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Taeho Park
San Jose State University, taeho.park@sjsu.edu

Tianqin Shi
San Jose State University, tianqin.shi@sjsu.edu

Ming Zhou
San Jose State University, ming.zhou@sjsu.edu

Shu Zhou
San Jose State University, shu.zhou@sjsu.edu

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Applications of Open Innovation to the Supply Chain System in the SMEs

Taeho Park

taeho.park@sjsu.edu

Lucas College and Graduate School of Business, San Jose State University
One Washington Square, San José, CA 95192 USA

Tianqin Shi

tianqin.shi@sjsu.edu

Lucas College and Graduate School of Business, San Jose State University
One Washington Square, San José, CA 95192 USA

Ming Zhou

ming.zhou@sjsu.edu

Lucas College and Graduate School of Business, San Jose State University
One Washington Square, San José, CA 95192 USA

Shu Zhou

shu.zhou@sjsu.edu

Lucas College and Graduate School of Business, San Jose State University
One Washington Square, San José, CA 95192 USA

Biographical notes: Dr. Taeho Park is Professor of Supply Chain and Operations Management in the Lucas College of Business at San José State University, (SJSU) USA. He is currently Director of School of Global Innovation and Leadership and Director of Silicon Valley Center for Operations and Technology Management at the Lucas College of Business. Dr. Park has B.S. and M.S. in Industrial Engineering from Seoul National University, Korea, and Ph.D. in Industrial Engineering from University of Wisconsin-Madison. He served on the journal of supply chain and operations management as editor-in-chief in a period of 2011-2016. His research focused on operations/supply chain management, environmental sustainability management, total quality management, enterprise risk management, and technology management. He has more than 30 years experiences on research projects, consulting, training, workshops, and seminars for various industries, such as electronics and logistics. Dr. Park has published research papers in many journals, including Journal of Operations Management, International Journal of Production Research, European Journal of Operational Research, Int. J. of Computer Applications in Technology, Int. J. of Advanced Manufacturing Technology, J. of Supply Chain and Operations Management, and so on.

Dr. Tianqin Shi is an Assistant Professor at Lucas College and Graduate School of Business, San Jose State University. She holds a bachelor's degree in mathematics and a master's degree in

management science and engineering from Shanghai Jiao Tong University, and a PhD degree in Business Administration from University of Illinois at Urbana-Champaign. Dr. Shi's research interests include topics in sustainable operations management and supply chain management, with a major focus on eco-friendly product design and environmental policies.

Dr. Ming Zhou is a full professor at Lucas College and Graduate School of Business, San Jose State University. Prior to joining SJSU in Fall 2006, Dr. Zhou served as an assistant professor of supply chain management at the Price College of Business, University of Oklahoma. Professor Zhou holds a PhD in Supply Chain Management from the Robert. H. Smith School of Business, University of Maryland, College Park, a BA degree in Finance & Accounting from the Guanghua School of Management, Peking University. Dr. Zhou's research focuses on electronic supply chain and application of information technology on supply chain operations. Recent research of his studies online transaction security issues, online auction strategies, and electronic supply chain practices.

Dr. Shu Zhou is an associated professor at Lucas College and Graduate School of Business, San Jose State University. Dr. Zhou received her Ph.D. in Operations Management from Cornell University, the S. C. Johnson Graduate School of Management. She got her bachelor's degree in Management Information Systems from Tsinghua University, China, and a master's degree in Management from Cornell University. Her research interests include supply chain management, inventory control, forecasting, and operations management-marketing interface.

Applications of Open Innovation to the Supply Chain System in the SMEs

Abstract: The close-knitted structure of a supply chain seems to leave no room for the word “open”. Closeness builds trust, enables information sharing, benefits transportation and more. Somehow, openness started to benefit supply chain management recently, through a trend called “open innovation”. Based on gathered anecdotes and our interviews of industry professionals, we attempted to present a more complete picture of open innovation in supply chain management, including its potential benefits, major concerns, adoption hurdles, and future solutions. Our findings identified current perceptions of supply chain practitioners on open innovation and major hurdles and difficulties of implementing open innovation in supply chain functions other than just product development. Our research contributed to the current literature of open innovation by updating its implementation status, identifying adoption and implementation issues, and proposing strategic considerations within the context of supply chain management.

Keywords: open innovation; supply chain management; small and medium-sized enterprises.

