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# Information Technology and Product/Service Innovation: A Brief Assessment and Some Suggestions for Future Research

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# Information Technology and Product/Service Innovation: A Brief Assessment and Some Suggestions for Future Research

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## Abstract

*In this paper, I follow up on my previous article about information systems as a reference discipline for new product development (Nambisan, 2003) and assess the extant research on this topic. To facilitate the assessment, I develop a framework that considers information technology's (IT's) dual roles as operand resource and as operant resource and its impact on innovation process and on innovation outcome. My analysis reveals the advance that has been made in understanding IT's role as operand resource in innovation and the considerable opportunity that exists to explore IT's emerging role as operant resource in innovation. I also comment on the need for IS scholars working in this area to make careful choices regarding their research topic and theoretical perspectives to enhance the potential impact on and contribution to the product/service innovation literature.*

***Keywords:*** *Information Technology, Product Development, Service Innovation, Operand Resource, Operant Resource, Innovation Ecosystem.*

* Nicholas Berente was the accepting senior editor. This article was submitted on 26th August 2011 and went through three revisions.

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# Information Technology and Product/Service Innovation: A Brief Assessment and Some Suggestions for Future Research

## 1. Introduction

In 2003, I wrote an article suggesting that the information systems (IS) field can potentially serve as a reference field for new product development (Nambisan, 2003). In this paper, I consider to what extent research in the area of IS has started impacting our understanding of product/service innovation, and further, going forward, what are some of the most promising research directions in this area.

Two key factors had motivated my 2003 article. First, the rapid infusion of information technology (IT) in product development had given rise to a host of managerial issues and challenges that could potentially be informed by theories and concepts from the IS field. Second, as an inter-disciplinary field, product development presented a fertile area to apply IS-based theories and concepts in conjunction with those from other fields (e.g., marketing, operations, finance, etc) to help broaden and enrich the IS field itself. The relevance of both of these factors has only increased in the period following the publication of the article.

In the last one decade or so, the nature of innovation has undergone considerable change in most industries. Innovation has become much more open, global, and collaborative in nature to involve a diverse network of partners and emphasizing distributed innovation processes (Chesbrough, 2003; Nambisan & Sawhney, 2007). Digital technologies are being embedded into an ever-increasing range of products and services—from cars and toys to household appliances and medical devices—thereby expanding the role and relevance of IT in any innovation. At the same time, the dominant focus on tangible goods and product innovation has been supplanted by the rapidly emerging interest in intangible offerings and service innovation (Vargo & Lusch, 2004). Finally, continued pressure to reduce the time and cost of innovation has forced many companies to adopt standardized innovation structures, tools, processes, and metrics. All of these changes have significantly enhanced the importance and relevance of IT—from digital innovations to product lifecycle management (PLM) systems to collaboration and social networking applications—and, in turn, they emphasize the need to incorporate IS-related theories and concepts as an inherent element in studies on any product/service innovation.

## 2. An Assessment of Extant Research

The question then is: how far have we been able to infuse IS theoretical concepts and ideas in the ongoing conversations on product/service innovation? I believe we have made a good start (albeit with some caveats). A brief review[1] of the product and service innovation literature since the early 2000s reveals a steady increase in the number of scholarly papers that have considered one or more aspects of IT (Figure 1). Further, it is also evident that the nature and the focus of these studies have changed considerably.

While the studies in the 1990s largely focus on identifying some of the broad organizational and managerial issues that lie at the intersection of information systems and product development, the more recent studies focus on more fine-grained issues, are empirical in nature, and have started integrating IS concepts with other management concepts. To better understand this, it would be useful to consider the research on IT and product/service innovation using a simple framework shown below (Figure 2).

[1] I did a search on the ABI/INFORM database using the keywords information technology and product/service development. The search was limited to peer-reviewed articles published in scholarly journals in the time period 2004 to 2011. The search revealed around 49 articles with a primary focus on IT and product development. Articles with a more tangential focus on this topic and those that didn't explicitly incorporate IS-related concepts and constructs in the study were excluded. In the six years or so preceding this time period (from 1997 to 2003), the number of articles published with a primary focus on IT and product development was only around 11. Note that my objective in doing this literature review was to illustrate the trend in the research on IT and product development (i.e., steadily increasing number of articles) rather than to give an accurate count of the articles published.

