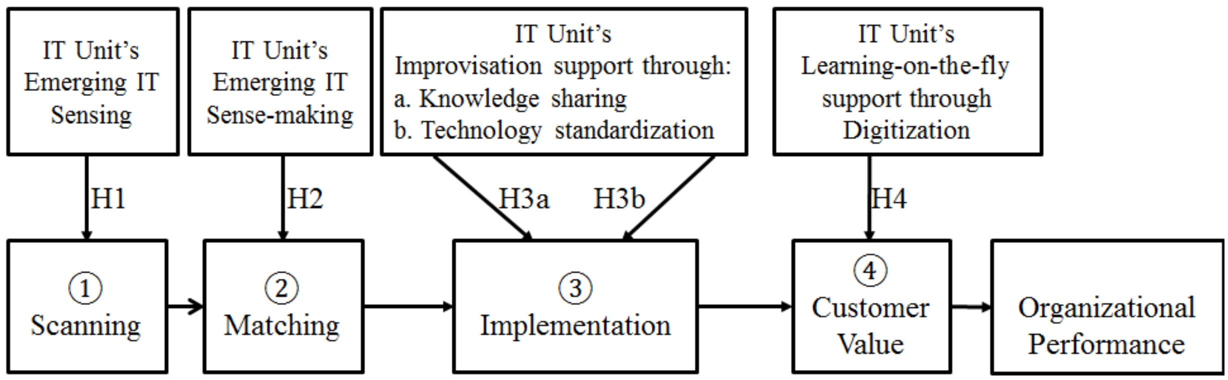

Figure 2. Proposed Research Model: IT Unit's Roles in IT-Embedded Product Innovation Process

3.1 Unit's Involvement and the Effectiveness of the Scanning Stage

Sensing is required to address the challenges the organization faces in the Scanning stage. With the embedding of IT in products, the sensing activity becomes difficult for organizations because it involves identification of relevant EIT in a complex environment that has many changing technologies and dependencies among them. For example, almost all IT used in the automobile, such as sensors, navigation systems, digital maps, networking, and media-content platforms, change and evolve quickly. Innovation-related business units such as R&D and marketing face adaptive tension because they do not have the requisite variety of expertise to accomplish sensing. They may find it difficult to track the multitude of EIT that are potentially relevant for IT embedded product innovation, evaluate them, and bring a subset of them to the firm. Involvement of the IT unit in the Scanning stage increases the internal variety by bringing in the necessary expertise to address the challenge. To capture this role, we frame a new construct: "IT Unit's Sensing." We define it as "the extent to which the IT unit of the firm spots potentially relevant EIT and brings them to the attention of business executives within the firm."

A number of activities are required to accomplish sensing (Kiesler & Sproull, 1982; Eisenhardt, 1989; Brown & Eisenhardt, 1997). The organization should continually acquire information about EIT from a range of external information sources, understand their characteristics and functionality, and bring the new knowledge thus generated to the attention of business units. The IT unit can potentially increase the effectiveness of the Scanning stage by accomplishing these activities for the organization.

The IT unit is uniquely positioned to acquire information about EIT because identifying technological trends is an important element of an IT worker's job (Ang & Slaughter, 2000). IT professionals typically attend vendor demonstrations, and subscribe to trade journals. They thus acquire information about EIT and their potential relevance for the organization (Nilakanta & Scamell, 1990; Rai, 1995). IT market research and analyses firms such as Gartner provide industry sector-specific technology research reports and organize conferences that allow for informative exchanges on current technology topics (Swanson, 2010). IT professionals attend such conferences, and thus, can bring back valuable insights about EIT that are relevant to the organization (Cegielski, Reithel, & Rebman, 2005). IT professionals also form a community of practice that develops and maintains specialized technical expertise and knowledge about EIT through interactions with peers in the IT industry. They can sense potentially relevant EIT more effectively because of their knowledge of existing IT.

In a follow-up interview, Steve Basra of Toyota described the participation of the IT unit in the Scanning stage as follows:

> *In the past, we would just take orders from the business and try to understand what they want and try to solve them. Whereas what is happening nowadays, as IT is moving and advancing rapidly, is that, as the IT [unit], we are starting to look at potentials the technology can be used [for]. If there is a potential new technology out there, we are thinking about potential use cases where it can resolve some business problems. . . . We try to bring some of those technologies to the business.*

The IT unit has context specific technology expertise that enables critical and mindful vetting (Wheeler. 2002; Swanson & Ramiller, 2004) of the EIT to filter in those that may have high potential for the organization. This could reduce the knowledge barriers to the adoption of the EIT (Attewell, 1992; Fichman & Kemerer, 1997). The IT unit can also disseminate the knowledge about the EIT to the rest of the organization to raise awareness of the business units about them (Swanson & Ramiller, 2004; Pawlowski & Robey, 2004). It can do so by conducting forums to share and discuss their own knowledge with functional managers within business units and top management (Luftman & Brier, 1999; Sambamurthy & Zmud, 1997; Agarwal & Sambamurthy, 2002). In summary, the IT unit could contribute to the effectiveness of the Scanning stage by sensing of the EITs that are potentially relevant and useful for new product innovations of the firm. Thus:

H1: The *IT Unit's Sensing of EITs* positively affects the firm's *Scanning* activities for ITEP innovations.

3.2 IT Unit's Involvement and the Effectiveness of the Matching Stage

ITEP innovation typically utilizes many existing and emerging technologies. It also engages many different stakeholders whose objectives and requirements from the innovation might be different (e.g., customers, regulators, vendors and partners). The organization faces significant uncertainty as to which configurations of the technologies would be technically and economically feasible to embed in products; whether they would lead to innovative new product features or brand new products, meet stakeholder objectives, and create economic value; etc. Addressing such uncertainties is challenging because of the large number of combinatorial possibilities in how the different technologies could be brought together to address different objectives and requirements. Given the uncertainty, an established knowledge base is not present. Thus, the organization cannot simply use a knowledge management system to find the answers. Sensemaking is thus critical for identifying potential answers. Such sensemaking would require participants to interpret and give meaning to the different combinatorial possibilities. Business units that are typically involved in the Matching stage, such as finance, marketing and corporate planning, do not have the requisite IT expertise to make sense of the possible configurations of the emerging technologies or to identify which ones might create new business and economic opportunities (McDaniel, 2007). Involvement of the IT unit in the Matching stage could bring in the IT expertise required for effective sensemaking of EIT driven economic opportunities. Steve Basra described the collaborative nature of the Matching stage activities and the role of the IT unit in them as follows:

> *We start working with business. . . . Maybe some of our technology partners would then come in and share some of their ideas. It is a collaborative piece. We all come together, we talk about potential solutions. We talk about some of the different options. It is not just purely IT, it is not just purely business, it is bit of both together. . . . We brainstorm, we ideate on certain options, and we take it forward.*

To capture this new role for the IT unit, we frame a new construct, "IT Unit's Sense-Making." We define this construct as "the extent to which the IT unit gives contextual meaning to EIT by interpreting what kinds of new features and functionalities the EITs can potentially enable in the firm's products; raising awareness about potential opportunities from the EIT if they are embedded in the firm's products; and articulating new relationships the firm could develop with partners if EITs are embedded in the firm's products."

Activities necessary for sensemaking include the contextual understanding of EIT with respect to the organization's products, and the imagining of a broad range of product innovations that could be created with the embedding of EIT in the products (Muhren, & Van de Walle, 2010; Weick, 1993). The IT unit can potentially help the organization in these activities as follows.

First, different EIT can have different functionalities, standards, configuration options, and dependencies with other IT. Their potential applicability in the organization's products and their pathways to potential economic opportunities entail significant ambiguity (Swanson & Ramiller, 2004). The task of understanding what the EIT might mean for the organization's product innovations entails high variety and high complexity, and hence, fundamental uncertainty. Addressing such ambiguities and fundamental uncertainties requires sensemaking and credible interpretation processes with inputs from a variety of expertise domains (McDaniel, 2007). Business units have functional domain expertise, but they lack the variety of IT expertise to develop credible interpretations as to what the different EIT might mean for product innovations. The lack of IT expertise in business units could raise knowledge barriers (Attewell, 1992) to the process of giving meaning to EIT in the context of the organization's product innovations.

Second, the task of imagining a broad range of product innovation possibilities with EIT also requires sensemaking and interpretation processes with input from a variety of expertise domains. The innovator's dilemma phenomenon informs us that business units such as R&D and marketing may have a bias against emerging technologies. They often evaluate emerging technologies with well-established performance metrics (Christensen, 1997). Since emerging technologies are often initially inferior to incumbent technologies when assessed by established performance metrics, these business units tend to overlook the EIT and what they might imply for product innovations. The IT unit can potentially help the business units overcome this bias by bringing in the variety and depth of IT expertise to the sensemaking process.

IT professionals interact with most of the business units and develop business knowledge and viewpoints about the organization's processes and products (Gordon & Tarafdar, 2010). The combination of business knowledge and IT knowledge places IT professionals in a position to identify ways in which EIT could be incorporated into specific products and services. Prior research shows that teams possessing a mix of business and technology experience identify a larger number of innovation opportunities than teams with only business experience (Gruber, MacMillan, & Thompson, 2008). Accordingly, the participation of the IT unit in the sensemaking activities could increase the effectiveness of the Matching stage by enhancing the organization's capacity to imagine a wide range of product innovation possibilities that could be created with EIT. Thus:

H2: The *IT Unit's Sense-Making of EIT* positively affects the firm's *Matching* activities for ITEP innovations.

3.3 IT Unit's Involvement and the Effectiveness of the Implementation Stage

Improvisation is required to address the key challenges in the Implementation stage, namely, the implementation of the envisaged innovation ideas through the development of technically and economically feasible ITEPs. Technical feasibility means that the product does what it promises to do technically. It delivers all the promised features and functions within the specified constraints. Economic feasibility means that there is a strong business case for the ITEP and that the price of the product is within the range of customer's willingness to pay.

Development of a technically and economically feasible ITEP is a complex task because it needs to take into account: (1) a diverse set of connected and mutually dependent technologies each of which is continually evolving; and (2) a diverse set of intelligent stakeholders who pursue their own interests and impose different constraints on the product (e.g., customers, technology vendors, regulators, etc.). The technical and economic feasibility of different configurations of such technologies and stakeholders cannot be predicted in advance due to emergent interactions among them. The organization thus needs to come up with technology solutions for the innovation without necessarily having a pre-scripted plan (Barrett, 1998). That is why improvisation is critical for the success of the Implementation stage. Improvisation is challenging because it involves inventing original and novel responses, and at the same time, being mindful of potential interdependencies (McDaniel, 2007).