1. Introduction

Innovation is at the core of competition for almost all businesses. Blackberry took over Motorola’s crown in the cell phone market with a full-keyboard device that could check/write emails and browse the Internet. But Blackberry’s very advantages of keyboards and business market focus soon turned into their own demise thanks to a newer and more innovative trend of smartphones, led by Apple’s iPhone and later Android phones to follow. Innovations succeed newer technologies while driving incumbent technologies obsolete. Comparative advantages created by innovations never stayed eternal. Business leaders endeavor to stay ahead of competition through innovation as this very word often brings in handsome profit margins, at least before the

innovativeness becomes stale. For instance, Reuter (2017) reported that an entry level iPhone X, not even at the peak of iPhone's innovativeness, still reaped a 64% gross margin for Apple. But where innovation comes from is always a challenge to business leaders. More interestingly, the concentration of an industry was found to be negatively correlated with the total number of innovation. In other words, almost half of innovations did not come from giant companies, but from the innumerable unknown small and medium sized enterprises (SMEs). A less concentrated industry populated with smaller businesses tends to favor the birth of innovations. A report by U.S. Small Business Administration (SBA) revealed that SMEs are surprisingly capable at inventing products and they are more innovative per dollar of R&D relative to large firms (Plehn-Dujowich 2013). The R&D investments for start-ups by the Small and Medium Business Administration of Korea increased by 33% in 2012, while the Ministry of Knowledge Economy allocated an estimate of 40% of its R&D budget to SMEs by 2015 (OECD, 2012).

SMEs and institutions external to giant corporations, such as university labs and freelancers, have become buzzing sources of new innovations. IBM Global CEO Study on innovation showed that 76% of 750 top CEOs worldwide believed that the key to innovation was external collaboration with business partners and customers (Rometty, 2007). Companies such as Dell, Fiat, General Mills, Kimberly-Clark, P&G, and Rolls-Royce regularly rely on external accesses for ideas, technologies, products, and processes (Bayus, 2013; Huston and Sakkab, 2006; Di Minin et al., 2010). A report by European Commission (2015) revealed a relatively strong growth in innovative SMEs collaboration with others and a decline in SMEs innovation in-house between 2007 and 2014. This clearly indicates that innovation coming from external sources, the so-called open innovation, has gained more attention among practitioners not only in large companies, but also in

SMEs nowadays. Strategically, business leaders are embracing the idea of “open innovation”: “the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation, respectively” (Chesbrough et al., 2006). The idea of open innovation received praise from various industries and scholarly research; it can help launch innovative products, reduce R&D costs, shorten product introduction cycle, and improve product quality (Ferreira and Peris-Ortiz, 2019).

Supply chain innovation is still relatively unfamiliar to many people as the field of supply chain management has not been at the epicenter of the hottest innovation trends. Most studies of open innovation pertinent to supply chains have been confined to the realm of early supplier involvement (Bidault et al. 1998) and collaborative product development. A supplier’s participation in the early stage of product development is proven to add values to better product development (Schiele et al., 2011; Brem and Schuster, 2012; Theyel, 2012; Ahn et al., 2015). But a supply chain is in charge of functions way beyond just product development. Supply chain management handles obtaining materials/parts from suppliers, manufacturing products, and delivering finished goods or services to customers. Improvements in supply chains can deliver results including better product design as well as time reduction, quality improvement, cost reduction in materials and parts, innovative/new manufacturing processes, changes in warehousing processes and supply chain networks, innovative/new packaging, new logistic routing, and many more. Open innovation in supply chain management possesses the potential to holistically improve procedural aspects of the overall supply chain, on top of existing applications on product developments.

Firms have already resorted to open innovation to improve supply chain processes. For example, a third-party logistics provider for LG Display proposed logistics improvement for the shipment from LG Display factory in Korea to its customers in Europe, which helped LG Display reduce delivery cost without noticeably increasing shipping time, and the vice president of DHL solutions and innovation division said to a reporter (Goh, 2017), “DHL knows that the logistics industry plays a significant role and we want to broaden our approach to City Logistics by also inviting people outside the company to contribute their perspective. With the views of others, we can better identify the challenges and generate ideas for new logistics solutions. We are asking participants to really think outside of the box.” As a result, DHL, the world’s leading international express shipping provider, was the first in its industry to launch an open innovation competition. The competition focused on “City Logistics,” the process whereby private companies optimise logistics and transport activities in urban areas while considering the traffic environment, traffic congestion, and energy consumption within the framework of a market economy. The contest invited businesses, academics, politicians, public authorities, and citizens to share ideas and recommendations for the implementation of sustainable logistics solutions in populated, urban areas.

This research studied open innovation from the perspective of overall supply chain benefits from open innovation within SMEs. We endeavored to understand:

- How open innovation has been implemented or adopted within the holistic supply chain system of SMEs, including but not limited to product developments?
- Where in a supply chain did SMEs most often employ open innovation?

