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Article

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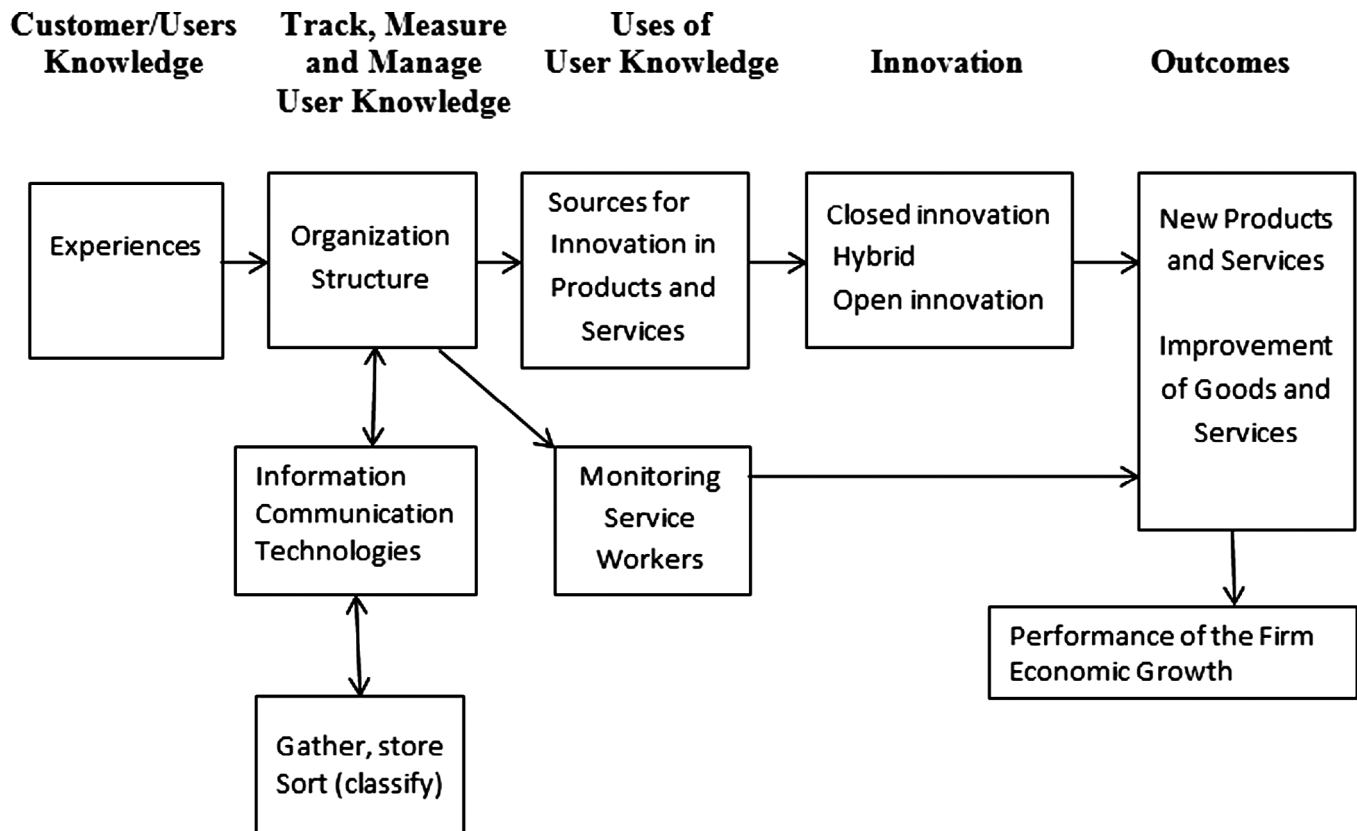
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OPERATIONS, INFORMATION & TECHNOLOGY | RESEARCH ARTICLE

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Information and communication technology and user knowledge-driven innovation in services

Hong Y. Park^{1,†}, Il-Hyung Cho^{2*}, Sook Jung³ and Dorrie Main³

Abstract: User knowledge has been an important source of novel product development and innovation, but gathering accurate user knowledge has been time consuming and difficult because user knowledge is tacit and globally dispersed. However, information and communication technology can expand the boundaries by making user knowledge easier and less expensive to access. Structures and organizations are emerging to perform the task of user information gathering. This paper examines the nature of user knowledge and the emergence of a new system/structure for user knowledge gathering and user involvement in innovation. Three case studies of business innovation in three different organizations illustrate the ways that the organization matches the type of innovation with the characteristics of user knowledge. User involvement can occur either through direct input or via feedback provided after customers received services. User input can also be either proactive or reactive. User knowledge is often employed to monitor service workers also, which has significantly contributed to recent improvement in service quality. The cases presented support our proposition.

Subjects: Information Technology; Innovation Management; Management of Technology; User Interface



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PUBLIC INTEREST STATEMENT

Innovation in services has become crucially important in gaining competitive advantage. Business service cannot be stagnant like the case of commodity. User knowledge has become a very important factor in innovating services. User knowledge is serving dual purposes: it is employed to innovate product and services and is often used to monitor service workers. Monitoring service workers addresses moral hazard and adverse selection problems. Monitoring service workers improves the quality of service delivery. We frequently experience that the service providers request to answer a short survey questions on rating service workers which serves as monitoring service workers. Improvement in information and communication technologies (ICTs) make user knowledge gathering, storing and sorting inexpensive and instantaneous with service delivery. User knowledge is deriving from customers and customers have become co-innovators in recent years. This study examines three cases to illustrate how user knowledge is exploited for service innovation.

Keywords: knowledge; information and communication technology; user knowledge; open source innovation; open innovation; monitoring service workers; quality of service; virtual organization

1. Introduction

Innovation is a key factor for sustaining profits in today's rapidly changing business environment. Many studies have researched the impact of innovation on business success (Chesbrough, 2011; Cohen & Levinthal, 1989; den Hertog, 2000; den Hertog, van der Aa, & de Jong, 2010; Hall & Mairesse, 2006). Studies by von Hippel (1986, 2005) focus on the user's role in business innovation and illustrate the importance of user-centered innovation over manufacturer-centered innovation. This research on user-centered innovation has been well documented in both manufacturing and service sectors (von Hippel, 2005). User-centered innovation is based on the premise that users who have firsthand knowledge from using products and services have a better understanding and knowledge of current needs, and will have better insight to innovate and spur development of exactly what they want, rather than relying on manufacturers to act as their (often very imperfect) agents (von Hippel, 2005).