For example, to embed a satellite-based tracking feature in an automobile requires solutions that involve sensors, location data, satellite communication equipment and interfaces with Cloud-based systems. However the implementability of the new feature would depend on compatibility with the car's existing computing and control platform, with the manufacturer's existing production control/testing software, and with software from vendors who provide emergency services and roadside assistance. A change in any one IT component can lead to cascading changes and consequent technical issues. Such changes could trigger a new cycle of improvisational design moves. Different stakeholders (e.g., regulators, vendors) have different requirements, such as safety, privacy and security, which also need to be satisfied. Being able to try many improvisational design moves is thus critical for the effectiveness of the implementation stage.

Steve Basra described the IT unit's participation in the Implementation stage as follows:

> *When you start thinking about technological solutions, you have so many parties involved, whether it is vehicle electronics guys, communications guy. . . . On top of that, you start thinking about the communications from the vehicle to the Cloud, and then all the infrastructure involved, and some of the new big data technologies. How do we address the uncertainties and reduce the many options? . . . The biggest challenge we have is that the technology can be very good on its own but how to make the business case with it? The margins on the vehicle are very small. So whenever you add cost to the vehicle, you have to show how you will get that cost back. The cost could be monetary; it could be safety related; it could be related to derivability enhancements that make the car more attractive to the customer. Each of those business cases have to be validated. That is the most difficult issue. We [IT unit] have to be involved. That is one of our core responsibilities. . . . The initial proof of concept may be very expensive. We may have to use the most up-to-date cameras, the high CPUs, etc. Then, as we prove out the use case to prove the potential benefit to*

> *the company, we have to start looking at each component in isolation and ask, "Can we get away with a cheaper component?" "Can we get away with some in-house IT to reduce the costs."*

Further, considerations of technical aspects such as bandwidth, reliability (e.g., what happens if the satellite gets out of alignment for a short time), security, and capacity, are likely to come primarily and perhaps only from the IT unit. For instance, a marketing specialist might have some general knowledge of a GPS, while an IT person would look at it as a set of complex components and would have the specific technical knowledge to be able to understand its interaction with the other components of the car and associated solutions and/or tradeoffs.

The IT unit's support for knowledge sharing and technology standardization could potentially increase the agility, flexibility, and adaptability of the organization as it tries to improvise on potential solution options until it develops a technically and economically feasible solution. To capture such roles of the IT unit, we frame two new constructs: (1) "IT Unit's Knowledge Sharing Support," and (2) "IT Unit's Technology Standardization Support."

3.3.1 IT Unit's Knowledge Sharing Support

We define "IT Unit's Knowledge Sharing Support" as "the extent to which the IT Unit builds IT hardware and applications to support electronic information and knowledge sharing across the organization."

Improvisation requires innovation teams to speedily experiment with and devise new solutions in response to unanticipated requirements, often by reworking existing solutions (Berliner, 1994). Related changes typically take place throughout the organization. Many business units would need to coordinate and share resources with each other: e.g., R&D unit for design; purchasing unit for interfacing with vendors providing the IT components used; manufacturing unit for producing the prototypes and designs; marketing & sales unit for incorporating the new features into product marketing and demonstration materials; etc. A knowledge sharing platform that makes the firm's knowledge resources available in a digitized form increases the organization's capacity to identify, retrieve, configure, and reconfigure these resources across business units. With a digital platform and digitized knowledge resources, cross-unit innovation teams can gain agility and flexibility in configuring the organization's knowledge resources in new ways to devise novel new solutions that could potentially lead to technically and economically feasible ITEP innovations (Sambamurthy, Bharadwaj, & Grover, 2003). A digital knowledge- sharing platform can also speed up collaboration, coordination and decision-making among cross-unit innovation teams across the enterprise. It can support the exploring, tinkering and change implementation activities of the teams (Kohli & Melville, 2009; Moos, Beimborn, Wagner, & Weitzel, 2013; Tarafdar & Gordon, 2007). Therefore, the IT unit, through its support of knowledge sharing could increase the effectiveness of the Implementation stage. Thus:

H3a: The *IT Unit's Knowledge Sharing Support* positively affects the firm's *Implementation* activities for ITEP innovations.

3.3.2 IT Unit's Standardization Support

We define "IT Unit's Technology Standardization Support" as "the extent to which the IT Unit identifies and maintains appropriate technological standards for the organization's EITs."

In general, technology standardization helps an organization create and maintain a mature enterprise IT architecture over which a portfolio of products could be developed, supported, serviced, and upgraded (Ross, Sebastian, & Beath, 2016). In the context of an ITEP innovation process, the organization needs to ensure that a diverse set of EITs from different vendors could work in compatible and interoperable ways with each other when embedded into a new product. The EITs also need to interface well with the hardware and applications in the firm's information processing infrastructure. In the absence of technology standards, implementation of spontaneous new configurations of the EIT components could require customized integration efforts and significantly limit the types and numbers of technology configurations that the innovation teams could experiment with. Improvisation activities could also prove time consuming and expensive (Swanson, 2010), and hence, hinder the ability of the teams to quickly find technically and economically feasible configurations. The IT unit could minimize such hurdles by maintaining technological standards that newly adopted EITs could adhere to.

We acknowledge the potential negative effects of technology standardization. At the level of an individual ITEP innovation project, standardization could potentially slow down the innovation process and stifle ITEP innovation by requiring compliance with the existing technology standards. However, at the level of the firm, technology standardization can create a mature enterprise IT architecture over which the firm can implement a portfolio of ITEP innovation projects faster, more flexibly, and with less cost. Prior research (e.g., Ross et. al. 2016) indicates that a standardized operational IT backbone could hurt local flexibility of individual projects but it minimizes operational IT problems, and ensures efficiency, predictability and quality of information processing at the firm level. It also enables the IT unit of the firm to shift IT professionals from operational IT issues to higher value adding activities such as supporting ITEP innovations. A standardized IT backbone also makes it easier and quicker to identify emerging new technology components that can interface and integrate with the existing information processing architecture of the firm. Accordingly, standardization enables the firm to execute digital innovations with greater dexterity and agility. We draw from these arguments to frame the logic of H3b.

The adherence of the EITs to technology standards can minimize potential compatibility, interoperability, and integration problems within the product as well as with the information processing infrastructure of the firm (Ross & Quadgrass, 2009). It also makes the process of incorporating the EIT into the product faster, given greater uniformity in testing and documentation processes. Further, it prevents the emergence of conflicting standards. Innovation teams can more quickly integrate different configurations of the EITs within the product and with the information processing infrastructure of the firm through adherence to the standards. They can experiment with different types and more numbers of prototypes, and quickly test, redesign, and retest them until they find technically and economically feasible EIT configurations for the new ITEP innovation. Therefore, the IT unit, through its support of technology standards, could help the organization to improvise, and to increase the effectiveness of the Implementation stage. Thus:

H3b: The *IT Unit's Technology Standardization Support* positively affects the firm's *Implementation* activities, the IT unit's involvement, and the effectiveness of the Customer Value stage for ITEP innovations.

3.4 IT Unit's Involvement and the Effectiveness of the Customer Value Stage

In the Customer Value stage, ongoing learning about how customers interact with the ITEP in use, and how their value perceptions about the product change over time is a challenge because the product and its ecosystem are dynamically evolving. Customer experience with the ITEP can change in response to the firm's own actions on the product as well the actions of the other stakeholders, such as vendors, competitors, regulators, and even malicious users such as hackers.

In the self-driving car example, if the vendor that provides vehicle connectivity to the Cloud can figure out how to provide uninterrupted connectivity, even in remote terrains, customer experience with the self-driving car can improve. Likewise, if the Cloud vendor that does the analytics for the dynamic discovery of road markings can improve its machine learning algorithms, it can positively impact the customer's self-driving experience by minimizing the need to transfer control to the customer. Conversely, even a seemingly short disruption in connectivity or a brief outage in the Cloud infrastructure could have a major negative effect on the customer's experience and reduce the value the customer perceives from the self-driving features of the car. Similarly, the firm's own remote firmware or software updates to the self-driving car can modify the features and capabilities of the car. Such changes carry both the potential of improving the customer experience positively and the risk of causing a negative customer experience. In this context, it is highly likely that only the IT unit would consider complex issues such as the bandwidth, reliability, security, and capacity of the satellite links and would correctly assess the matter of connectivity as one that includes a set of complex components. Professionals from other functions involved in ITEP innovation (such as marketing) might see connectivity as in a black box fashion without necessarily understanding the components and interfaces involved. The IT unit thus has specific skills that would enable them to propose solutions and/or tradeoffs.

As the ITEP becomes a node on the Internet, malicious users, such as hackers, could also negatively affect customer experience and value. In 2015, two security researchers, Charlie Miller and Chris Valasek, were able to wirelessly hack into a Jeep Cherokee. Andy Greenberg, the Wired Magazine correspondent who was at the wheel to serve as a "digital crash test dummy" described his experience as follows:

> *I was driving 70 mph on the edge of downtown St. Louis when the exploit began to take hold. Though I hadn't touched the dashboard, the vents in the Jeep Cherokee started blasting cold air at the maximum setting, chilling the sweat on my back through the in-seat climate control system. Next the radio switched to the local hip hop station and began blaring Skee-lo at full volume. . . . Then the windshield wipers turned on, and wiper fluid blurred the glass. . . . Immediately my accelerator stopped working. As I frantically pressed the pedal and watched the RPMs climb, the Jeep lost half its speed, then slowed to a crawl. This occurred just as I reached a long overpass, with no shoulder to*

offer an escape. The experiment had ceased to be fun.[1]

These kinds of possibilities punctuate the need to monitor the ITEP in use and how the customer interacts with it, as well as the need to learn on the fly how customer experience evolves in response to the dynamic changes in the product. Since the product embeds IT, various remote tracking and management capabilities, such as product-use monitoring, diagnosis, maintenance, upgrades, and feedback, are typically possible. However, the organization may need to monitor not only the product and the customer but also the other stakeholders such as vendors and business partners whose actions affect the performance of the product and the customer experience. Different stakeholders may interface with the organization at different parts of the value chain. Vendors providing technology components to the ITEP may interface with the organization through supply chain management (SCM) systems. Customers may interface with the organization through customer relationship management (CRM) systems. Collaborators may interface through enterprise resource management (ERP) systems. These systems complement and positively reinforce each other. The extent to which the firm uses these systems to digitize and integrate its value chain enterprise-wide can also affect the extent to which the firm can digitally interact with the stakeholders and learn on the fly how customer experience and value perceptions evolve as a function of dynamic changes in the product and ecosystem.