- What were the factors that held SMEs back from adopting open innovation within supply chains?

We first conducted an extensive review of literature in order to identify potential answers to the questions above. Then, we were fortunate enough to interview seventy six Korean SMEs regarding their adoption of open innovation in supply chain management. Our results presented a most up-to-date picture of open innovation in supply chain management with both anecdotal evidence from literature and real business insights from our interviews. To the best of our knowledge, this is the first research which documented the most current status of open innovation adoption, application patterns, and its adoption hurdles in the field of supply chain management.

2. Literature Review

Open innovation is a new paradigm for management of innovation that emphasizes on the utilization of external know-how in the innovation process and the exploration of external paths for commercializing internal innovation (Chesbrough, 2012b). Since Chesbrough (2003) introduced this concept, open innovation has become a popular business strategy that helps firms develop new technologies, launch innovative products, reduce R&D cost, shorten product introduction cycle, and improve product quality (Laursen, 2006). With more implementation of open innovation in various industries, research in open innovation theory studies (e.g., Chesbrough 2003, 2007; Gassmann and Enkel 2004; Wang et al. 2012; Yun et al., 2016), open innovation case studies (e.g., Dittrich and Duysters, 2007; Chiaroni et al., 2010; Westergren and Holmström, 2012; Han and Cho, 2015), and open innovation empirical studies (e.g., van der Meer, 2007; Yeniyurt et al., 2014; Yoon et al., 2016) has increased substantially in the past decade (see reviews by West and Bogers, 2014; Greco et al., 2015; Love and Roper, 2015; Zimmermann et al., 2016).

Our study built upon current literature related to open innovation in supply chain management and implementation of open innovation in SMEs. Supply chain innovation has been well documented for the past decade. Zimmermann et al. (2016) concluded that abundant innovation could be observed in supply chain management, which was facilitated by environmental factors, such as trust-based relationship, information sharing mechanism, information systems integration, and technology compatibility. Suppliers turned out to be one of the main sources of innovation, in which suppliers worked as the potential idea providers or innovation initiators (Brem and Schuster 2012; Van Echtelt et al. 2008). Drawing from resource dependence and social capital theory as well as survey data from 207 manufacturing firms in Australia, Oke et al. (2013) found that innovativeness of supply chain partners enhanced innovation strategy, which in turn improved innovation performance. Innovative suppliers not only could provide businesses with leading-edge components, materials, and technologies to be integrated into the production process (Hoetker 2005), but also offered design suggestions or assumed complete responsibility for the design, engineering and development of new products (Henke and Zhang, 2010). Lau et al. (2010) emphasized that information sharing and product co-development with suppliers had a direct and positive impact on product innovation and performance, especially in the early stages of product development.

The implementation of open innovation in supply chain management has been mainly focused on early supplier involvement and collaborative product development. Early supplier involvement (ESI) is a type of supplier involvement at the manufacturer's an early stage in the product development or innovation process (Bidault et al. 1998). ESI can benefit a manufacturer by

reducing product development cycle times, improving product quality, making use of supplier technology expertise, and better managing cost, as summarized by Zsidisin and Smith (2005). Johnsen (2009) reviewed the empirical research into supplier involvement in new product development (NPD) and identified a series of factors that contribute to the success of supplier involvement in NPD. As Johnsen (2009) pointed out, few studies have considered the role of wider supply networks on innovation that aligns with the idea of open innovation. Collaborative product development (CPD) goes beyond ESI and helps a firm to reduce the costs and risks while increase efficiency and effectiveness in product development, to share expertise and know-how, and to even provide access to global markets (Bruce et al 1995, Büyüközkan and Arsenyan 2012). Nevertheless, the scope of both early supplier involvement and collaborative product development is generally restricted to product development stage, and hence is a subset of the scope of open innovation.

This study is designed to bring in more up-to-date information concerning open innovation implementation within supply chain management. More specifically, this study builds upon current cases and systemically structurizes how implementation of open innovation can benefit supply chain functions. To that end, we compiled a list of open innovation practices from previous literature and categorized them based on various supply chain functions affected by open innovation (see Table 1). From Table 1, it is clear that most of the previous application cases of open innovation in supply chains were from large corporations. Hence, our study supplemented existing literature by bringing in real cases of SMEs, and interviews we conducted in our study targeted SMEs, which was another differentiating yet rarely taken perspective in extant literature.