Capturing this knowledge provides important information on what innovations need to be made. The term "open innovation" is often used to refer to the use of knowledge to accelerate internal innovation and to expand the markets for external use of innovation (Chesbrough, 2006, 2011). Knowledge that is generated internally can be used for the firm's own innovation and can also be marketed to external users. Firms can also use outside knowledge for product and service innovation (Chesbrough, 2003a, 2003b, 2006, 2011; Huston & Sakkab, 2006; Park, Chang, & Park, 2015). Use of these inflows and outflows of knowledge for innovation has become common practice in today's firms. Whereas traditional closed innovation conducts research and develops new products and services within the organization, open innovation has been gaining popularity among firms that are competing in the global market.

Because quality of products is more or less a given nowadays and may no longer be a competitive edge, organizations have also begun to tap vast user knowledge for innovations in services. A new competition pattern is emerging as a result of the current emphasis on service improvement. This drive for improving services has developed a service improvement mechanism such that good service would eventually become an industry standard, similar to the improvement in the quality of products and services in the 80s and 90s; in that era, US firms, keenly aware of the value of quality in competition and the need for quality improvement, adopted Total Quality Management, supplier certification, etc. (Park, Reddy, Shin, & Eckerle, 1996; Park, Wafs, & Shin, 2011). According to Chesbrough (2011), innovation in services is now the escape route from the commodity trap and a solution for growth, giving firms a significant competitive advantage. den Hertog (2000) argues that services do matter and knowledge-intensive business services (KIBS) play an important role in innovation, because they contribute to co-creation of new products as the global economy has become a knowledge intensive economy.

Gathering user knowledge has now become a common practice. This user knowledge serves a dual purpose. First, it is employed to innovate products and services. Second, it is used to monitor service workers. Services improve by better service design and delivery. Employees who deliver better service are the most important factor in service improvement. However, literature on innovation in services does not adequately deal with monitoring service workers. Today, information and communication technologies (ICTs) have become essential in gathering user knowledge on both the nature of services and service workers. Therefore, we also focus on how ICTs can facilitate service innovation by providing easy and inexpensive access to user knowledge, making it easier to gather, store, and sort user knowledge. Monitoring service workers addresses moral hazard and adverse selection problems stemming from information asymmetry, which improves quality of service delivery. We frequently observe that user knowledge is utilized for monitoring service performers, but research on user knowledge has primarily been on the role of user knowledge on new service

development and innovation. Therefore, we include monitoring service performers in our study. There is a paucity of empirical studies linking ICTs with service innovation and the monitoring of service workers. This study, an attempt to fill the gap, examines three cases and provides an example of monitoring service workers.

The paper consists of seven sections. We present a literature review on the role of users in business innovation in Section 2. In Section 3, we briefly show a four-dimensional model of service innovation presented by den Hertog (2000); this helps us develop our understanding of user knowledge-driven innovation by focusing on the key players in service innovation. We present examples of business innovation based upon user knowledge in Section 5 and discuss model cases in Section 6. Finally, we conclude our paper in Section 7.

2. Literature review

Many studies have shown the linkage between innovation and business success (Cohen & Levinthal, 1989; Crepon, Duguet, & Mairesse, 1998; Hall & Mairesse, 2006). Gibbons and Johnston (1974) indicate that while R&D expenditures and patent counts often indicate the source of innovation in large manufacturing companies, innovation other than the internal source (R&D from the company) account for 34% of the total innovation and Langrish, Gibbons, Evans, and Jevons (1971) and Conway (1993) show that it makes up 65% of the total innovation. The external sources have been diverse, including users, academia, suppliers, competitors, and government research laboratories (Park et al., 2015). Since the mid-1970s, many studies have focused on the role played by users or customers in the innovation process (Chesbrough, 2011; Spital, 1979; von Hippel, 1976, 1986). With the advance in ICT industries since the mid-1980s, much attention was given to user innovation in ICT sectors (von Hippel & von Krogh, 2003; Voss, 1985). Many recent models and frameworks have been proposed to better present and understand the effect of innovation in successful business. This paper focuses on user knowledge, ICTs, and the service industry in exploiting user knowledge.

First, user knowledge has become an important source of innovation as firms are compelled to improve products and services in a growing global competition. Users are globally distributed and they are demanding better products and services based on firsthand experiences with products and services. According to Whitehead (1933), “all knowledge is conscious discrimination of objects experienced” (Whitehead, 1933, p. 176). He further points out that “all knowledge is derived from, and verified by, direct intuitive observation” (p. 177). Therefore, users’ experiences with products and services are sources of knowledge. Park et al. (2015) provide a detailed discussion of experience and knowledge creation, arguing that the experiences of employees, customers, and competitors are the basis of new knowledge for organizational innovation. The experience of these stakeholders presents many possibilities because the products they are consuming reveal many facets of the product to them and consumers may perceive products based on their own perception. The organization needs to establish a process to identify and select relevant possibilities. In this process, information technology (IT) plays a crucial role.

Second, information technologies help gather, store, and sort out user knowledge for innovation, helping the organization access user knowledge and making the access cost inexpensive. Nowadays, firms in most industries, such as automobile, health care and ICT firms, seek user feedback and knowledge for innovation and monitoring service performance of their employees. This tacit knowledge according to Polanyi (1969) is indispensable in the discovery of new knowledge, as all knowledge “is either tacit or rooted in tacit knowledge” (*Knowing and Being*, 1969, p. 195). Firms need to wring out this tacit knowledge and make it explicit to be able to exploit it for their innovation. As firms employ information technologies to gather tacit knowledge from users (knowers), they store it for future use and sort it to make sense of it. Most service producing firms ask customers to answer questions on their performance. We argue that this user knowledge serves three purposes: (1) as a source of innovation (Chesbrough, 2011; den Hertog, 2000; den Hertog et al., 2010; Durst, Mention, & Poutanen, 2014), (2) to measure the degree of satisfaction with the firms’ products and services (Lin, 2013), and (3) to monitor employees. First, we frequently observe that when we buy a new car,

car makers send an extensive survey to buyers about their cars and car buying experiences. As the new buyers gain experiences by driving the car, car makers need to capture the fresh experiences of users while they are new. The multiple experiences of users (customers) capture various realities of a new automobile. Car makers initially want to obtain user knowledge for innovation and monitoring dealer services. Second, when car makers get high satisfaction from users, they use it for their advertisements. Therefore, they try to improve user satisfaction. Third, employees or service performers are also agents of product producers and service providers. They may not always serve the best interests of the car maker, so monitoring helps improve dealer services, which are crucial to an automaker's success. The car makers also gather information on car dealers' regular oil change services. Because the car maker's successes depend on service performances, these have become more important in organizational successes as end users or customers demand better services. Financial and health care service industries are likewise competing in services they provide, so firms in these industries survey customers to obtain feedback on their services. They electronically send out surveys to customers immediately after they received services and ask about the nature of the service, the service system and individual service providers. They track customer experiences on services, measure the quality of services, and then analyze and manage the quality of services (Chesbrough, 2003a, 2011).