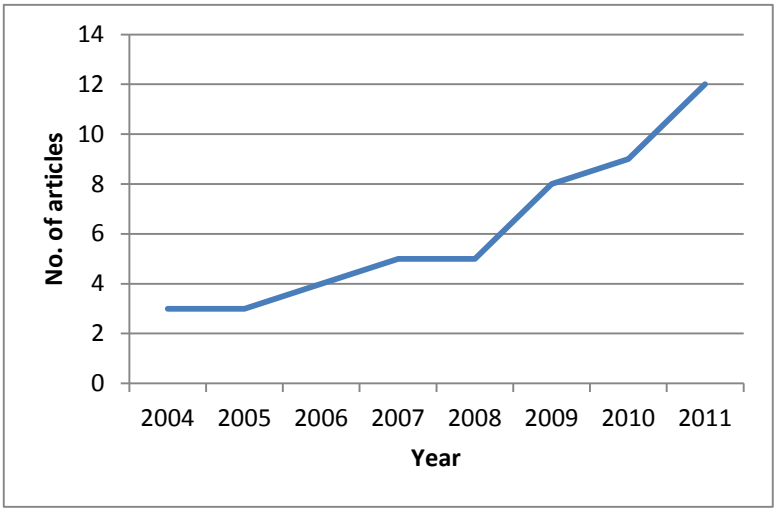


**Figure 1. Number of Articles on IT and Product/Service Innovation**

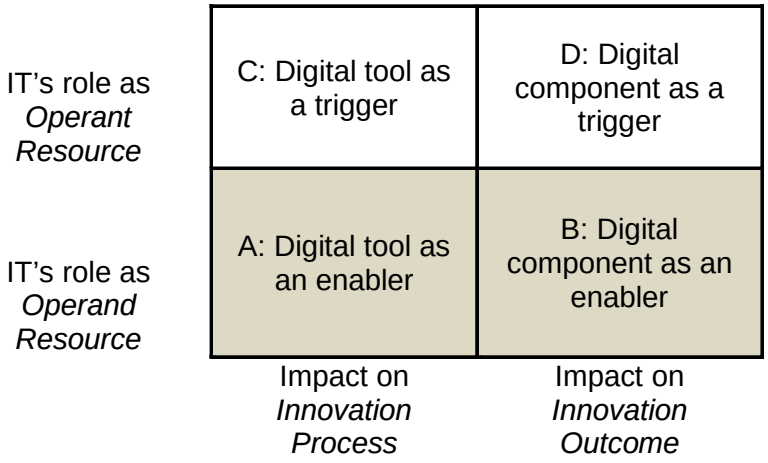


**Figure 2. Research on IT and Product/Service Innovation**

First, consider the two primary roles for IT in product/service innovation; that is, as an operand resource and as an operant resource. Operand resources are those resources (often tangible and static) that an actor acts on to obtain support for executing a task, whereas operant resources are those resources (often intangible and dynamic) that act on other resources to produce effects; that is, they act or operate on other things rather than being operated on (Constantin & Lusch, 1994; Vargo & Lusch, 2004)[2]. It is evident that the extant studies on IT and product/service innovation have largely focused on the role of IT as an operand resource (i.e., as an enabler of innovation) compared to its role as an operant resource (i.e., as a trigger or an initiator of innovation) (the shaded area in Figure 2). To further analyze the research topics related to each of these roles it will be useful to differentiate between their impact on innovation processes (the tasks and activities related to product/service development) and that on innovation outcomes (the functionalities associated with a new product or service). Note that such a differentiation is contextual: an innovation outcome from the perspective of one user maybe a process tool from that of another user. However, it will serve our purpose here of examining the extant literature on IS and product/service innovation.

[2] For a more detailed explanation of operant and operand resource, see Vargo & Lusch (2004).