To capture the IT unit's digitization support for learning-on-the-fly challenges about changing customer experiences and perceptions during the Customer Value stage, we frame a new construct: "IT Unit's Digitization Support," which we define as "the extent to which a digital foundation is used to achieve enterprise-wide integration in the firm's customer-facing, supplier-facing, and internal processes."

Digitization of the firm's SCM, CRM, and ERP systems could help the firm to redesign and streamline how ITEPs are delivered to customers, how they are monitored in use, and how they are supported and upgraded. For example, SCM applications could enable the firm to share information with suppliers about how the ITEPs are being used. Near real-time intelligence about product usage patterns could enable suppliers to identify potential problems and improvement opportunities in the products. Similarly, digitization of CRM systems could enable the firm to deliver new ITEPs to customers directly through digital channels, receive customer feedback about the products in a more timely fashion, discover emerging new customer needs and preferences, and deliver new product features and upgrades. Digitization of other processes, such as product lifecycle management, could also increase the organization's ability to communicate and collaborate better with both the internal business units and the external business partners who contribute to the ITEPs. In summary, the extent to which the organization digitizes its value chain with the use of enterprise-wide SCM, ERP, CRM systems could add customer value by supporting the learning-on-the-fly activities of the organization regarding dynamically changing customer experiences with ITEPs. Thus:

H4: The *IT Unit's Digitization Support* positively affects the *Customer Value* the firm delivers through ITEP innovations.

4 Methods

The study of complex social phenomena often requires both variance and process approaches (Webster & Watson, 2002; Burton-Jones, McLean, & Monod, 2011). The model we propose in Figure 2 has elements of both variance and process. Wheeler (2002) suggests that such models can be tested empirically using a variance approach to capture the simultaneous relationships among the stages at any point in time. Prior empirical research has operationalized and tested such stage models of innovation antecedents and outcomes using cross-sectional survey data and structural equation modeling. For example, McGrath et. al., (1996) used survey data to test a stage model that hypothesizes four antecedents in a sequence as precursors for a firm's ability to capture rents from an innovation. They used structural equation modeling and found that achieving each of the four antecedent processes increased the rents from an innovation. We adopt a similar empirical approach for testing the proposed research model.

For a given firm at a given time, there are multiple ITEP innovation projects that can be at different stages of Wheeler's four-stage model. At the firm level of analysis, the theorized ordering of the four stages serves as a way of logically organizing and guiding the innovation activities of the firm in a portfolio of ITEP innovation projects. Regarding the variance element of the proposed model, the expectation is that the variance in aggregate activity levels and effectiveness of one stage affects the variance in aggregate activity levels and effectiveness of the subsequent stage and lead to better results.

We measure the aggregate activity levels of the firm in each of the four stages. When the activity levels of the first stage go up, it means that the firm is actively scanning the environment, sensing the emerging information technologies (EITs) that might be relevant and useful for its

[1] http://www.wired.com/2015/07/hackers-remotely-kill-jeep-highway/

ITEP innovation projects, and bringing them inside the firm. It is then logical to expect that the increased activity levels of the first stage will trigger and positively reinforce the activity levels in the second stage. That is, the firm will become more likely to match the EITs to ITEP innovation opportunities inside the firm. In contrast, if the activity levels of the first stage are low, it would mean that the firm is not actively identifying and bringing relevant EITs into the firm for ITEP innovation consideration. Without a sufficient inflow of relevant EITs, the activity levels in the Matching stage would also stay low. Likewise, when the activity levels in the second stage go up, it means that the firm is actively matching the EITs to ITEP opportunities. Thus, the expectation is that more ITEP innovation projects will move to the Implementation stage, i.e., the third stage. In contrast, if the matching activity levels are low, implementation activity levels would also remain low. Finally, when the implementation activity levels go up in the third stage, it would mean that more ITEPs are being implemented and it would trigger and positively reinforce more activities in the fourth stage that seek to create customer value. In contrast, if the ITEP implementation activity levels are low, the firm would not have the ITEPs that would motivate it to engage in activities that create customer value. Deviations from the theorized sequence of the four stages are possible at the level of individual ITEP innovation projects. For example, if a particular team struggles in the second stage to match a given EIT to its ITEP project, it may go back to the first stage to identify a different EIT that is likely to be a better match. If the team runs into implementation challenges in the 3rd stage, it may go back to the second stage to change its EITs and find different matches that address the implementation challenges better.

The process elements of the proposed model are highlighted by three aspects. First, there is dependency among the four stages. Effectiveness of the Scanning stage could influence the effectiveness of the Matching stage; the effectiveness of the first two stages could influence the effectiveness of the Implementation stage. The effectiveness of the previous three stages could affect the Customer Value stage, and ultimately the firm performance. Second, there is an element of probability in the relationships among the stages (Mohr, 1962). Earlier stages could enable or constrain what is possible in later stages. It is possible that a threshold of enablement in a preceding stage might be necessary to successfully engage in a later stage. It is also possible that successful performance at a later stage (e.g., excellent convergence on a solution) could make up for a poor initial stage (e.g., poor consideration of the range of possible combinations of technology and business elements). Third, the four stages could be ordered in multiple different ways. Whether one ordering is superior to the others could ultimately be an empirical question. All else being equal, we expect later stages to be advantaged by better performance at earlier stages. Thus we expect the ordering theorized by Wheeler to enable a firm to more logically organize and guide its ITEP innovation activities, and as a result, increase the of success of its ITEP projects on average.

4.1 Sample and Data

The proposed theory applies to organizations that have institutionalized product innovation processes and established IT units. All organizations which satisfy these boundary conditions could potentially be included in the sampling frame of this study. ITEP innovation is a global phenomenon. To test the generalizability of the theory, we sought to include organizations from multiple countries. In their study of innovation antecedents and outcomes, McGrath et al. (1996) collected data from organizations across eight countries. We collected our data in two countries: The U.S.A. and India. The U.S.A. is an advanced economy which is a leader in IT and ITEP innovations.[2] India is an emerging economy which, through its economic and technology policies, views its IT industry and IT-related innovations as engines of economic growth.[3] Thus, these two countries provide diversity to test the generalizability of the proposed theory.

We collected the data using the survey method. While the phenomenon of ITEP innovation is perceived to be relatively new, as our theoretical foundations and hypotheses development sections above illustrate, there is sufficient prior knowledge to frame the stages of ITEP innovation process and how the IT unit can address the IT-specific challenges faced in each stage of the process. We build on these foundations to develop the constructs and measurement instruments of the study.

4.1.1 Survey Instruments

Table 1 summarizes the key constructs of the study, their definitions, and theoretical underpinnings. When available, we adopted previously validated measurement items from the literature (e.g., firm performance, customer value, and the control variables). For new constructs, we developed new measurement instruments based on the literatures reviewed. First, we drafted measurement items that are consistent with the definitions and the theoretical underpinnings of the constructs. Second, we tested the face and content validities of the items with three CIOs and two vice presidents of technology of

[2] See The Global Innovation Index (https://www.globalinnovationindex.org/content/page/data-analysis) and the Bloomberg Innovation Index (http://www.bloomberg.com/graphics/2015-innovative-countries)

[3] See India's National Information Technology Policy 2012 (http://deity.gov.in/content/national-information-technology-policy-2012)

manufacturing firms, and with two academics who had teaching, research, and former industry experience in the IT domain. They reviewed the relevance, clarity, and salience of the items. Based on their feedback, we revised and improved the content and wording of the items. The resulting questionnaire items are presented in Table 2.

Table 2. Survey Instruments

Constructs	Instructions, measurements items, and response scales[1]
Scanning	**Instruction: The following questions are related to technology monitoring in your unit.** We have formal processes (like company bulletins), for regularly communicating information about emerging technologies (EIT). We have formal processes for regularly researching on EIT. We have frequent informal discussions among different departments regarding EIT.* We have formal processes for regularly identifying and choosing EIT.
Matching	**Instruction: The following questions relate to business planning in your business unit.** Our business strategic planning processes considers the capabilities of EIT. Our business strategic planning processes articulates the businesses case for product initiatives based on EIT. Our business strategic planning processes identifies financial benefits from product initiatives based on EIT. Our business strategic planning processes identifies operational benefits from product initiatives based on EIT.
Implementation	**Instruction: The following questions describe activities with respect to EIT based projects in your business unit.** Processes & product technology changes resulting from EIT enabled initiatives are executed swiftly. Processes & product technology changes resulting from EIT enabled initiatives are executed through incentives. Processes & product technology changes resulting from EIT enabled initiatives are made familiar to manages through training programs. Processes & product technology changes resulting from EIT are planned systematically.* Processes & product technology changes resulting from EIT enabled initiatives are executed through incentives and made easier through hand holding during execution.
Customer Value	Our customers perceive that they receive their money's worth from our products. Our customers value products. Our customers refer our product to new customers.
Organizational Performance	Relative to our expectations, we are satisfied with our sales growth. Relative to our expectations, we are satisfied with our market share. Relative to our expectations, we are satisfied with our return on investment. Relative to our expectations, we are satisfied with our profit margin.
IT Unit's Sensing	**Instruction: The following questions describe the role of IT professionals in your business unit.** The IT department conducts regular information sessions on EIT for other departments. The IT department discusses and shares knowledge on EIT with other departments. The IT department has regular communications with end users to make them aware of EIT. The IT department has regular communications with top management to make them aware of EIT.
IT Unit's Sense-Making	**Instruction: The following questions describe the role of IT professionals in your business unit.** The IT department helps to identify ways in which EIT can be used to change products. The IT department helps to identify ways in which EIT can be used to change processes. The IT department helps to identify ways in which EIT can be used to develop strategic relations with business partners. The IT department influences top management to adopt EIT.* The IT department helps to identify ways in which EIT can be matched with business opportunities.
IT Unit's Knowledge Sharing Support	**Instruction: The following questions describe capabilities related to IT in your business unit.** We have capabilities for electronic document sharing within the organization. We have capabilities for information sharing within the organization. We have capabilities for knowledge sharing within the organization. We have capabilities for knowledge sharing with business partners.* We have capabilities for information sharing between different departments.
IT Unit's Technology Standardization Support	**Instruction: The following questions describe the role of IT professionals in your business unit.** The IT department helps to identify standards for EIT. The IT department helps to choose standards for EIT. The IT department helps to maintain standards for EIT.
IT Unit's Digitization Support	**Instructions: Please indicate the extent of usage of the following technologies in your organizations.** SCM (supply chain management) software. ERP (enterprise resource planning) software. CRM (customer relationship management) software.