Chesbrough (2011) argues that innovation in services is the escape route from a commodity trap and a solution for growth. He points out that those companies must think beyond their products and move outside their own four walls to innovate. User knowledge is outside knowledge and a company's ability to open up the innovation process is crucial to the success of the company. Customers' experiences on products and services are tacit knowledge and companies compete to tap that tacit knowledge for innovation in services. Scholars (Durst et al., 2014; Lin, 2013; Ryu & Lee, 2012) made empirical studies on the impact of service innovation on firm performance since den Hertog's (2000) publication of the conceptual model on service innovation. Ryu and Lee (2012) studied service innovation patterns in the service industry and identified four patterns: service-delivery-based high-tech, client interface and service delivery-integrated, client interface-based high-tech, and strongly balanced innovators. They found that strongly balanced innovators explain firm performance better. Lin's (2013) study examines the impact of service innovation on performance in developing countries such as China. He found that the innovation mode is cost-reductive and the assessment of service quality emphasizes the dimensions of assurance and reliability. Durst et al. (2014) reviewed service innovation and its impact on performance for two time periods in 2006 and 2014. They report that knowledge on the relationship between service innovation and performance is limited, and point out that this area of research deserves further scrutiny. We examine three cases to add some insight to the area and discuss our observations on monitoring service workers and its impact on service improvement.

We frequently observe that automakers conduct a survey on their products and car dealers' services to measure the degree of satisfaction on their products and quality of dealers' services. Their practices are prevalent in most industries and have become an industry standard. As a result, new organizational structures are emerging to provide user knowledge for manufacturing and service providing firms. ICTs make user knowledge gathering, storing, and sorting inexpensive. ICTs generate interactions among users, and these interactions create new knowledge, with new entrepreneurs emerging based on the needs and new knowledge they generate. ICTs also help gather user knowledge globally and reduce the distance between producers and users. ICTs caused the importance of distance to diminish as Cairncross (1997) predicted in her book, *The Death of Distance*. ICTs connect producers of products and services with suppliers and customers. ICTs also help manage open innovation (Chesbrough, 2003a, 2011) by tracking, measuring, and managing customers' experiences. Managers analyze the contents of user surveys and then categorize them to efficiently address issues that are raised by survey respondents. User-driven innovation reduces risk, economizes cost, and saves time because producers can create what users want (von Hippel, 1986).

Third, Gadrey, Gallouj, and Weinstein (1995) view services innovation as a key factor in organizational success, and they present six innovation models to describe service innovation: radical innovation, improvement innovation, incremental innovation, ad hoc innovation, re-combinative innovation, and formalization innovation. Their study shows that non-technical capabilities like human and organizational capabilities are important in innovation. Miles (1993) argues that services have become more prominent factors in the new industrial economy. den Hertog (2000) and den Hertog et al. (2010) studies on the role played by KIBS in the innovation process present a four-dimensional model of (services) innovation, which points to the significance of such non-technological factors in innovation as *new service concepts*, *client interfaces*, *service delivery system*, and an optional *technology* that facilitates service innovation. Previously a service industry was mainly viewed as supplier-dominated with little interaction with clients. However, den Hertog (2000), den Hertog et al. (2010) and Chesbrough (2011) show that business services can function as facilitator, carrier, source of innovation, or even as co-producers of innovation with close relationships with clients. We will examine more details of this model in the next section and develop our model to incorporate ICT for the service innovation model and monitoring for service workers.

3. Four-dimensional business services model

Service innovation is not limited to the introduction of a new service product, but it also has to do with how the service—new or existing—is practiced by the service provider, and how clients respond. These three components are shown in Figure 1 with the optional technology support component. The four-dimensional service innovation model is not limited to service products alone, but is also relevant to manufacturing products. This model helps the researcher to approach and understand the complex issues of service innovation in a more structured way.

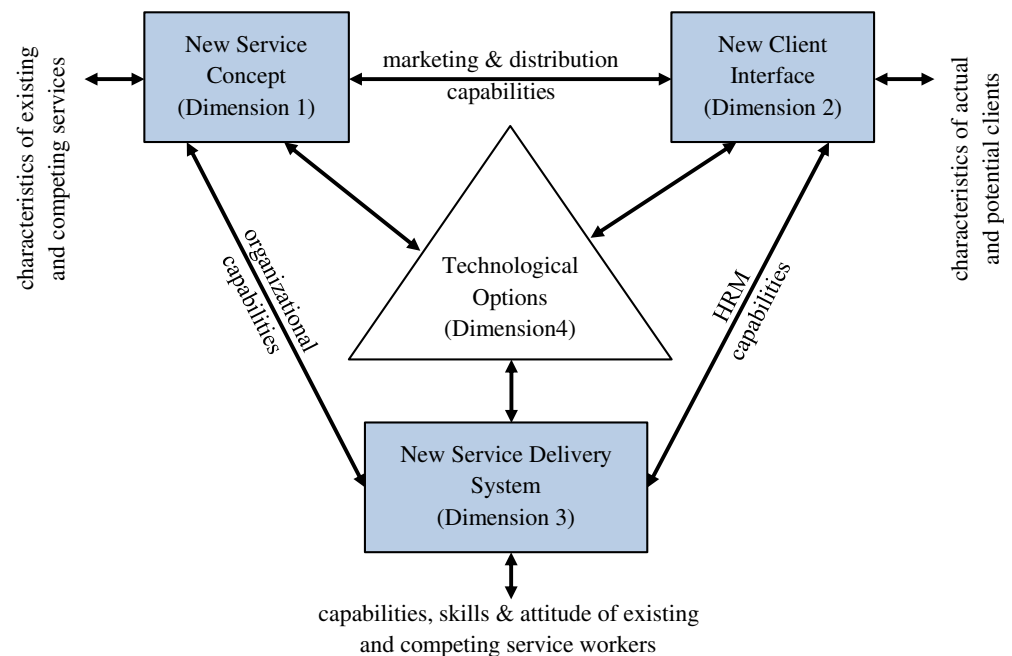
3.1. The service concept

While most manufactured products are tangible and visible, most service products are intangible and conceptual, such as new ideas of how to organize a solution to a problem. Examples of business services are tax services, investment services, 24 × 7 customer services, ICT services, etc.