Table 1 Cases of supply chain functions influenced by open innovation (OI)

Supply chain functions	OI practitioners	Literature
Supplier R&D involvement	P&G Loncin	Huston and Sakkab (2006) Manyika et al. (2008)
Inventory management	Anonymous	Billington and Davidson (2013)
Distribution and logistics management	P&G and Clorox Kimberly-Clark DHL GE LG	Chesbrough and Schwartz (2007) Sloane (2011) Ulrich (2011) Chesbrough (2012a) This paper
Process and production innovation	P&G Dell GE TSMC Apple and AT&T Volkswagen and Porsche Samsung Goldcorp Hormel Foods	Chesbrough (2007) Gangi and Wasko (2009) Chesbrough (2012a) Chesbrough (2012b) Theyel (2012) Theyel (2012) Youn et al. (2012) Billington and Davidson (2013) Chesbrough and Di Minin (2014)
Supply chain technology and information management	Metro AG DHL Coca-Cola	Graczewski and Man (2006) Ulrich (2011) Massa and Testa (2017)
Operations strategy and cost management	IBM TopCoder TSMC Aurea Productiva	Chesbrough (2007) Manyika et al. (2008) Chesbrough (2012b) Hitchen et al. (2017)

Theoretical studies already documented open innovation in general operations of SMEs (Love and Roper, 2015). Open innovation was critical to many SMEs because of limited financial resources, little opportunities to recruit specialized workers, and lack of ability of spreading innovation-

related risks (Van de Vrande et al., 2009). Zeng et al. (2010) conducted surveys with 137 Chinese manufacturing SMEs and posited, based on structural equation modeling, that customer integration, supplier cooperation, and other inter-firm collaboration plays a more prominent role in SMEs' innovation process than horizontal cooperation with research institutions and government agencies. Inter-firm cooperation, in particular, has significantly greater positive impact on the innovation performance of SMEs than any other forms of cooperation. Similarly, adopting an empirical approach of a survey with 517 Korean SMEs and in depth analysis of 241 successful and unsuccessful open innovation projects, Yoon et al. (2016) found that open innovation benefited SMEs by allowing them to share innovation-related risks, to be more adaptive to market changes and technological advances, and thus to achieve long-run sustainability. However, they argued that open innovation in SMEs was hampered by numerous challenges, such as intellectual property management. Kim et al. (2016) concluded that government support programs have had a much more significant effect on service innovation of SMEs than large enterprises. Although there have been many studies assessing the impacts of openness of SMEs on R&D and innovation, very few studies investigated how supply chain functions of SMEs could benefit from open innovation. Our paper focuses more on the role of open innovation in the supply chain functions of SMEs. In this paper, we make a first attempt to evaluate the current status and recognition of open innovation in the supply chain of SMEs.

3. Open Innovation in Various Aspects of Supply Chains

In this section, we collected current research and anecdotes of how open innovation may work within supply chains. Our goal in this section was to establish a summary of current findings and cases regarding how open innovation in Supply Chains has worked.

3.1 Supplier R&D Involvement

Supplier R&D involvement has been one of the most studied applications of open innovation (Frishammar and Parida, 2019). One widely cited example, as illustrated in Huston and Sakkab (2006), was Procter & Gamble (P&G). The top 15 suppliers of P&G had a total of about 50,000 R&D staff, which could be an important source of P&G's innovation. To make the best use of such innovation source, P&G established a secure IT platform to facilitate the technology sharing between the company and its suppliers. A hypothetical scenario, mentioned in Huston and Sakkab (2006), was that if P&G wanted to make detergent perfume last longer after washing and drying, then the company could share this idea through its supplier network. It was very likely that one of P&G's chemical suppliers might already have a solution. Such joint innovations, also known as "cocreation" in P&G, worked in various ways: P&G shared its labs with suppliers' researchers, or P&G's researchers worked in suppliers' lab. Since the creation of supplier network in the early 2000s, P&G enjoyed a 30 percent increase in joint innovation projects. The case demonstrated that open innovation with suppliers improved supply chain relationships and utilized each company's capabilities to a greater extent.

3.2 Inventory Management

Although ample literature in supply chain management linked information sharing with higher performance in inventory management (Cachon and Fisher, 2000), few studies have evaluated the relationship between open innovation and inventory management. Billington and Davidson (2013) reported that one company in the electrical goods industry attempted to reduce its finished goods inventory by leveraging open innovation through intermediary network, which assisted the company in developing algorithmic methods to set safety stock levels. Many companies still took

a conservative attitude toward sharing inventory information with business partners or non-partners to achieve open innovation in inventory management.