## 2.1. Digital Tool as an Innovation Enabler

Many studies have focused on the role of IT as an operand resource and its impact on innovation processes (cell A). One set of studies has focused on providing empirical evidence regarding the impact of IT on product design and development processes and the nature of the business value and competitive advantage derived from IT in the product development context (e.g., Banker, Bardhan, & Asdemir, 2006; Durmusoglu & Barczak, 2011; Kleis, Chwelos, Ramirez, & Cockburn, 2012; Pavlou & Sawy, 2006; Pavlou & Sawy, 2010). A second set of studies with narrower focus has applied specific IS concepts and constructs to better understand collaborative structures and work processes that underlie product development (e.g., Chen, 2007; Bardhan, 2007; Li & Qiu, 2006). A third set of studies have focused on deploying specific IT tools and applications (for example, PLM, data mining tools, decision support systems, social media, and virtual simulation tools) to enable different product development activities (e.g., Becker, Salvatore, & Zirpoli, 2005; Chao-Ton, Yung-Hsin, & Sha, 2006; Hewett, 2009; Malins & Liapis, 2009; Nambisan & Baron, 2010; Xu, Li, Li, & Tang, 2007). These and other such studies have helped to empirically establish that the use of appropriate set of IT tools and applications can enhance the efficiency and effectiveness of product development activities. More recent studies in this area have started to focus on the potential interaction effects between digital tools and other organizational resources and mechanisms in the product development context. For example, Fichman and Nambisan (2009) draw on the logic of complementarities (Milgrom & Roberts, 1995) and posit that the impact of IT tools will be enhanced if they are fit into a system of product development context-specific complementary organizational elements (strategies, structures, processes, etc). Future studies that adopt such a 'fit'oriented perspective could offer a richer set of insights about why some companies succeed more than others in deriving value from digital tools and applications (such as PLM) in innovation activities.

## 2.2. Digital Component as an Innovation Enabler

Next, consider the role of IT as an operand resource and its impact on innovation outcome or functionality (cell B). Such a role envisions the support (or complementary) functionality that digital components can provide in varied product and service innovations. One set of studies in this area has focused on the nature and extent of value generated by digital components or IT applications as part of varied service innovations (from bank ATMs to electronic commerce to on-demand services) and the organizational capabilities and assets needed to enhance such value (e.g., Dos Santos & Peffers, 1995; Kauffman & Wang, 2002; Ordanini & Rubera, 2010). Much of this literature may be classified as traditional IS literature given their focus on IT applications; however, their larger context is that of a service innovation of which the IT application is a part (i.e., the IT application supports or enables the service innovation). The major insight from these studies is the importance of integrating the digital component with other components of the service innovation to ensure success and realize maximum value from the investment in the service innovation. More recent studies in this area (e.g., Henfridsson, Mathiassen, & Svahn, 2009; Woodard, Ramasubbu, Tschang, & Sambamurthy, forthcoming; Yoo, Henfridsson, & Lyytinen, 2010) have focused on contexts where digital technologies are embedded into varied products. Such contexts are emergent in nature and consequently there is scant literature in this area; at the same time, it is increasingly evident that the focus of the studies will need to shift to examining how the digital components fit in the broader product architecture and the associated strategic and managerial issues (for example, the nature of the enabling role played by the digital components, product design tradeoffs and interface specifications, intellectual property management, etc). All of this, in turn, makes it imperative that future studies in this area adopt broader theoretical framing in order to incorporate important concepts and constructs from other business disciplines in examining the impact and the value of digital components (more on this in Section 3.2).

IT's role as an operant resource in product/service innovation relates to the ability of IT—digital tools and components—to independently initiate or trigger innovation. Such a role is of much more recent origin, particularly with digital resources assuming central importance in varied products and services, and there has been limited focus on this topic in extant studies on IT and product/service innovation.

## 2.3. Digital Tool as an Innovation Trigger

Consider IT's role as an operant resource with impact on innovation process (cell C). This relates to how digital tools can initiate or lead to new innovation processes or associated organizational routines and mechanisms. A small, but growing, number of studies have examined the intersection among information technology, organizational design, and product innovation; particularly, the ways by which new IT tools drive innovative organizational arrangements and processes in product innovation (e.g., Boland, Lyytinen, & Yoo, 2007; Dougherty & Dunne, 2012; Faraj, Jarvenpaa, & Majchrzak, 2011; Zammuto, Griffith, Majchrzak, Dougherty, & Faraj, 2007). For example, Boland et al. (2007) consider the "wakes of innovation" unleashed by the deployment of a suite of 3D visualization tools in the construction industry as they impacted the roles and responsibilities of other actors (for example, surveyors) in a construction project. Similarly, Dougherty & Dunne (2012) show how the use of new digital tools in drug discovery transformed the knowledge partitioning between two key actors, digital scientists and traditional wet therapy scientists, and led to radical changes in the innovation activities carried out by both groups of scientists. Another set of studies (e.g., Bailey, Leonardi, & Barley, 2012; Leonardi, 2011) show that the impact of digital tools on innovation routines and processes are often dynamic, unpredictable, and not always positive. While the above studies may employ different terminologies (for example, technological agency, material agency, and so on), they all refer to the role of IT (digital tools) as an actor or operant. Importantly, these studies also indicate the promise of this research stream to offer critical insights on how digital tools as operants may transform or reconfigure innovation processes and activities and on the broader organizational implications.