3.2. The client interface

This service innovation component is focused on the client’s needs: how well the service provider interacts with the client can be a source of innovation. Sometimes, the client activity becomes

Figure 1. den Hertog’s four-dimensional model of service innovation.



integrated into the service provider’s activity, which results in co-design and co-production of service products. Most computerized and automated services for clients can be examples of client interface innovations.

3.3. The service delivery system and organization

This refers to the internal organizational arrangements that have to be implemented to allow service workers to perform their job properly to develop and deliver innovative services. While new services may require new organizational structures and new personal skills, it can also work the other way around: changing the organizational structures and training employees with new skills can produce innovations or provide solutions to practical problems. Service delivery is made by service companies independent of manufacturing firms. Service workers are agents in service delivery companies. These workers have the classical incentive incompatibility with managers and owners of the company.

User knowledge also serves as a monitoring mechanism. Capabilities, skills, and attitude of existing and competing service workers (see Figure 2) are crucially important. However, service workers are agents and agent costs are large in the economy (Alchian & Demsetz, 1972; Boudreaux & Holcombe, 1989; Fama, 1980; Jensen & Meckling, 1976; Stiglitz, 1975). When user knowledge is employed to monitor service workers at a minimal monitoring cost, agent costs are economized. Monitoring service workers addresses the incentive incompatibility, moral hazard, and adverse selection problems by eliminating information asymmetry. Figure 2 is a graphical presentation of user knowledge for innovation in services and monitoring service workers.

User experiences are tacit knowledge and the organization creates an organizational structure to capture user knowledge (Park et al., 2015). As shown in Figure 2, user knowledge becomes sources of innovation in products and services, and monitoring workers. Innovation can be closed, open or hybrid. Many firms choose to engage in closed innovation because they can develop patents which are protected by patent laws. Firms can maintain monopoly positions for many years and gain monopoly profits by using patents. Open innovation, on the other hand, offers speed and helps to attain the vast knowledge available in the field. Firms also choose hybrids of varying degrees between open and closed innovation. A firm’s innovation choice is matching its innovation with the characteristics of services and products that the firm is developing. Innovation in products and services, and monitoring service workers contribute to improvements in firm performances (see Figure 2).

Figure 2. User knowledge and innovation.

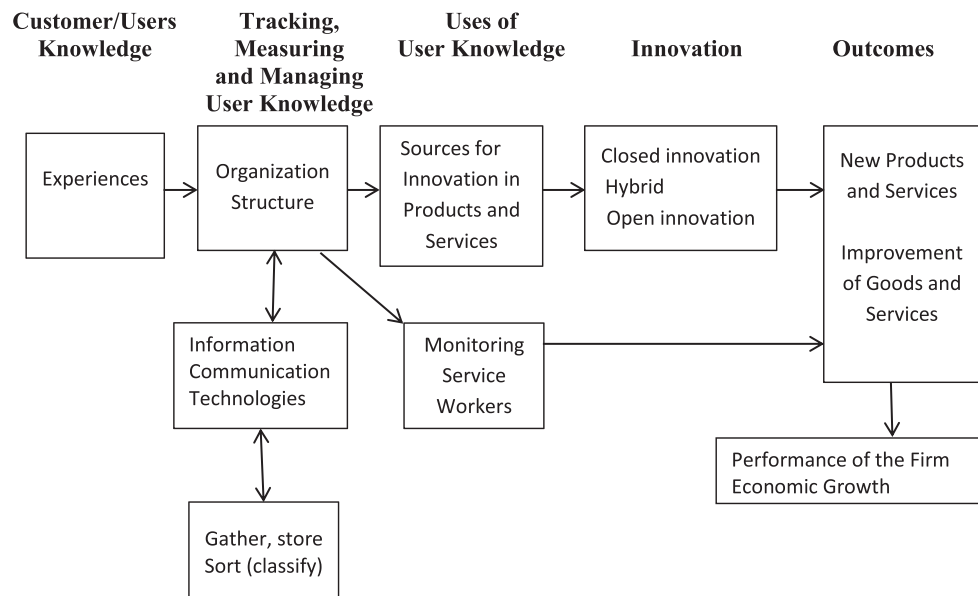


Table 1. The nature of user involvement

	Direct user involvement		Through user feedback	Proactive (voluntary)	Reactive
	Devel	Non-devel			
IONA (CRM)		O	V	O	
WSU (genome database)		O	V	V	O
Drupal	O			O	
SVSU			V		O

Note: The O and V represent strong or weak involvement of users in innovation, respectively.

3.4. Technological options

Even though service innovation is possible without technological innovation, technology often plays a diverse role from facilitating innovation to bring a major force in driving innovation. ICTs are dominant factors in service innovation: the wide spread use of the Internet and Web, smart phones, tablet computers, cloud computing services, and application software are all enablers of service innovation. Most innovations in hardware technology are dominated by manufacturing companies (supplier-dominated), but many users (and clients) are directly involved in application software development. Those users vary in large degrees from individual users, to users in academia and government research institutions and software developers in firms. Information and communication technologies gather, store, and classify user knowledge for innovation (see Figure 2).

3.5. Linking the four dimensions

Even though each component in the four-dimensional model may play a dominant role in service innovation, it is likely that any service innovation will prompt a set of changes in other dimensions, and involve some combination of multiple components in the model to varying degrees. The linkages between components show the communication and activities involved. Different innovations in different business sectors may exhibit varying degrees of involvement from each component and different strengths of linkages between them. Based on the literature, we propose the following:

We propose that user knowledge is not only an important source of service innovation, but serves the most important role in monitoring service workers. Information technologies gather, store and sort user knowledge to innovate services and monitor service workers.

There can be different ways in supporting propositions. We examine three cases to support our proposition.

4. Methodology

We use cases to support our propositions and use an example of the IT services of Saginaw Valley State University as monitoring service workers. The user involvement varies depending on the nature of the projects which are seeking user knowledge (Table 1). In open systems' development, the user involvement is proactive and users are directly involved in product development. Users are proactive in all three cases and they all directly involved in innovation.

5. Case studies

In this section, we present three cases of service innovation that directly involve the user. All have been directly or indirectly experienced by the authors. Our first case is the use of Customer Relationship Management (CRM) software called Vantive at IONA Technology in 2000. CRM is a model for managing a company's interactions with current and future customers. It involves using technology to organize, automate, and synchronize sales, marketing, customer service, and technical support (Shaw, 1991). The second case is the development of the Genomics website that is currently in use and under development by Washington State University. The third case is the Content Management System (CMS) called Drupal which is under development by an open source license. These cases all show the users' role in the success and innovation in business.