Notes: [1]Unless otherwise stated, 5-point Likert scale ranging from (1) Strongly Disagree to (5) Strongly Agree.
*Denotes items that were dropped after Exploratory Factor Analysis due to poor loadings.

4.1.2 Data Collection Procedures

We used a single informant approach for data collection. As in prior IS studies that examine IT-related phenomena at the firm level of analysis, we targeted CIOs. We assumed that CIOs were appropriate informants for reporting on IT-related innovation activities of both the IT unit and the business units of their firms. As shown in Table 2, we included instructions to alert CIOs to the specific context and perspective of each question.

In the U.S.A., we procured an email list of 1000 IT executives who had titles indicating senior IT positions: e.g., CIO, executive VP, senior VP, VP of IT, or director of IT. We sent them an email to explain the purpose of the study and asked about their willingness to participate. From the undelivered email reports, we inferred that our email did not reach about 400 of the intended respondents. Out of the remaining 600, we received 138 responses indicating willingness to participate. 36 of them specified that they would participate only if the survey took 15 minutes or less. We had to exclude them from further communication since our survey took about 20-30 minutes. We sent a web-based survey to the remaining 102. We received a total of 56 completed responses from them.

In India, we did not have a readily available email list of IT executives for the targeted organizations. Thus, we tried reaching them through the network of a well-recognized business school. We identified MBA students who did internships in the targeted organizations, and requested their help in reaching the senior-most IT executives in the target organizations. We reached IT executives of 168 firms who confirmed that their firms produce ITEPs. We gave them a paper copy of the survey instrument and received completed surveys from 109 of them.

4.1.3 Assessment of Informant Competency

For both the Indian and the U.S. samples, we assessed if the CIOs who responded to our survey were knowledgeable enough about IT-related innovation activities of their firms. First, we included an "I don't know" option in the response scales of the survey. There were no respondents who selected this option for any of the questions in the survey. This implies that the respondents felt knowledgeable enough to answer all of the questions. Second, we asked the respondents the extent to which they: (1) acted as a bridge between the IS and other business units; (2) developed relationships with other executives in the business unit; and (3) communicated regularly with the firm's top management team. The average scores of responses on these questions were, respectively, 4.05, 4.11 and 4.11 on a scale of 1 to 5. The high average scores indicate that the respondents were in touch with business executives, which was likely to increase their knowledge of IT-related innovation activities in the business units. Third, 72% of the respondents reported having an organizational tenure of three or more years. This indicates that they had participated in multiple annual planning and budgeting cycles of their firms and were likely knowledgeable about IT-related innovation activities in the firms. Overall, these measures indicate that the informants were competent to answer the questions of the survey.

4.1.4 Subsample Equivalence

We received a total of 165 usable responses, 34% of them were from the U.S. organizations, 66% were from Indian organizations. To assess if the two subsamples were similar and whether they could be combined, we compared them along several variables of theoretical relevance. Our theory focuses on established firms that follow institutionalized innovation processes and have established IT units. Thus, we compared the two subsamples along: (1) firm age, to identify whether the maturity levels of the firms in the two subsamples differed (Damanpour, 1991); (2) strategic profiles of the firms with respect to innovation, to identify whether the firms in the two subsamples differed in terms of competing on innovation (Venkatraman, 1989); (3) innovation cultures of the firms, to identify whether the firms in the two subsamples differed in terms of their innovation cultures (Leidner, Preston, & Chen, 2010); (4) IS budgets of the firms as percentages of their revenues, to identify whether the firms in the two subsamples invested differently in IS (Bharadwaj, 2000); and (5) CIO characteristics with respect to innovation, to identify whether the CIOs of the firms in the two subsamples differed in terms of their innovation focus (Peppard, Edwards, & Lambert, 2011). Table 3 reports the details of the comparisons. We used two tests to assess if the two samples differed along the comparison variables: (1) difference of means T-test, and (2) Mann-Whitney U test. There were no statistically significant differences between the two samples along any of the comparison variables. Thus, we combined the two subsamples in further analyses.

Table 3. Test of Equivalence of India and U.S. Subsamples

Comparison variables	India (mean)	U.S. (mean)	Difference of means T-test[4]	Mann-Whitney U test[5]	Results
Age of organization[1]	2.59	2.5	0.35	0.19	Not significant
IS budget of organization as a percentage of revenues[2]	1.95	1.92	0.86	0.87	Not significant
CIO's innovation orientation:[3] • The CIO is an idea generator. • The CIO creates awareness about how IT can be used for business innovation.	4.25 3.98	4.18 3.77	0.63 0.21	0.78 0.86	Not significant
Strategic profile of the organization with respect to innovation:[3] • Being among the first to introduce new products in the market. • Seeking new opportunities related to present operations.	3.61 3.58	3.71 3.59	0.46 0.10	0.20 0.16	Not significant
Innovation culture of the organization:[3] • Creativity is encouraged. • Challenges are encouraged.	3.89 3.91	3.80 3.75	0.53 0.23	0.47 0.44	Not significant

Notes:
1. Response scale: (1) less than 2 years; (2) 2 to 5 years; (3) 6 to 10 years; (4) more than 10 years.
2. Response scale: (1) less than 2%; (2) 2 to 4%; (3) 4 to 6%, (4) 6 to 8%; (5) 8 to 10%; (6) 10 to 15%; (7) over 15%.
3. Response scale: Likert scale ranging from (1) strongly disagree to (5) strongly agree.
4. Difference of means t-test assumes normal distribution; p-values in cells; values > 0.05 indicate that the difference between samples is not significant.
5. Mann-Whitney U test does not assume normal distribution; values in cell; values > 0.05 indicate that the difference between samples is not significant.

In the combined sample, 51% of the firms were in the manufacturing sector and 49% were in the service sector. In terms of size of firms, the sample had the following distribution: 23% had 0-500 employees, 24% had 500-1000 employees, 17% had 1000-5000 employees, 30% had 5000-10000 employees, and 6% had above 10000 employees.

4.2 Control Variables

The overall thesis of the paper is that the IT unit's involvement would increase the effectiveness of each stage of the ITEP innovation process. Prior literature identified possible alternative determinants of the effectiveness of each stage. To account for such alternative explanations and minimize potential endogeneity concerns, we include them as controls. Table 4 presents the controls we use at each stage of the model.

Table 4. Construct Definitions, Descriptions, and Theoretical Underpinnings

Stage of model	Controls for the stage	Measurement items of control	Supporting literatures
Scanning	Organizational climate for creativty[1]	• In our organization creativity is encouraged. • In our organization risk-taking is encouraged.	Amabile & Khaire (2008); Moss-Kanter (2006)
Matching	Top management's IT awareness[1]	• Top management is knowledgeable about strategic use of emerging informational technologies (EIT). • Top management is knowledgeable about the probable effects of EIT products. • The top management is knowledgeable about competitors' use of EIT. • Top management is aware of the mismatches between the current and potential future uses of EIT.	Teo & King (1997); D'Averi (1999)
Implementation	Organization's IT risk profile[1]	• In general our organization is risk-taking with regard to IT. • We constantly seek to identify new opportunities based on IT. • We constantly seek to be at the forefront when it comes to trying out new IT.	Wheeler (2002)
	Organization's EIT project management performance[1]	• Projects based on EIT are completed on schedule. • Projects based on EUT are completed within budget.	Nan & Harter (2009); Cooke-Davies (2002)
Customer Value	Digitization of customer facing process[2]	Please indicate the extent of usage of the following technologies in your organization. • Electronic billing software	Straub et al. (2004)
Organizational Performance	Industry profile Firm size[3]	Our industry is competitive Please indicate the range of annual sales in (US$)	Ravichandran & Liun(2011); Kearns & Lederer (2004)

Notes:
1. Response scale: (1) Strongly Disagree to (5) Strongly Agree. "Not Applicable" and "I do not know" options included.
2. Response scale: (1) Not at all; (2) To a small extent; (3) To a moderate extent; (4) To a considerate extent; (5) To a very large extent.
3. Response scale: 0-1 million | 1-10 million | 10-25 million | 25-50 million | 50-250 million | 250-500 million | 500-1000 million | more than 1 billion.

At the Scanning stage, we control the extent to which organizational climate promotes creativity and risk-taking (Amabile & Khaire, 2008). Promotion of creativity and risk-taking increases the effectiveness of scanning by encouraging employees to follow new trends in emerging technologies, learn, and share ideas (Earl, 1989; Wheeler, 2002). Measurement items of this control are adopted from Amabile and Khaire (2008) and Moss-Kanter (2006).

At the Matching stage, we control for: (1) top management's IT awareness, and (2) organization's IT risk profile. Top management's IT awareness increases the effectiveness of the opportunity matching stage by focusing the firm's attention on strategic implications of emerging IT for the firm's products, identification of IT gaps vis-à-vis the competitors' products, and envisioning of potential new product innovations with IT (Teo & King, 1997; D'Aveni, 1999). We adopt the measurement items of this control from Teo & King (1997) and D'Aveni (1999). Organization's IT risk profile refers to the risk-taking propensity of the firm with respect to IT: e.g., deploying emerging new IT systems and applications that have not been sufficiently tested yet (Earl, 1989; D'Aveni, 1999; Wheeler, 2002). Such risk- taking can increase the effectiveness of the opportunity matching stage by enabling the firm to explore new IT capabilities, how they can be embedded in products, and assessing the technical and economic feasibility of ITEP innovations (Wheeler, 2002). We develop the measurement items of this control based on Wheeler (2002).