## 2.4. Digital Component as an Innovation Trigger

Finally, IT's role as operant resource with impact on innovation outcome (cell D) reflects the generativity that can potentially be unleashed by new digital resources and the ensuing implications for the design of digital products and components. While there has been limited focus so far on IT's role as operant resource, the exposition of underlying concepts such as service ecosystems, digital platforms, resource liquification, resource density, and layered modularity in recent studies could help much in advancing the discourse on this topic. For example, Lusch & Nambisan (forthcoming) view innovation from a service-dominant (S-D) logic perspective (Vargo & Lusch, 2004), and note that a digital component in a service platform may "seek out" and pursue unique resource integration opportunities on its own and, in the process, engage with (or act upon) other actors in the innovation ecosystem, thereby leading to innovation or value co-creation. Similarly, recent studies (e.g., Boudreau, 2012; Lee & Berente, 2012) have considered the generative nature of the affordances of digital components (Zittrain, 2006) and its impact on (and implications for) the design of innovation platforms and the nature of contributions of other actors in the ecosystem. Admittedly, these and other such studies may only be scratching the surface and more work may be needed to bring clarity to the underlying issues and concepts. However, it is evident that this presents a fertile and important area for future research, particularly in developing a deeper understanding of the role of IT as operant resource in innovation and explicating the implications on the design and development of digital resources and architectures or, more broadly, on digital business strategies.

In summary, the above brief assessment of the extant literature on IT and product/service innovation indicates both the cumulative knowledge that we have built over the years (particularly with regard to the role of IT as operand resource) and the considerable opportunity to extend our knowledge in a rapidly emerging area (with regard to the role of IT as an operant resource). It is also evident that, to a limited extent, the mainstream literature in product (service) development has started drawing on (and even building on) some of the IS-related theories and concepts. For example, the application of media richness (or media capacity) theories in evaluating communication in virtual product development teams and the impact on performance (Montoya, Massey, Hung, & Crisp, 2009), communication and decision-support as dual functionalities of IT and their relative impact on enhancing R&D-Marketing integration (Song & Song, 2010), the incorporation of network externalities into the technology acceptance model to investigate consumer purchase intentions of new digital products (Song, Parry, & Kawakami, 2009), and IT embeddedness in product development processes as an indicator of the impact of IT on product development performance (Barczak, Hultink, Sultan, 2008), and so on.

At the same time, there are some common characteristics of the extant studies on IT and product/service development that indicate potential concerns regarding their broader impact on the innovation field. I discuss these in Section 3.

# 3. Broader Issues & Future Research Directions

## 3.1. Choice of Research Topic

The first characteristic of the extant research on IT and product/service development relates to the choice of the research topic. With few exceptions, most of the above studies have focused on issues that are of primary concern to IT managers (for example, the impact of IT, the adoption/application of specific technologies such as PLM, data mining, etc) and less so on topics in the product/service development area that have engaged mainstream innovation researchers and practitioners (for example, value co-creation and governance in innovation ecosystems, managing service innovation, etc). By focusing on some of the contemporary challenges in the innovation area (where IT might play a valuable but perhaps secondary role) and by joining the ongoing conversations on these topics via relevant IS concepts, the IS studies may have significantly broader and quicker impact on the field. For example, consider the topic of innovation ecosystems and the role of IT.

### *3.1.1. Innovation Ecosystems and IT*

In recent years, the increased emphasis on organic growth strategies has been accompanied by a growing realization regarding the need to "look outside" for innovative product ideas and technologies and to collaborate with a diverse set of external partners including independent inventors and customers (Chesbrough, 2003; Nambisan & Sawhney, 2007). The innovation networks or ecosystems established by companies with this objective have varied in both form and function—from "open" to "closed" ecosystems and from ecosystems focused on well-defined platforms to those focused on ill-defined, emergent areas (Adner & Kapoor, 2010; Almirall & Casadesus-Masanell, 2010; Nambisan & Sawhney, 2007). Over the last few years, there has been growing interest among innovation scholars in studying the nature and form of these different types of ecosystems and the factors that shape innovation success. IS theories and concepts can inform on two broad areas of inquiry on this topic.