5.1. Innovation through enhancing customer relationships (Case 1)

CRM technology supports and improves current business processes by focusing on streamlining customer support. CRM software varies in size, complexity, and cost, but its core function is to help improve and manage the customer relationship, even though it usually also includes market planning and sales management capabilities. In this paper, we focus on the customer relationship part and show how it contributes to business innovation.

The second author, Cho, worked for IONA Technologies from August 2000 to August 2001 as a software engineer in the customer support team. This was when the dotcom bubble burst and stock prices sank. Billions in venture capital were given to IT start-up companies with little or no experience in customer support and customer relationships, and most such IT companies, even with a solid technology background, collapsed and went out of business. As a result of the burst and the following economic downturn, most companies had to reduce their IT budgets, which made it even harder for IT companies to survive. However, some companies managed to survive the dotcom bubble by adapting to the new economic environment through reorganization, new leadership and redefined business plans. The author notes that many of the surviving companies had kept a good customer relationship and IONA Technologies was one of them.

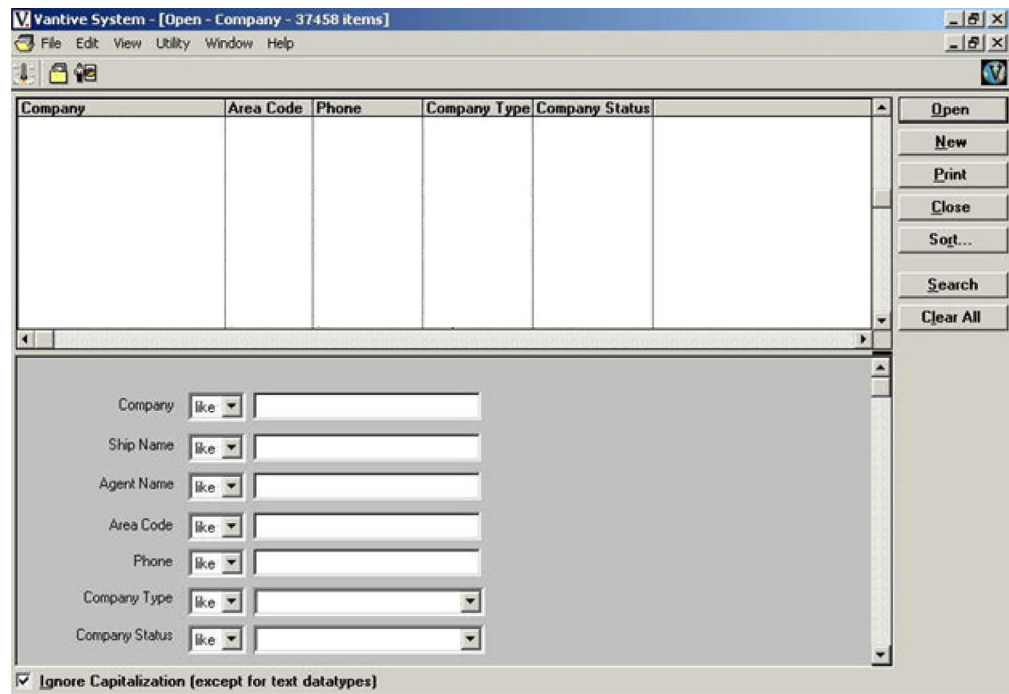
IONA Technologies produced an Enterprise software that helps integrate software applications written in different languages and running in different platforms in a distributed computing environment. IONA Technologies was one of the leading edge technology companies in the world in the 90s. The main source of their revenue was services users and customers. Most of their software was free or available at a nominal charge. They had different levels of customer support systems: bronze, silver, gold, and platinum. Platinum-level customers had 24/7 worldwide direct supports. Bronze-level customers had access to IONA's knowledge base, a database of tips for handling frequently occurring tasks, and solutions for known and recurring problems. If they wanted, bronze-level customers could raise their support level for an additional charge.

When a customer enquiry was received by customer service via phone or email, the problem was logged into the Vantive system (see Figure 3) along with customer information details and the nature of the enquiry. Most of the enquiries were about problems the customers had faced with implementation, and sometimes bug reports. Support team leaders would see entries in Vantive and assign tasks to their software engineers to resolve the problems by entering those tasks into the work queue of their engineers. Higher priorities were given to higher support-level customers by assigning tasks to more experienced or senior-level engineers. The engineers were notified once tasks were entered into their task queues. Since IONA had branches in Asia, Europe, and North America, they could run the support system 24/7.

The use of the Vantive CRM software made the overall customer support system very effective. The close contact with customers also made further technical innovation easier. The inquiries entered into Vantive were used as a source not only for fixing bugs or resolving customer issues, but for uncovering future customer needs. Satisfied customers were enthusiastic about the enhancement of the product they used, and were willing to spend their time and effort to contribute to further innovation of the product. Such input from customers was discussed and analyzed, then handed over to the product support and development team where it became a candidate for implementation in future releases. This type of user knowledge offers valuable foresight for the development of future products and services. In this case, the user involvement is proactive and the user is not directly involved in the product development.

Making good judgment and correct reading of user knowledge can be very important in successful products/services development. IONA managed to stay in business after the dotcom burst, and the author attributes its success to their technological edge and to the well-implemented customer support system based on effective use of the CRM software that facilitated the user involvement in the product and service innovation. User involvement in new CRM software development creates a feeling of ownership which engenders loyalty to the new software.

Figure 3. Vantive system.



5.2. Genome database website for academic research (Case 2)

The Genome Database for Rosaceae (GDR) provides a second perspective on the value of user knowledge. Genome databases are repositories of DNA sequences and other related genomic data from many different species of plants and animals (Carroll, Nguyen, & Batzer, 2002). Many publicly accessible databases can be viewed by web browsers from the database servers operated by government organizations like National Center for Biotechnology Information, European Bioinformatics Institute, DNA Data Bank of Japan, and Beijing Genome Institute. Also, there are many databases operated by private companies like Celera or by academic research groups funded by federal agencies such as National Science Foundation (NSF) and US Department of Agriculture (USDA). In this case, we look at the GDR, a web-based relational database providing centralized access to Rosaceae genomics, genetics, and breeding data and analysis tools to facilitate cross-species utilization of data (Jung et al., 2004). The GDR started in 2003 as a small research project. With two successive federal funding grants (2003–2008 from NSF and 2009–2014 from USDA), GDR has been expanded to become the major web database for Rosaceae researchers worldwide, accessed by almost 100 different countries. Below we will show how the involvement of the users resulted in the service innovation in GDR using the four dimensional model described above.