At the Implementation stage, we control for the firm's IT project management capability. It can potentially increase the effectiveness of the Implementation stage by enabling the firm to complete its EIT projects within time and budget. We measure this by the extent to which the firm executes its projects on schedule and within budget (Nan & Harter, 2009; Cooke-Davies, 2002).

At the Customer Value stage, we control for the extent to which the firm digitizes its customer-facing processes such as billing. Digitization of the customer-facing processes increases the scalability of the firm's sales and after sales services. As more customers adopt the ITEP innovations, the firm can serve them through digitized self-service processes without worrying about capacity constraints. Hence, customer satisfaction and value are likely to be higher when customer-facing processes are digitized. We measure digitization of customer facing processes by the extent to which the firm has electronic billing software, based on Straub (2004).

Finally, regarding firm performance, we control for industry profile and size of the firm. By industry profile, we refer to the competitiveness of the industry. Higher industry competiveness can cause firms to rapidly lose their advantages (Wheeler, 2002). We adopt the measurement item of this control from Ravichandran & Liu (2011) and Kearns & Lederer (2004). Firm size is a standard control in studies of firm performance. We measure it with the number of employees of the firm.

Table 5 summarizes the descriptive statistics, correlations, average variance extracted, and reliabilities of the study constructs.

Table 5. Descriptive Statistics, Correlations, Average Variance Extracted, and Reliabilities of Constructs

	1	2	3	4	5	6	7	8	9
1. Scanning	0.90								
2.Matching	0.65**	0.85							
3. Implementation	0.49**	0.5**	0.76						
4. Customer Value	0.12	0.07	0.30**	0.86					
5. Organizational Performance	0.45**	0.45**	0.51**	0.23**	0.86				
6. IT Unit's Sensing	0.59**	0.46**	0.56**	0.25**	0.4**	0.84			
7. IT Unit's Sense-Making	0.36**	0.47**	0.38**	0.12	0.18*	0.39**	0.87		
8. IT Unit's Knowledge Sharing Support	0.35**	0.44**	0.39**	0.3**	0.45**	0.31**	0.10	0.87	
9. IT Unit's Technology Standardization Support	0.45**	0.44**	0.37**	0.12	0.21**	0.58**	0.48**	0.22**	0.93
10. IT Unit's Digitization Support	0.29**	0.25**	0.27**	0.14	0.12	0.24**	0.34**	0.12	0.25**
11. Organization's climate for creativity	0.18*	0.19*	0.29**	0.33**	0.08	0.23**	0.19*	0.21*	0.24*
12. Top management's IT Awareness	0.36**	0.51**	0.52**	0.28**	0.38**	0.44**	0.49**	0.38**	0.29**
13. Organization's IT risk profile	0.37**	0.44**	0.52**	0.25**	0.28**	0.41**	0.62**	0.18**	0.27**
14. IT project management performance	0.36**	0.47**	0.33**	0.18*	0.33**	0.26**	0.40*	0.26**	0.37**
15. Digitization of customer facing processes[3]	0.39**	0.34**	0.28**	0.03	0.18*	0.29**	0.22**	0.19*	0.34**
16. Industry profile[3]	-0.06	0.08	0.29**	0.27**	0.26**	0.17*	0.10	0.36**	0.02
17. Firm size[3]	0.06	0.04	-0.15	-0.26**	-0.19*	-0.13	-0.03	-0.16*	0.03
Mean	3.40	3.86	3.79	4.01	3.95	3.69	3.76	4.31	3.90
Standard deviation	0.99	0.76	0.67	0.67	0.75	0.82	0.83	0.69	0.83
Cronbach's alpha	0.88	0.88	0.75	0.83	0.89	0.86	0.89	0.89	0.92
Composite reliability	0.92	0.92	0.84	0.90	0.92	0.90	0.93	0.93	0.95

	10	11	12	13	14	15	16	17	
10. IT Unit's Digitization Support	0.80								
11. Organization's climate for creativity	0.21**	0.91							
12. Top management's IT Awareness	0.26**	0.24**	0.84						
13. Organization's IT risk profile	0.33**	0.32**	0.65**	0.87					
14. IT project management performance	0.17	0.21*	0.30**	0.35**	0.88				
15. Digitization of customer facing processes[3]	0.45**	0.21**	0.19*	0.21**	0.34**	1.00			
16. Industry profile[3]	0.02	0.11	0.30**	0.19**	-0.02	-0.03	1.00		
17. Firm size[3]	-0.06	0.00	0.16*	0.14	0.05	0.25**	-0.18*	1.00	
Mean	2.45	3.80	3.80	3.60	3.60	2.50	4.20	3.60	
Standard deviation	1.04	0.77	0.86	0.91	0.84	1.30	0.79	2.34	
Cronbach's alpha	0.74	0.81	0.86	0.83	0.73	NA	NA	NA	
Composite reliability	0.83	0.91	0.91	0.90	0.87	NA	NA	NA	

4.3 Measurement Model

4.3.1 Reliability of Constructs

As shown in Table 5, Cronbach's alpha coefficients of the constructs are above the recommended threshold of 0.70 (Nunnally, 1978). Composite reliability values are also high, 0.83 or above. These metrics provide evidence of reliability for construct measurements.

4.3.2 Convergent and Discriminant Validity

First, we conducted an exploratory factor analysis (EFA). Most items loaded on their respective constructs. Items with very low loadings in EFA were dropped from further consideration. They are marked with "*" in Table 2.

Second, we conducted a confirmatory factor analysis (CFA) using SmartPLS. The results of the CFA are presented in Tables 5 and 6. Table 5 presents the interconstruct correlations and the average variance extracted (AVE), which measures the amount of variance that a latent variable component captures from its items relative to the amount due to measurement error. The square root of the AVE for each construct is higher than the correlation of the construct with other constructs indicating that each construct is more highly related to its own measures than to the other constructs. In addition, the minimum AVE value is 0.76, which is well above the recommended level of 0.5, meaning that 76% or more variance of the items is accounted for. These results provide evidence of convergent and discriminant validity (Fornell & Larcker, 1981).

Table 6 presents further details of the CFA. Going down a particular column, we observe that within-construct loadings of the items are much higher than the cross-construct loadings. Similarly, going across a particular row, we see that items are more strongly related to their construct columns than any other construct columns. These patterns provide evidence of convergent and discriminant validity for the constructs.

To check further for discriminant validity, we specified and compared two alternative measurement models for all possible pairs of the constructs: (1) a correlated two-factor measurement model in which indicators of the two constructs loaded on to their respective constructs; and (2) a single-factor measurement model in which all indicators of the two constructs loaded on to a single factor. For all pairs of the constructs, the two-factor model had better fit with the data: chi-square / degrees of freedom ratio < 5; GFI > 0.85, AGFI > 0.8, CFI and TLI > 0.90, and RMR < 0.1. For the single-factor models, all of the fit indices were lower than the recommended thresholds, indicating poor fit. These results confirmed the discriminant validity of the constructs further.

Table 6. Confirmatory Factor Analysis: Loadings on Intended Construct and Cross-Construct Loadings

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Scanning 1	0.84	0.53	0.40	0.15	0.43	0.52	0.20	0.30	0.29	0.26
Scanning 2	0.93	0.59	0.49	0.14	0.42	0.53	0.36	0.33	0.44	0.20
Scanning 3	0.92	0.62	0.42	0.05	0.38	0.55	0.39	0.30	0.49	0.23
(2) Matching 1	0.57	0.85	0.41	0.06	0.39	0.47	0.46	0.38	0.38	0.18
Matching 2	0.57	0.79	0.32	-0.09	0.27	0.33	0.43	0.20	0.46	0.16
Matching 3	0.53	0.89	0.47	0.16	0.48	0.39	0.35	0.47	0.31	0.16
Matching 4	0.55	0.87	0.52	0.14	0.45	0.45	0.39	0.47	0.36	0.14
(3) Implementation 1	0.44	0.48	0.85	0;23	0.46	0.51	0.34	0.33	0.30	0.25
Implementation 2	0.38	0.39	0.79	0.23	0.35	0.48	0.33	0.25	0.29	0.27
Implementation 3	0.37	0.42	0.81	0.26	0.44	0.42	0.21	0.46	0.24	0.11
Implementation 4	0.28	0.18	0.56	0.19	0.28	0.29	0.28	0.15	0.32	0.16
(4) Customer Value 1	0.17	0.09	0.26	0.86	0.27	0.25	0.19	0.25	0.13	0.12
Customer Value 2	0.05	0.08	0.24	0.85	0.17	0.18	0.05	0.24	0.09	0.20
Customer Value 3	0.09	0.04	0.27	0.89	0.24	0.22	0.07	0.27	0.08	0.13
(5) Organizational Performance 1	0.34	0.37	0.44	0.13	0.81	0.37	0.21	0.29	0.24	0.02
Organizational Performance 2	0.34	0.36	0.40	0.12	0.81	0.27	0.09	0.35	0.20	0.03
Organizational Performance 3	0.46	0.46	0.45	0.27	0.93	0.39	0.16	0.45	0.18	0.15
Organizational Performance 4	0.41	0.42	0.49	0.29	0.91	0.36	0.16	0.47	0.11	0.14
(6) IT Unit's Sensing 1	0.57	0.39	0.55	0.22	0.44	0.86	0.30	0.26	0.45	0.17
IT Unit's Sending 2	0.36	0.25	0.33	0.27	0.24	0.80	0.28	0.16	0.48	0.28
IT Unit's Sensing 3	0.48	0.48	0.47	0.14	0.34	0.86	0.34	0.28	0.47	0.24
IT Unit's Sending 4	0.54	0.44	0.50	0.23	0.30	0.81	0.41	0.32	0.54	0.16
(7) IT Unit's Sense-Making 1	0.31	0.35	0.30	0.16	0.14	0.33	0.8t	0.06	0.35	0.19
IT Unit's Sense-Making 2	0.27	0.38	0.32	0.12	0.08	0.32	0.85	0.07	0.45	0.30
IT Unit's Sense-Making 3	0.33	0.42	0.27	0.05	0.14	0.38	0.89	0.07	0.42	0.33
IT Unit's Sense-Making 4	0.33	0.48	0.40	0.11	0.23	0.36	0.89	0.15	0.45	0.27
(8) IT Unit's Technology Standardization Support 1	0.31	0.41	0.30	0.26	0.43	0.28	0.10	0.92	0.28	0.10
IT Unit's Technology Standardization Support 2	0.30	0.43	0.34	0.19	0.40	0.20	0.09	0.95	0.22	0.11
IT Unit's Technology Standardization Support 3	0.21	0.33	0.39	0.30	0.46	0.22	0.04	0.92	0.02	0.07
(9) IT Unit's Knowledge Sharing Support 1	0.38	0.41	0.38	0.26	0.34	0.38	0.14	0.28	0.88	0.21
IT Unit's Knowledge Sharing Support 2	0.39	0.36	0.32	0.12	0.16	0.55	0.47	0.12	0.92	0.16
IT Unit's Knowledge Sharing Support 3	0.42	0.38	0.33	0.10	0.14	0.53	0.44	0.15	0.83	0.22
IT Unit's Knowledge Sharing Support 4	0.47	0.47	0.37	0.11	0.23	0.54	0.45	0.34	0.84	0.22
(10) IT Unit's Digitization Support 1	0.21	0.12	0.23	0.19	0.12	0.25	0.29	0.15	0.15	0.93
IT Unit's Digitization Support 2	0.28	0.29	0.20	0.05	0.13	0.18	0.35	0.05	0.26	0.60
IT Unit's Digitization Support 3	0.20	0.17	0.20	0.11	0.07	0.14	0.20	0.09	0.20	0.83