The first relates to the role of IT in facilitating innovation in these ecosystems; that is, as an element of the innovation infrastructure. Regardless of the nature of the ecosystem, it has become evident that innovation success is shaped by a range of factors including how well organizations can establish and sustain a set of shared goals and objectives, how inter-firm dependencies are managed, and to what extent the ecosystem offers an architecture of participation. More broadly, these issues relate to the nature of the ecosystem governance and the support for both value creation and value sharing (or appropriation). On all of these issues, IT assumes considerable significance—in particular, in managing the tensions that exist among the different choices (for example, between centralized and diffused governance structures, between open IP and closed IP management, etc) and in enhancing trust, knowledge sharing, and coordination among diverse partners in the ecosystem. Recently proposed IS concepts such as "fluidity" in online communities (Faraj et al., 2011) and "digitalization" or the socio technical processes accompanying digitization (Tilson, Lyytinen, Sørensen, 2010) have the potential to inform the above issues.

The second stream of inquiry relates to those innovation ecosystems that focus on the development of IT-embedded products and services. The incorporation of such digital elements in a product or service has implications on the innovation processes, the choice and diversity of partners in the ecosystem, the nature of network governance, and so on. This raises several interesting issues that can be informed by IS theories and concepts. A good example is Henfridsson et al. (2009) who examin how traditional modularity theory may be supplemented by concepts from software engineering to address the issues related to a firm's control over innovation processes when digital technology is embedded in its products. Similarly, Woodard et al. (forthcoming) build on the concept of technical debt from software engineering to consider how firms may formulate their digital business strategy in digital architectures. Another issue relates to the opportunities offered to complementary developers by digital technologies to develop newer services/functions and the associated need for ecosystem leaders to exercise both control (to maintain platform integrity) and openness (to promote

innovation). While this is an issue that is relevant to all types of platforms (Gawer & Cusumano, 2002), it is particularly intriguing for those platforms that incorporate digital elements (given the diverse innovation opportunities afforded by software). Tiwana, Konsynski, & Bush (2010) suggest several issues that IS scholars can attend to with regard to software-based or digital platforms; in particular, in viewing the platform architecture as an IT artifact to explain the evolution of platform-centric ecosystems and in relating technology architectural choices to the nature and structure of platform governance. Similarly, Yoo et al. (2010) suggest a related set of issues in the context of digital platforms; in particular, the consideration of a layered modular architecture for digital innovations and the technical and strategic dimensions that would likely shape a firm's decisions on such architectures.

Thus, the topic of innovation ecosystems (particularly those focused on digital innovations) is one that has considerable contemporary significance and, at the same time, one that would present a fertile area for integrating IS related theories and concepts with other management theories to contribute to the broader innovation and strategy literatures.

## 3.2. Choice of Theoretical Perspectives

The second characteristic of the extant research on IT and product/service development relates to framing the studies or choosing theoretical perspectives. Again, with a few exceptions, most studies cited earlier have focused on applying one or two IS theoretical constructs (e.g., extent of use of an IT application, investment in IT infrastructure for product development, and extent of employee training in IT). While such a narrow framing does help to explain specific issues related to IT usage, the application of a broader theoretical perspective drawn from the IS field (e.g., adaptive structuration, design science, and media richness) may lead to much richer IS contribution as well as fuel further research on those issues.

### *3.2.1. Experimentation and Design Science*

For example, consider the topic of experimentation in innovation. Experimentation has assumed considerable importance in recent years—both in business in general (Davenport, 2009), and in product/service development (Thomke, 2003). At the same time, there is limited theoretical understanding of how such experiments should be conducted. Much of the extant literature on this topic is devoid of any foundational theories and has largely focused on ad-hoc frameworks and anecdotal evidence. The IS field has the potential to offer a significant contribution in this regard. Specifically, design science could potentially offer a more rigorous (or more scientific) approach to address several important challenges related to innovation and business experimentation (e.g., the basis for the selection of the "test" variables, the scale and scope of business experimentation, the identification and operationalization of environmental uncertainties/risks, etc). The lack of a rigorous approach would only further accentuate the already high costs and risks associated with business experimentation and make it less appealing.