The initial database had limited functionality since it did not have comprehensive genomics and genetic data. However, the proof of concept was done right, in that the database schema was designed to include most of the genomics and genetics data types that were available at the time, and the interface was designed to allow comprehensive query on the integrated data, even though the amount of the data was limited. To become more functional, Rosaceae researchers worldwide, the potential users of the website, needed to recognize GDR as their community database, and send their data and provide their input in further development. The GDR team realized the importance of community input from the beginning and made consistent efforts to help build the Rosaceae research community and gather input from them. These efforts included participation in the US Rosaceae Genomics, Genetics and Breeding Executive Committee (RosEXEC) and the Rosaceae International Genomics Initiative (RosIGI), and serving as a communication and coordination focal point of the US and International Rosaceae community, to facilitate scientific interactions and define research priorities. The GDR project leader, Main, was part of these committees from their inception,

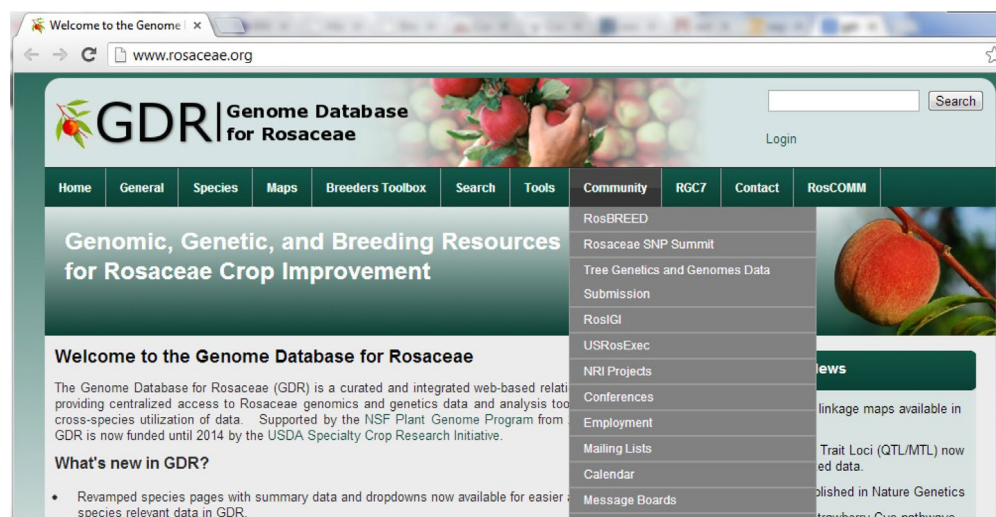
and another author, Jung, has served as an executive committee member since 2012. All committee members serve a three year term but the community decided that at least one person from GDR should always serve as a committee member.

To communicate with its community, GDR sends out frequent newsletters to notify users of new data, functionality, and community news. GDR mailing lists have also been created to facilitate communication among users. Each GDR website has a header bar, and one of the main menus is “Community.” Figure 4 shows the homepage of GDR and its Community link.

In the Community section, numerous pages facilitate communication between GDR and users, as well as among users. These include the RosEXEC/RosIGI page, which provides the official documents, meeting minutes, membership, and subcommittee information. Other community pages include mailing lists, conferences, meetings, funding, message boards and employment. In addition to gathering user input from the various meetings, mailing lists, and conferences, the GDR team also frequently checks the number of visits to each page using Google Analytics to see how often each page is visited. Currently, a Twitter account was created for GDR to further facilitate rapid communication. These efforts of the GDR team in community-building demonstrate the client interface model in service innovation. This active involvement in the community resulted in integration of the service provider, the GDR team, and the clients, Rosaceae researchers.

The prototype of the project was developed by the authors (Cho, Jung, and Main) using Java Servlet/JSP, MySQL database, and Tomcat web server (Turner, 2002). (Different technologies could have been used, for example, PHP or Perl instead of Servlet/JSP, and Apache web server instead of Tomcat. However, the choice of the technology was due to the popularity of the Java technology in the early 2000s and familiarity with the Java technology by the authors.) Upon receiving NSF funding in 2003, GDR switched to Perl/Oracle from JSP/MySQL, then to PostgreSQL (www.postgresql.org) following the funding agency’s recommendation to use open-source software. In 2010, the website was rebuilt using Drupal (<http://www.drupal.org>), an open source, popular, and well-supported CMS that has been used to construct a wide variety of websites from small- to enterprise-level. A major benefit of using a CMS is that it helps simplify website installation for site administrators, web development for programmers and content changes for non-technical users. By using a CMS like Drupal, many site administration features (like user management and security) are free, and developers can focus on developing the core functionality of the site. This allowed the GDR team to spend more time and effort on the data curation and interface design than on the site construction. In addition, Drupal’s user management system allowed GDR to host users’ private data, which can be viewed with a secure login. This meant users could view and analyze their new data integrated with the

Figure 4. GDR and community link.



publicly available data in GDR before publication. This technology also allowed GDR to host breeders' private data that they do not want to release to the public until new cultivar release. The use of appropriate technology, Drupal in this case, significantly enhanced the quality of the service. The GDR team made the tool accessible to field researchers and then reached out the community for their feedback. User involvement was initially reactive; however, once the tool became popular, many researchers around the world proactively provided feedback and began to contribute to product improvement.

5.3. Open source software: Drupal, CMS (Case 3)

The third case is the development of the Drupal Open Source CMS. Open Source Software (OSS) is software that is made freely available to all users, who have the right to modify the source code. The most prominent example of OSS is software developed under the GNU General Public License (GPL) (www.gnu.org/gnu/thegnuproject.html) and the Apache license (www.apache.org). For example, MySQL and the Linux operating system are developed under a GPL license, and the Apache web server is developed under the Apache license.

The OSS innovation model is well documented by von Hippel and von Krogh (2003). In the OSS community, developers contribute their time and effort for free to develop software systems. Many OSSs are first developed from a small number of students and researchers in academia and research laboratories, where they develop software applications for their own use; as the popularity grows, the number of users increases and more users/developers get involved in the development. OSS developers do not get paid for their services. Lerner and Tirole (2002) ask, "Why should thousands of top-notch programmers contribute freely to the provision of a public good?" They provide a preliminary exploration of the economics of OSS. Many studies have provided further understanding of key motivations for OSS development. Raymond and Young (2001) suggest that scratching a developer's personal itch is the intrinsic motivation for an OSS developer. Yunwen and Kishida (2003) argue that learning is one of the motivational forces. Overall, OSS developers are largely motivated by personal use for the code and personal learning, personal recognition among the development community, personal satisfaction from doing something good for the community, and even fun.