4.4 Structural Model

Having validated the measurement models of the constructs, we next tested the structural model, and the hypothesized relationships. Our structural model is relatively complex. It has a total of seventeen constructs, most measured with multiple items. The partial least squares (PLS) algorithm is known for its ability to handle complex models with smaller sample size requirements than the covariance based structural equation models (Chin & Newsted, 1999). Thus, we adopt SmartPLS. PLS uses bootstrapping for estimating parameters of interest and calculating standard errors and associated t-tests. We chose the default option of 200 samples to obtain the estimates (Chin, 1998).

4.4.1 Test of the Baseline Model

We first test the validity of Wheeler's (2002) stage model of innovations as our baseline model. The coefficients of the paths from Scanning to Matching

(0.65, p < 0.001), Matching to Implementation (0.51, p < 0.001), Implementation to Customer Value (0.30, p < 0.01), and from Customer Value to Organizational Performance (0.27, p < 0.01) are all positive and significant with two-sided t-tests. R-square values for all respective dependent variables are also high, as reported in Table 7. These results provide support for the validity of Wheeler's (2002) model.

Table 7. Hypothesis Testing

Structural relationships		Base Model	Research Model
Base model			
Scanning	→ Matching	0.65 ***	0.50 ***
Matching	→ Implementation	0.51 ***	0.29 ***
Implementation	→ Customer Value	0.30 ***	0.29 ***
Customer Value	→ Organizational Performance	0.27 ***	0.20 †
Hypotheses			
H1: IT unit's sensing	→ Scanning		0.59 ***
H2: IT unit's sense-making	→ Matching		0.19 *[3]
H3a: IT unit's knowledge sharing support	→ Implementation		0.22 *
H3b: IT unit's technology standardization support	→ Implementation		0.16 †[4]
H4: IT unit's digitization support	→ Customer Value		0.13 ns
Controls			
Organizational climate for creativity	→ Scanning		0.05 ns
Top management's IT Awareness	→ Matching		0.26 *
Organization's IT risk profile	→ Matching		-0.02 ns
IT project management performance	→ Implementation		0.10 ns
Digitization of customer-facing processes	→ Customer Value		-0.09 ns
Industry profile	→ Organizational Performance		0.10 ns
Firm size	→ Organizational Performance		-0.14 ns
R-Square			
Scanning			0.36
Matching		0.42	0.53
Implementation		0.26	0.33
Customer Value		0.09	0.11
Organizational Performance		0.07	0.10

Notes:
1. †p < 0.10; *p < 0.05; **p < 0.001; (ns): not significant.
2. Unless otherwise stated, results report significance levels with two-sided t-tests.
3. H2 is a directional hypothesis. It's significant at 5% level with one-sided t-test.
4. H3b is also a directional hypothesis. It is significant at 10% level with one-sided t-test

4.4.2 Test of Hypothesized Relationships

Next we tested the hypotheses. All of our hypotheses are directional hypotheses that specify positive relationships. Thus, one-sided t-tests would be appropriate for testing them. However, for reporting consistency across all relationships in the base model, the controls, and the hypotheses, we continue reporting the results with the more conservative two-sided t-tests. If a hypothesized relationship is only marginally significant or not significant at all with two-sided t-tests, we also report the results of one-sided t-tests that afford more statistical power for directional hypotheses such as ours. The second column of Table 7 presents the path coefficients, significance levels, and r-square values.

In H1, IT Unit's Sensing of EIT positively affects Scanning activities (0.50, p < 0.001). In H2, IT Unit's Sense-Making of EIT has a positive and significant effect on Matching activities at 10% level with two-sided t-test (0.19, p < 0.10). Since the hypothesis is directional, we also tested it with one-sided t-test and found that it is significant at 5% level. In H3a, IT Unit's Knowledge Sharing Support has a positive and significant effect on Implementation activities (0.22, p < 0.05). H3b is not significant with a two-sided t-test. Since it is also a directional hypothesis, we tested it with one-sided t-test as well and found that IT Unit's Technology Standardization Support positively affects Implementation activities (0.16, p < 0.10). Finally, the relationship between IT Unit's Digitization Support and Customer Value was not significant with two-sided or one-sided t-tests. Overall, these findings provide support for H1, H2, H3a, and H3b. In the discussion section, we discuss the possible reasons for the lack of significance for H4.[4]

4.4.3 Test of Alternative Model Specifications

Upon the suggestions of reviewers, we specified and tested several alternative structural models as shown in Appendix B.

First, we tested the suggestion that alternative orderings of Wheeler's stages could be plausible in practice, and that they could possibly produce better data fit. Since Customer Value is the ultimate dependent variable in Wheeler's model, we fixed it, and generated all possible orderings of the remaining three stages. As indicated by the Cmin/dof ratios in the last column, the ordering theorized by Wheeler and adopted in this study, ("Hypothesized Model" in Table B1), has the best fit with the data compared to all alternative order specifications (Alternate Models 1 through 5). This finding reinforces the validity of Wheeler's model.

Second, we implemented the suggestion that the IT unit constructs could affect not just the respective stages of Wheeler's model that we hypothesized about, but also all other stages. We linked all IT constructs to all stages (Alternate Model 6 in Table B1). In this specification, Wheeler's baseline model was not supported. The link from Implementation to Customer Value was not significant. Further, H2, H3a, and H4 were not supported. Thus, we dropped this specification from further consideration.

Third, we tested whether there could be feedforward links among the four stages of Wheeler's model. As shown in Alternative Models 7 through 9, we examined all possible feedforward links and found that the links from Scanning to Implementation; from Scanning to Customer Value; and from Matching to Customer Value were not significant. In unreported results, we also specified and tested all possible feedback links among the four stages. They were not significant either.

The overall pattern of the results from alternative model specifications indicates that Wheeler's model and the hypothesized IT unit roles of this study have the best fit with the data among the alternative models considered.[5]

4.5 Test for Common Method Bias

We used a single informant to collect data on both the independent and the dependent variables of the study. This raises the possibility of common method bias. We use two tests to assess the presence of common method bias. First, we use Harman's single factor test (Harman, 1967). Bias could be present if (1) a single factor emerges from an exploratory factor analysis, or (2) one factor accounts for the majority of the covariance among the variables (Podsakoff, MacKenzie, Jeong-Yeon, & Podsakoff, 2003; Doty & Glick, 1998). Our exploratory factor analysis generates 10 distinct factors accounting for 75% of the variance in the unrotated factor solution. The highest variance explained by any single factor is 31%. Thus, there is no evidence of common method bias according to the Harman's single factor test. Second, we introduced an "unmeasured," latent method factor and linked it to each item in the measurement model to capture the variance attributable to the method factor (Lindell & Whitney 2001, Malhotra, Kim & Patil, 2006). After controlling for the effects of the latent method factor, all path loadings of the hypothesized links remained statistically significant on their respective constructs. In addition, none of the links between the method factor and the items were statistically significant. The average item variance explained by the model's constructs was considerably higher than the variance explained by the method factor. Based on these results, we conclude that the likelihood of common method bias is low (Podsakoff et al., 2003), and that common method variance is not a substantial explanation for the findings of the study.

4.6 Limitations

Before discussing the findings, contributions, and implications, it is important to recognize some limitations of this study.

First, we used a single informant approach. We collected the data from the perspective of the CIO. Informant competency measures indicate that the responding CIOs were knowledgeable enough to answer our questions. However, we did not corroborate the CIO views with views of other business unit leaders. Future studies may want to use matched sample designs to collect and corroborate data from multiple informants representing different business units.

Second, we did not measure the governance mode of the IT unit (central, decentral, or hybrid). We did not measure if business units might be bypassing the formal IT unit and relying on shadow IT units or external IT consultants in their ITEP innovation

[4] In Appendix A, we also present the results of the hypothesis tests separately in the India and U.S. subsamples. Despite the lower sample sizes and lack of sufficient statistical power, the majority of the hypothesized relationships receive support in the subsamples as well.

[5] We also included a country control variable (1 = India, 0 = US) and linked it to organizational performance to account for the potential effects of country level differences. The country control is positive and significant. The hypothesized relationships remain qualitatively the same. These results indicate that the organizational performance effects of the proposed model are more pronounced in the India sample compared to those in the U.S. sample.

projects. Thus, we do not know how the use of internal versus external IT skills and knowledge might impact the process and outcomes of ITEP innovation. This might be an interesting research question for future research.

Third, we only examined if the extent of IT unit's involvement affects the stages and outcomes of the innovation process. We did not measure the quality of the IT unit's involvement. Future research could examine how the quality of IT skills and expertise in the organization affects the stages and outcomes of the innovation process over and beyond the effects of IT unit's involvement.

Fourth, we conducted a large sample study, which has advantages such as external validity and generalizability. But, it also has limitations such as not being able to explore rich, in-depth insights on the phenomenon of interest. Future studies could adopt grounded theory approaches or in-depth case study approaches to generate richer insights on ITEP innovation.