In the business field, design science has traditionally been associated with IS development (e.g., Hevner, March, Park, & Ram, 2004; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008). In recent years, however, there has been effort made to apply it in a broader context—particularly in areas such as organizational studies, innovation management, and so on (e.g., Holmstrom, Ketokivi, & Hameri, 2009; Denyer, Transfield, Van Aken, 2008). Innovation involves "problem solving" or "exploration through design" and, as such, design science offers an appropriate analytical framework to examine issues related to the nature and process of innovation experimentation (e.g., March & Smith (1995) suggests a set of design processes and design artifacts). Further, the design science approach allows us to gain an in-depth understanding of a complex problem domain in the very process of building or designing the artifact (i.e., the potential solution), and thereby allows us to derive insights that may not be acquired through a behavioral science approach (in other words, design science may complement the behavioral science approach). As such, in combination with extant theories on innovation, the design science approach could potentially inform on the nature and process of business experimentation. With an increasing number of companies adopting experimentation as the cornerstone of their innovation strategy, there is critical need for more rigorous examination of the underlying issues and IS scholars have the potential to contribute to this effort through theoretical perspectives such as design science.

Adopting broader theoretical perspectives from the IS/IT area to examine critical issues in product development could not only generate a number of unique and valuable insights on innovation but also help launch new research streams (that may even extend to topics and areas beyond product development) and attract a larger number of non-IS scholars.

### 3.3. Choice of Research Collaborators and Outlets

A third characteristic of the extant studies in this area—and one which potentially limits their broader impact—is the choice of collaborators and publication outlets. With a few exceptions, most studies cited earlier have involved only scholars from the IS field and have largely targeted publication outlets that primarily cater to IS scholars. While there is nothing wrong with such an approach in itself, collaboration with scholars in other business areas might help to ensure the development of more integrative research models that span IT and non-IT issues in product development. It could also help propagate relevant IS concepts and theories applied in such studies among non-IS scholars thereby broadening the contribution of IS. Similarly, pursuing the publication of such research in outlets that cater to a wider audience interested in product/service innovation could also help accelerate their impact. Admittedly, getting the attention of some of these broad-audience journals (for example, academy of management journals) may be difficult given their lack of focus on IT and related topics. A good exception in this regard is *Organization Science*, which has been particularly receptive to inter-disciplinary articles focused on IT and Innovation. Alternatively, there are field journals focused on product innovation (for example, *Journal of Product innovation Management*, *IEEE Transactions on Engineering Management*, etc) that may provide a more favorable avenue to reach a broader audience. A good strategy in this regard will be to focus on issues that are of interest to the larger community of innovation scholars and to frame the study in such a way that its contributions will flow primarily to the same audience (albeit with by-products that may enrich and fuel further research in the IS area too).

## 4. Conclusion

I believe that the IS field is well positioned to make valuable theoretical contributions to inform many of the contemporary issues and challenges in the area of product/service innovation. The initial set of studies indicates a promising start in this direction, and, as noted previously, some preliminary progress has been made in infusing IS theories and concepts into the discourse on product/service innovation. However, clearly, a broader and sustained effort is called for. I have outlined here some issues and some possible avenues in this regard—specifically, in terms of pursuing issues of contemporary importance to innovation scholars and practitioners, applying broader IS theoretical perspectives, and engaging greater number of scholars both in IS and in other business areas.

These approaches are not likely to be without challenges. For example, new IS scholars may deem it too risky to focus their work on topics that are outside the mainstream IS literature and/or to publish in non-IT outlets. Some IS scholars may be dissuaded from focusing on topics where the role of IT is secondary and/or are of limited concern to practicing IT managers. Similarly, applying IS theories and concepts to product innovation contexts may not always be easy or direct and may require considerable adaptation, making such projects less appealing to IS scholars. Recruiting non-IS scholars to such projects may also not be easy, given the silos that still exist in most business research areas. However, despite all these challenges, I believe that as the digital world expands and as more and more products (services) become embedded with IT (digital innovations), the incorporation of IT concepts and issues will become a necessity and of considerable interest to not just IS scholars but innovation scholars as well. In particular, as our earlier brief review reveals, there is considerable potential for future research to enhance our understanding of the role of IT as an operant resource and its impact on both the process and the outcome of innovation.

It is also worth pointing out that, by serving as the reference discipline for innovation, the IS field itself can benefit in terms of new issues and areas of inquiry. To some extent this has started happening as evidenced by the renewed focus on modularity in the IS literature (drawing on the product development literature) (e.g., Tiwana et al., 2010; Henfridsson et al., 2009). Greater extent of sharing of theories and ideas from and across the IS disciplinary boundaries can only lead to much richer research streams within the IS field too in the years to come.

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