OSS evolved because the Internet allows users to collaborate or share ideas and interests by communicating online. Until the availability of the World Wide Web (WWW) in the early 90s, communication was limited to email systems and primitive forms of bulletin board systems (BBS) via phone line and modem. The shared content was mostly text-based or small size image or video files due to communication speed/bandwidth and the limitation of file size and storage size. However, the ability to communicate and share contents online tremendously changed the work environment. First, there is virtually no time delay for content delivery. Users in a community can instantly share an idea or thought perceived by other users, which may trigger a new idea or thought to other users, and so on, which was not possible for users separated geographically before online communication was available.

The concept of community sharing became very popular and widespread among more diverse community groups in business, education, research, and public-private groups of people with similar interests with the advent of WWW, the high speed internet, and the corresponding IT advancement in hardware (CPU speed and storage size) and software. Hyper Text Markup Language (HTML) was fairly easy to learn for IT savvy users and many primitive forms of CMS websites were developed in the mid 90s using HTML. Many users could easily post, search, and retrieve and share contents, but such websites were limited mostly to static contents. As the community size grew with the number of users and content posted, many websites became outmoded and sluggish. Many sites, especially e-commerce sites and sites like GDR, needed dynamically generated contents, but the early technology was not able to meet the demand.

Then by the early 2000s, many web scripting languages that are suited to website development became popular, for example, PHP (www.php.net), Python (www.python.org), and Ruby (www.ruby-lang.org), to name a few. Many CMSs were developed by both private and public efforts (open source)

by the mid-2000s by using the new web scripting languages. Drupal was one of them. By the late 2000s, after many mergers and acquisitions, three open source CMS systems became dominant: WordPress (www.wordpress.org), Joomla (www.joomla.org), and Drupal, developed under the GPL license. All three CMS systems have very strong followers, and hundreds and thousands of developers worldwide are involved in the maintenance and development of each system. Drupal especially has wide support from government, financial sectors, education, media (newspaper and broadcasting companies, and magazines), and the health care industry. To find out more, refer to <http://www.drupalshowcase.com/>.

Drupal was first developed in 2001 by Dries Buytaert, a college student at the University of Antwerp. It started as a small news site with a built-in web board, allowing a group of friends to leave each other notes about the status of the network, to announce where they were having dinner, or to share some noteworthy news items (drupal.org/about/history). Drupal became very well known when it was used to build a website for the US presidential candidate Howard Dean in 2004. It was chosen by a software engineer for Dean's campaign to boost social networking for the campaign. Dean's innovative use of the internet and social media, and Drupal for building a grass roots campaign, resulted in the most funds raised among presidential candidates at the time, even though he did not win the nomination from the Democratic Party. After the campaign, Drupal's use exploded and Drupal development efforts followed. Now over a thousand developers continue to work on maintaining and developing Drupal.

Groups.drupal.org provides a place for groups to organize, meet, and work on projects based on interest or geographic location. Events and meetings are held nationwide, and community members (users and developers) can meet face to face, swap tips, and get inspiration for further development. Also, there are online support forums, Internet Relay Chat, and mailing lists for contributions, questions and answers, and product help. These activities establish close contact among developers, between developers and users, and among users. Such live communities helped Drupal go through a series of upgrades and innovation; it now is ranked the second most popular open source in CMS, next to WordPress. This may be an example of open innovation that used purposive inflows and outflows of knowledge to accelerate innovation (Chesbrough, 2003a, 2011; Chesbrough & Appleyard, 2007). Chesbrough argues that the key to success is creating an open platform around your innovations, so your customers, your employees, and even your competitors build upon it, because only by building will you create an ongoing, evolving community of users, doers and creators. As in most open system development, user involvement in this case is proactive and users are directly involved in product development.

5.4. ITCs and monitoring service workers (Example)

Our example of service improvement illustrates how ITCs help monitor service workers and improve IT services. When Saginaw Valley State University (SVSU) hired a new IT manager several years ago, he made changes to IT staff orientations concerning their work. He reoriented them from being university employees to being service providers for university employees, asking them to treat university employees as their customers. He also introduced a survey instrument to rate IT staff services and obtain feedback from customers. IT observed a significant improvement in services after the introduction of employees' rating and feedback on IT services. The system, implemented on 18 November 2013, has continued. The system has 5,700 cases and to study its impact, we took 100 cases from three different time periods: initial, middle, and the last period. Average scores of customer satisfaction were 4.76, 4.82, and 4.77 on a five-point Likert scale, respectively. A significant improvement was noticed after the initial installation of the monitoring system compared to the time period before the installation. However, it has diminished over time. This may be due to the fact that the manager does not frequently discuss customer satisfaction with his staff and there is a lack of incentives for better service performance. This outcome supports the argument that a performance measurement has to include incentives for better performance (Brickley, Smith, & Zimmerman, 2008).

6. Discussion

We focused our cases on service-providing organizations. As we argue in this paper, user knowledge has become a very important source of innovation in such organizations, as they compete to obtain user knowledge for their innovation. User knowledge is tacit, embedded in individuals, abundant and globally distributed. ICTs help gather, store, and sort user knowledge; they also facilitate increased interactions between the organization and employees and among customers (users). These interactions improve knowledge creation and new product and service development. The model (Figure 2), the three case studies, and the examples of firms' customer surveys lead us to six key points.

First, organizations obtain user knowledge via customer surveys and user participation in an organization's knowledge creation and innovation. Gathering knowledge from users serves two purposes: (1) knowledge for product and service innovation and (2) a method for monitoring service workers. The organization can identify items in new service development by employing user knowledge, because users have firsthand experiences with the products/services the organization produces. Experiences are sources of user knowledge. As the organization tracks performances, measures quality of performance and manages employees, monitoring service workers will lead to improvement in services, providing a competitive advantage over competitors. As improvement in service has become a major driving force in competition among organizations in many industries such as financial services, health care, and the automobile industry, services have improved significantly in recent years. We observed a similar pattern in improvement in the quality of products in the 80s and 90s. When the quality of the product was a driving force for competition in the 80s and 90s, total quality control, continuing improvement and the supplier certification program became newly adopted business practices which led to significant improvement in product quality.

Second, user knowledge and user involvement in service production have been driving forces in service innovation in the three cases discussed in Section 4. The use of the Vantive CRM software made the overall customer support system very effective, and closer contact with customers made further technical innovation easier. Customer inquiries entered into Vantive were used as a source not only for fixing bugs or resolving issues raised by customers, but for uncovering future customer needs. Discovering future customer needs presented an opportunity to provide a new service. User knowledge shared by Vantive customers offered good foresight for development of future products. Such foresight of managers is a crucially important factor in the success of new products/services; it is hard to overemphasize the value of foresight in the success of new products/services (Nelson & Winter, 1982; Park et al., 2011).