Fifth, we tested Wheeler's stage model at the firm level of analysis rather than at the level of individual ITEP innovation projects. We looked at a firm's portfolio of ITEP innovation projects at one point in time, measured the aggregate activity levels in the four stages, and tested how activity levels in one stage affect the activity levels in the subsequent stages. Our findings provide support for the ordering of the four stages as theorized by Wheeler. However, we can only claim that these findings are valid at the aggregate, firm level of analysis, for a portfolio of ITEP innovation projects. To test if the model is also valid at the level of individual ITEP innovation projects, future studies would need to collect data at the level of individual ITEP innovation projects and at multiple points in time.

5 Discussion

This paper seeks to contribute to the literature on IT-enabled business innovations by developing and validating a new theoretical explanation as to how IT units increase the effectiveness of the stages and outcomes of the ITEP innovation process.

5.1 Contribution to Research

5.1.1 Operationalization, Test, and Validation of ITEP Innovation Model.

To our knowledge, this is the first study to operationalize, test, and validate Wheeler's model. It is also the first study to adapt this model to the context of ITEP innovations. As noted in our boundary conditions, our theoretical explanations apply only to organizations that have institutionalized product innovation processes. As recognized in the limitations section, we test Wheeler's stage model at the firm level of analysis, i.e., at the level of a firm's portfolio of ITEP innovation projects. The findings suggest that the ITEP innovation portfolios of the firms in our sample follow the sequence of the four stages as theorized by Wheeler: i.e., scanning, matching, implementation, and customer value. None of the alternative model specifications that represent various different orderings of the four stages fit the observed data any better than did the theorized ordering. The tests of feedback and feedforward links among the four stages did not produce any better fitting models either.

The model we develop for explaining the IT unit's role in ITEP innovation is important for several reasons. First, it acknowledges and incorporates the uncertainties inherent in product innovation processes when the product embeds IT into it. Previous studies have examined various communication, influence, and knowledge barriers to the adoption and assimilation of new IT (Rogers, 2003; Attewell, 1992; Fichman & Kemerer, 1997; Swanson & Ramiller, 2004). This paper builds on them to explain that these barriers are important to ITEP innovation, and theorizes how the IT unit can help the firm to overcome them. Second, our results suggest that Wheeler's model may represent a central tendency or a benchmark that is broadly followed for ITEP innovation. This provides significant scope for future research to conceptually and empirically build on our theory to examine emerging areas of ITEP innovation, and underscores its value and potential to future research. For example, the Internet of Things is expected to lead to real time interconnectedness among ITEPs, making the different stages of innovation of each product potentially interdependent with that of other, connected products. Our model provides a theoretical basis on which such interdependence can be further examined. To give another example, innovations in "smart" products embedding big data and intelligent algorithms would need to leverage the product's "learning" capabilities in order to quickly respond to customer behavior. The learning-on-the-fly role of the IT unit, as theorized in this model and contextualized to these new situations, is likely to be useful. Third, the constructs and survey instruments we developed and validated in this study have the potential to accelerate new IS research on ITEP innovations. The constructs of Scanning, Matching, Implementation and Customer Value can be contextualized and adapted to specific instances of ITEP innovation. The constructs embodying IT support for sensing, sensemaking, improvisation and learning can be applied to understand the IT unit's contributions for specific product embedded innovations. New constructs can also be developed to study additional aspects of the IT unit's support for these activities, such as development of new IT skills and competences. These constructs can also be tested and validated with other demographics of respondents (e.g., middle managers, users, etc.) to understand where in an organization the locus of ITEP innovation is present.

We recognize that feedback links among the four stages are plausible in an individual ITEP innovation project. For example, if the Matching stage is not able to make the economic business case for a technically feasible ITEP solution, the IT unit can help the organization go back to the Scanning stage to search for new EIT that could substitute expensive IT components and reduce the overall costs of the solution. As noted above, we specified and tested various feedback and feedforward links among the four stages of Wheeler's model. But we did not find support for any of them. One reason for the lack of support for feedback and feedforward links could be that we conducted the analysis at the firm level rather than an individual innovation project level. Our structural equation model looks at the overall patterns of the firm's activities in the four stages simultaneously to capture how the changing activity levels in stages affect the activity levels in the subsequent stages. If Wheeler's model were to be adapted to the level of an individual innovation project, it would be plausible to expect feedback and feedforward links among the four stages. At the firm level of analysis, the lack of feedback and feedforward links among the stages are plausible for firms following institutionalized ITEP innovation processes. However, in samples of entrepreneurs and small startup firms that follow ad hoc and serendipitous approaches for each innovation project, feedback and feedforward links among the four stages are might be more likely.

The proposed research model has elements of both variance and process. To test the variance element, we measure aggregate activity levels and effectiveness in each of the four stages and test how the variance in aggregate activity levels and effectiveness of one stage affects the variance in aggregate activity levels and effectiveness of the subsequent stage. We find positive and significant relationships, which suggest support for the variance element of the proposed theory. As for the process element, we test which ordering of the four stages best captures the sequence followed by the firms in our sample. We specify and test alternative possible orderings among the four stages. We find that the ordering theorized by Wheeler (2002) has the best fit with the observed data.

5.1.2 Conceptualization and Validation of IT Unit Roles in ITEP Innovation

We considered Wheeler's stage model of innovation as our starting point and superimposed the IT unit's hypothesized roles on it. The findings indicate that the IT unit contributes significantly to the effectiveness of the first three stages of the ITEP innovation process over and beyond the contributions of the business units. The improvements in the effectiveness of the ITEP innovation process in turn increase customer value, and ultimately improve firm performance. These findings support the new theoretical explanations we developed as to how and why IT units can contribute to the effectiveness of the ITEP innovation process, and in turn, to customer value and firm performance. They extend recent research on the role of the IT unit in in supporting new product development activities of traditional products, such as IT support for project management, IT support for information and knowledge management, IT support for collaboration, process management, modeling and simulation, and IT support for communication management (Moos et al., 2013; Nambisan, 2010; Gordon & Tarafdar, 2010; Pavlou & El Sawy, 2006)

The exception to the proposed theoretical explanation is that of the IT unit's role in the fourth stage. In H4, we had hypothesized that firm's extent of usage of SCM, ERP, and CRM applications could increase Customer Value. We reasoned that SCM, ERP, and CRM applications digitize the firm's value chain end-to-end and increase the firm's capacity to support sales and after-sales support services as well as the firm's ability to track product-usage patterns for the purposes of learning on the fly about dynamically changing customer behaviors. However the findings do not provide support for this hypothesis in our sample. We also note that while the result for H3b is suggestive and in the right direction, it does not support the hypothesis at the standardized p-value level of .05. This could be because of the constraining effects of standardization that we discussed in Section 3.3. Further research is needed to understand how standardization of firm's enterprise IT systems might affect Customer Value.

Regarding why H4 did not receive support in our study, it is possible that lack of the IT unit's support adds strongly to the probability of failure of the firm to accomplish the activities embodied in the Customer Value construct, but numerous other factors are involved for it to be a guarantor or even a major influence on the organization's ability to successfully accomplish these activities. There could be multiple explanations as to why H4 did not receive support in our sample. One plausible reason is that the firms in our sample use

SCM, ERP, CRM systems for sales and after sales support services only, but they do not use them for tracking postsale usage of the ITEP innovation. It is also possible that these enterprise-level IT systems have already turned into strategic necessities and that they do not serve as strategic differentiators for customer value. Yet another plausible explanation is that, without further add-on capabilities, the usage of SCM, ERP, CRM systems may not be sufficient for tracking the post-sale usage patterns of innovations for the purposes of learning on the fly about dynamically changing customer behaviors. For example, Steve Basra emphasized that the idea of dynamically tracking the sensory data of self-driving cars to discover road markings was still at the R&D stage. Although the IT-embedded car had connectivity to the Internet and to the information processing infrastructure of Toyota, the IT unit was not yet using the remote monitoring, diagnostics, product usage tracking features of the car for the purposes of learning on the fly about changing customer behaviors. If the majority of firms in our sample have not yet used such features in their ITEPs, then, H4 would not receive support. Thus, we propose H4 as an idea to be tested further in future studies. As more firms activate product usage tracking features of their ITEPs, evidence may emerge to support H4.

Notwithstanding the lack of support for H4, an important theoretical novelty and contribution of this study is that it frames IT-specific uncertainties and challenges faced in the ITEP innovation process through the lens of complexity science. As a product embeds IT, complexity levels increase in both the product and the ecosystem in which it is developed and used. Thus, business and IT units working on the ITEP innovation face complex systems that continually change, morph, and produce emergent, unexpected outcomes. These outcomes are infeasible to predict in advance due to the nonlinear interactions among a diverse set of technologies and stakeholders. There is fundamental uncertainty in such complex adaptive systems. The fundamental uncertainty does not lend itself to reduction through data collection and processing. The IS literature on IT-enabled innovations identifies the need for the management of the unexpected outcomes (Swanson & Ramiller, 2004). It also offers insights on the IT unit's role in activities such as product analysis (Chui et al. 2012), providing firm-specific points-of-view on the feasibility of particular technologies (Han & Mithas, 2013), building IS systems and dashboards that can trigger sensemaking processes in decision makers (Houghton et al. 2004), and enabling IT-related risk- taking and forward thinking in the organization (Benbya & McKelvey, 2006; Burn, 1996). However, it does not offer a theoretically grounded approach as to how IT units could help the organization manage the emergent and the unexpected. Our study explains how IT unit can engage in sensing and sensemaking activities and support the improvisation and learning-on-the-fly activities to increase the organization's capacity to cope with the emergent, unexpected outcomes in complex ITEP innovations. While it may be impossible to predict the outcomes on an innovation-by-innovation basis, our empirical findings suggest that IT unit's involvement in all stages of the innovation process leads to better outcomes and improves firm performance, as examined in a portfolio of ITEP innovation projects.

An important implication of this study is for the scope of the IT unit's roles. IT-embedded, Internet-enabled products have the potential to become nodes in the firm's extended information professing infrastructure. This potential might require IT units to become involved in the entire lifecycle of the IT-embedded, Internet-enabled products. For example, the Jeep Cherokee security incident cited earlier indicates that IT-embedded, Internet-enabled products could have major security vulnerabilities. If connected to the firm's extended information processing infrastructure, they can also expose the entire infrastructure to such vulnerabilities. IT units use a variety of IT governance, risk, and control (GRC) frameworks such as ITIL, COBIT, NIST, ISO standards, etc. to build mechanisms to reduce such risks. Before adding any new hardware or software components to the infrastructure, IT units require them to align well with the firm's business objectives, adhere to the firm's enterprise-IT architecture standards, and meet the firm's security and privacy requirements. They also require that any future changes, patches, and updates to the operational IT hardware and software go through well-controlled change management processes. Such IT-GRC mechanisms may need to be extended to ITEPs as well if they are to become nodes in the firm's extended information processing infrastructure. Vendors, consultants, and subcontractors who contribute to various stages and components of ITEP innovation process may come and go, but the IT unit of the firm needs have a continuous presence, in order to integrate all aspects of the project and. The quality of understanding and integration of all components is likely to be critical to the innovation process. Future studies could examine how IT units integrate the various stakeholders and components of the ITEP, how they integrate the product to the firm's information processing infrastructure, how such integrations affect the risk profile of the firm, and whether and how IT-GRC mechanisms could mitigate the probability of loss and magnitude of loss associated with such risks.

5.2 Implications for Practice

With the emergence and the maturation of the Cloud (i.e., the global market for IT outsourcing services), IT units have started to outsource a significant portion of their traditionally in-house IT tasks and services to the Cloud. The adoption rate of the Cloud-based IT outsourcing services reached 93% in the US.[6] This suggests a major transformation in the role of the IT unit in the organization. In a recent Society of Information Management meeting, the CIO of James Avery argued that the majority of the traditional "build" and "run" tasks of the IT unit can now be outsourced to the Cloud. He described the changing role of the CIO and the IT unit as follows:

> *My job is not to run applications. My job is to drive innovation in the company. The IT unit's new role is to make the company agile in innovation. Innovation is a survival issue. The consumer is changing very fast.*

How could the CIO and the IT unit fulfill these new roles? Our study generated actionable insights on these questions in the context of ITEP innovations. In the Scanning and Matching stages, CIOs and IT units that are skillful at sensing EIT and making sense of what new features and functionality the EIT can enable in the firm's products could drive innovations in the company. In the Implementation stage, CIOs and IT units that support improvisation activities of the company could increase the agility of the company in ITEP innovations. In the Customer Value stage, CIOs and IT units that support the learning-on-the-fly activities could ensure the continued relevance and survival of the company by enabling it to understand how consumer needs and preference change dynamically over time. Further, the activities associated with sensing, sensemaking, improvisation, and learning, provide a checklist of elements for new product development. Irrespective of whether those activities are performed by the IT unit or someone else, they are likely to be critical to effective ITEP innovation.

The enlarged scope of the IT unit's roles in the ITEP innovation process could also have implications for skill sets and career progression of the organization's IT professionals. Early-stage innovation activities, such as technology scouting, product ideation, product prototyping, and business case justification used to be the responsibility of R&D and business domain professionals. These roles are beginning to shift to IT professionals in the context of ITEP innovations as our theory explains. Thus, it is important for future IS studies to examine how well IT professionals are adapting to their emerging roles in the context of ITEP innovations, and how the new roles change their skill sets and career progression. While such changes may not currently reflect on the majority of IT professionals in an organization, it would not be incorrect to anticipate that new IT roles with specific skills would emerge for those that are involved with embedded IT in products. These roles may represent a fruitful avenue for skill relocation of the IT human resource in the light of cloud-based sourcing and outsourcing of IT.

If the formal IT unit of the organization lacks the aforementioned skills, business units may have a tendency to work with external IT consultants or develop their own IT savvy personnel, often referred to as the "shadow IT unit" (Westerman, Bonnet, & McAfee,. 2014; Westerman, Calméjane, Bonnet, Ferraris, & McAfee, 2012). In this study, we have not distinguished between the roles of the formal IT unit and the roles of external IT consultants and shadow IT units. Future studies might want to investigate how the firm's reliance on IT consultants and shadow IT units might affect the success of ITEP innovations.

In conclusion, the increasing pervasiveness of ITEP innovations creates new opportunities and challenges for organizations in conceptualization, development, operation, and renewal of ITEPs. This study provides insight into how and why IT skills are essential to innovation and new product development of ITEPs, how organizations can address the associated challenges, and how IT units can increase the success of the process and outcomes of ITEP innovation. The ideas and explanations offered in this study are likely to spark new scholarly interest in how the IT unit can and should drive innovations in organizations, especially IT-embedded, Internet-enabled product innovations; how the IT unit can increase the agility of organizations in their innovation processes; and how IT units can contribute to the survival and improved performance of organizations in complex, dynamically changing technology landscapes and business ecosystems. We hope that they will propel organizations to leverage the offerings of knowledge and expertise of their IT units in a thoughtful and systematic way, for innovation in their ITEPs.

[6] http://assets.rightscale.com/uploads/pdfs/RightScale-2015-State-of-the-Cloud-Report.pdf

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Appendix A: Analyses of the Relationships in the India and the U.S. Subsamples

As reported in Table 3, the characteristics of the firms in the India and the U.S. subsamples do not show any statistically significant differences. Thus, we combine them and report the results for the combined sample in Table 7. Here, we also present the subsample results. Appendix Table 1 reports the results for: (1) the combined sample (n = 165); (2) the India subsample (n = 109); and (3) the U.S .subsample (n = 56). Due to the lower sample sizes, the statistical power levels in the subsamples are not sufficient to detect the hypothesized relationships. Assuming an effect size of 0.15, alpha level of 0.05, and power level of 0.90, the minimum sample size for detecting effects is n = 271. The combined size of our U.S. and India subsamples is n=165, with the India sample = 109 and the U.S. sample = 56. Nevertheless, four of the five hypothesized relationships are detected in the India subsample whereas three of them are detected in the U.S. subsample. These findings suggest that the hypothesized relationships are probably so strong that most of them are detected even with very low sample sizes and statistical power levels. We cannot rule out the possibility that a bigger sample size would either more strongly support the relationships in the U.S. sample or show some unexpected differences between the two subsamples. This is a weakness of the study. However, the fact that more of the hypothesized relationships are detected as the sample size increases from n = 56 (US) to n = 119 (India) and n = 165 (combined) suggest that the proposed theory is robust and that more of its hypothesized relationships are detected in bigger sample sizes that have higher levels of statistical power.

Table A1. Hypothesis Testing

Structural relationships		**Full (n = 165)**	**India (n = 109)**	**U.S. (n = 56)**
Base model				
Scanning	→ Matching	0.50 ***	0.45 ***	0.529 ***
Matching	→ Implementation	0.29 *	0.20†	0.204†
Implementation	→ Customer Value	0.29 *	0.20†	0.196 ns
Customer Value	→ Organizational Performance	0.20†	0.25 *	0.061 ns
Hypotheses				
H1: IT unit's sensing	→ Scanning	0.50 ***	0.51 ***	0.529 ***
H2: IT unit's sense-making	→ Matching	0.19 *[3]	0.16 *[3]	0.188 *[3]
H3a: IT unit's knowledge sharing support	→ Implementation	0.22 *	0.07 ns	0.542 ***
H3b: IT unit's technology standardization support	→ Implementation	0.16†[4]	0.35 **	0.115 ns
H4: IT unit's digitization support	→ Customer Value	0.13 ns	0.24 *	-0.066 ns
Controls				
Organizational climate for creativity	→ Scanning	0.p5 ns	0.21 **	-0.016 ns
Top management's IT awareness	→ Matching	0.26 *	0.37 ***	0.165 ns
Organization's IT risk profile	→ Matching	-0.02 ns	-0.08 ns	0.060 ns
IT project management performance	→ Implementation	0.10 ns	0.15 ns	-0.172 ns
Digitization of customer-facing processes	→ Customer Value	-0.09 ns	-0.04 ns	-0.185†
Industry profile	→ Organizational	0.10 ns	0.05 ns	0.234 ns
Performance		-0.14 ns	0.03 ns	-0.296 ns
Firm size	→ Organizational			
Performance				

Notes:
1. †p < 0.10: *p < 0.05: **; ***p < 0.001; (ns): not significant.
2. Unless otherwise stated, results report significance levels with two-sided t-tests.
3. H2 is a directional hypothesis. Its significant at 5% level with one-sided t-test.
4. H3b is also a directional hypothesis. It is significant at 10% level with one-sided t-test.

Appendix B: Test of Alternate Models

Table B1. Test of Alternative Structural Models: Different Ordering of the Stages of Innovation and Feedforwad Links

	Tested models	Results on base model (Wheeler, 2002)[1]	Hypothesized IT unit roles[2]	Cmin/d of[4]
Hypothesized model	① → ② → ③ →	Base model supported.	All except H4 supported	1.86
Alternative orderings[1] Alternative Model 1 Alternative Model 2 Alternative Model 3 Alternative Model 4 Alternative Model 5 Alternative Model 6[3]	② → ① → ③ → ① → ③ → ② → ③ → ① → ② → ② → ③ → ① → ③ → ② → ① → ① → ② → ③ →	Base model supported. Not supported: ②→④ not significant ②→④ Not supported: ①→④ not significant ①→④ Not supported: ③→④ not significant Not supported: not significant Not supported: not significant	All except H4 supported H3b and H4 not supported All except H4 supported All except H4 supported All except H4 supported H2, H3a, H4 not supported	1.90 1.89 1.90 1.95 1.88 1.85
Feedforward links[5] Alternative Model 7	① → ② → ③ →	Base model supported. Feedforward link ①→③ not supported.	All except H4 supported	1.94
Alternative Model 8	① → ② → ③ →	Base model supported. Feedforward link ①→④ not supported.	All except H4 supported	1.94
Alternative Model 9	① → ② → ③ →	Base model supported. Feedforward link ②→④ not supported.	All except H4 supported	1.95

Notes:

1. The four stages of Wheeler's (2002) innovation model are represented as follows:

   ① Scanning

   ② Matching

   ③ Implementation

   ④ Customer Value

2. IT unit relationships with the four stages of innovarion are as hypothesized in Alternative Models 1 through 5.
3. In Alternative Model 6, all IT unit constructs are simultaneously linked to al four stages.
4. Chi-square/Degrees of Freedom ratio
5. Alternative Models 7 through 9, feedforward links are added to the hypothesized model of the study, shown in the first row.

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