The genome data base case illustrates that users' input and the interactions between users and researchers are crucial in the creation of values for the community of researchers and for users of the research. One very important aspect of this case demonstrates how interactions among users and researchers help to create knowledge.

The OSS case shows how interaction and sharing between users and programmers help to improve web language and website development. OSS employs inputs from users and also contributes to innovation in OSS. However, OSS faces challenges in sustainability, because the benefits of openness are contributions to innovation and OSS may not be sustainable in the long-run without capturing some value from the system (Chesbrough & Appleyard, 2007). OSSs harness collective creativity through open innovation, but need to capture value to be commercially sustainable. The process of value creation and value capturing generates an incentive incompatibility among participants, which dulls incentives to continuously improve OSSs. Eventually an optimal organizational structure will emerge between the two extremes: closed innovation and open innovation. Currently, an organization needs to choose a hybrid or some combination of closed and open innovation. The choice may depend on the nature and characteristics of innovation (see Table 1). There are varying degrees of open innovation in companies such as Dow Chemical, IBM, Proctor & Gamble, Apple and Samsung (Chesbrough & Appleyard, 2007; Huston & Sakkab, 2006; Park et al., 2015; Park, Shin, Jung, & Park, 2013). This may be similar to the

choices for governance in transaction cost economics: make, buy or hybrid in supply chain management (Williamson, 1985, 2008).

Third, ICTs connect users (customers), producers and employees who are distributed globally. ICTs eliminate geographic distance, promote communication and interactions among participants, and help track, store, and sort user knowledge. ICTs have made monitoring of service workers easy and inexpensive. ICT is also a dominant factor in service innovation, as we can observe in IT firms such as Facebook, Google, and Amazon.

Fourth, users in CRM, GDR, and Open Source systems also register dissatisfaction and problems with these platforms. Providers of these platforms can classify dissatisfaction and problems to efficiently address them and also use the platforms as a monitoring device for service providers.

As stated previously, service worker monitoring has become ubiquitous. Most automobile companies, such as GM, Ford, Chrysler, Toyota, Hyundai, and Honda, conduct a follow-up survey on buyers' experiences at a dealership, then track their dealers' services on experiences of purchases and regular oil change services. Airline companies ask customers to rate their reservation workers' quality of services when customers make reservations. This practice has also become prevalent in most large service-providing organizations, such as hospitals and financial institutions. This monitoring of service workers improves the performance of service workers because the survey rates the individual performance of the service worker. Workers are in general conscious of their job performance; thus user ratings on individual performance make service workers more conscious of their work and improve services. Currently, a new industry is emerging to produce user knowledge on products and services, and many user knowledge gathering firms have emerged in recent years. For example, Angie's List is a collection of user knowledge. Continuous Improvement (CI) is a business practice that solicits and seeks user knowledge (feedback) to make CI in products, processes, and services. Since users are globally distributed and have diverse knowledge and experience on products/services, user knowledge can be very valuable input for innovation. CI has become a routine business practice in innovation for products, processes and services since the 90s, and productivity in service workers will continue to increase as service-producing firms employ user knowledge to monitor service workers. Improvement in services and an increase in productivity of service workers significantly contributed to the nation's economic growth and quality of life in recent decades, and are likely to continue to make contributions in the future.

Fifth, innovations in service contribute to the productivity of service workers and organizational performance. Although we did not investigate the impact of innovation on productivity, studies are available in the literature. Griliches (1979) laid out a framework for the analysis of innovation and productivity growth in the form of a flow chart that showed the path by which investment in research generated knowledge, and the outputs and indicators of that knowledge (Hall & Mairesse, 2006). Crepon et al. (1998) developed a numerical model to assess the innovation impacts of research and the productivity impacts of innovation and research. Their results show that the probability of engaging in R&D for a firm increases with its size (number of employees), its market share and diversification, and with the demand pull and technology push indicators. Furthermore, the firm innovation output, as measured by patent numbers or innovative sales, rises with its research effort and with the demand pull and technology push indicators, either directly or indirectly through their effects on research.

Finally, new organizational structures are emerging as a result of coordinating creative activities between users and service producers. IT capabilities vary from organization to organization. The organizational structure in the three cases discussed above was an open platform (Chesbrough, 2003b) where users (customers), employees, and competitors interact; share and offer new ideas; Nonaka and Konno (1998) refer to this as "ba." For Nonaka and Konno, ba is a place where knowledge workers can share, socialize and interact. The place may be physical or virtual. Dow Chemical Company refers to its platform as Idea Central (Park et al., 2015).

Chen, Hung Tai Tsou, and Huang (2009) found that IT capability has positive effects on service delivery innovation, as it makes service workers monitoring possible and inexpensive. We can observe that a virtual organization coordinates activities and facilitates interactions between the service-producing firm and users, and among users. This type of platform is ubiquitous and the current platform structure is flexible and fluid to meet the ever-changing needs of a rapidly changing global economy. ICTs and social media such as Facebook make numerous platforms possible. Through market competition, an efficient structure can be selected from among various structures. We also observe that a new industry is emerging to capture and process user knowledge for product and service innovation, and to monitor service workers as the organizations outsource these services. As we have seen in the above cases, ICT capability has become crucially important in service innovation.

7. Conclusion and implications for managers and policy-makers

This paper examined user knowledge as a source of innovation, and ICTs as a capturing device for globally distributed user knowledge in the context of a service producing organization. Cases in our paper offer evidence that user knowledge is an important source of innovation and ICTs help facilitate the capture of user knowledge. Tapping into vast user knowledge has become a major global competition driver. Because user knowledge in products/services from diverse users offers many different perspectives on products/services, it is a source of service innovation. We conclude that user knowledge will continue to serve as an important source of innovation in products and services, and provides an effective monitoring device for service workers. Such monitoring contributes to better service performance, lower agency costs, and increased productivity of service workers. However, monitoring needs to be managed by providing incentives for better performance; otherwise the impact may diminish over time.

Innovation is important in the sustainability of today's business and political organizations and user knowledge is an important source for innovation. User knowledge is abundant and relatively inexpensive to obtain. Managers and policy-makers need to be aware of its value for innovation and design an effective structure or platform to capture it. Thus, the organization's ITC capability is crucially important and it is requisite for managers and policy-makers to acquire state of the art ITC capability.

Case studies in this paper offer detailed knowledge on how organizations capture and utilize user knowledge for service innovation and monitoring service workers. However, case studies have limitations in generalizing their findings, and the cases in this paper are no exception. Generalization of findings of the paper requires more cases and larger sample size statistical studies. Further research on the role of user knowledge on monitoring service workers is required to validate the monitoring aspect of user knowledge for service improvement.

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