3.3 Distribution and Logistics Management

With more logistics companies providing tailored solutions to their clients, open innovation in distribution and logistics management has become more beneficial than before. A case in point was LG Display. Semenza (2010) showed that the prices of TFT-LCD panels fell by a factor of 10 since 2000, due to larger substrates, higher throughput equipment, and the learning that comes from cumulative production. This stiff price reduction caused a plunge in the profit of LG Display business. In order to survive in such a harsh market environment, LG Display had to switch its transportation mode to ship from air for the shipments to Europe from Korea in the middle of 2000s to reduce its shipping costs by sacrificing shipping time. But, they found that the long shipping time created issues in meeting their production schedule of LCD panels. Knowing such a need for reducing a shipment time while still maintaining relatively low transportation cost, a logistics partner of LG Display proposed a logistics improvement for the shipment of LCD cells from an LG Display factory in Korea to its LCD panel manufacturing factory in Europe: instead of shipping them directly from Korea to Europe by air, they were first shipped to US by ship and then to Europe by air, which could reduce delivery time by a week, compared with the shipment time from Korea to Europe by ship.

3.4 Process and Production Innovation

Process and production innovation is well documented to have stronger positive impacts on business performance. Process and production innovation usually involves multiple firms along a

supply chain, which positions itself well beyond the limitation of firm boundaries, in comparison to product innovation. However, researchers rarely studied process/production innovation (Prajogo, 2006; Theyel, 2012), let alone open innovation in process and production. One example of achieving process open innovation was the co-development and co-production of Cayenne by Volkswagen and Porsche. The two companies not only designed vehicles cooperatively, but also were engaged in joint manufacturing. Based on its production experience, Volkswagen focused on producing vehicle components while Porsche contributed its expertise in automobile assembly to ensure that the final product met high quality standards. In this example, the benefits of such open innovation were twofold: first, open innovation opened the door for the implementation of just-in-time and lean manufacturing; second, it helped Cayenne to enhance the adaptation, flexibility and innovativeness of its production processes (Fear and Knoop, 2006; Theyel, 2012).

3.5 Supply Chain Technology and Information Management

Supply chain technology and information management not only can facilitate the coordination of different aspects of operations, but also allow companies to delegate innovation process to innovators outside firm boundaries. An interesting relevant case was the Future Store Initiative (FSI), led by METRO Group, one of the largest international retailers in the world. FSI, with an aim to redefine retailing for the 21st century, developed and tested new concepts and technologies for the retail industry (Graczewski and Man, 2006). The success of FSI relied on a network of 58 small- to large-scale partners. These partners were responsible for making everything needed to operate the Future Store. Despite the large number of partners, they all showed commitment to innovation in retailing and willingness to invest in the experiment. These partners involved themselves in RFID, trade technology (partners delivering a technology specific to retail), brands

(producers of consumer goods), IT technology and services, software and other services. The coordination and innovation around supply chain technology and information management enhanced the sharing of expertise and accelerated the implementation of new technology, allowing business to continuously grow and improve.

3.6 Operations Strategy and Cost Management

While innovation-related cost reduction has been one of the key drivers of implementing open innovation, our focus here is the impact of open innovation on the saving of operations cost. One example is Taiwan Semiconductor Manufacturing Corporation (TSMC), the world's largest semiconductor foundry, who manufactures semiconductor chips designed by the clients. Powered by its Open Innovation Platform, TSMC fabricated the designs onto silicon wafers efficiently, which saved TSMC's customers from investing in manufacturing plants (Chesbrough, 2012b). The Open Innovation Platform first combined the design and manufacturing services of TSMC's and those of third-party companies, and then tested them simultaneously. The purpose of the test by TSMC was to decide whether the chip would be manufactured properly once it went through the process. It could help avoid one of the very costly design steps in which the chip had to be redesigned for large-volume manufacturing. The Open Innovation Platform aided the customers of TSMC in shortening the time to market and in reducing design costs. The implementation of open innovation by TSMC not only facilitated the management of both internal and external design sources as well as the simplification of customer design process with a compatibility guarantee, but also helped TSMC implement its operations strategy and achieve its goal in cost management. Open innovation in this case strategically changed supply chain structure while offering all participating parties cost savings that were unattainable under traditional business models.

Figure 1 summarizes the supply chain functions where the above open innovations transpired.

Figure 1 Supply Chain Functions and Where Open Innovation Transpired

(§ number points to the subsection whose open innovation case occurred in the labelled supply chain function.)

4. Interview Results of Open Innovation in SME Supply Chains

Our review of extant cases attested to strategic and tactical benefits open innovation can bring to the world of supply chain management. Open innovation has touched almost every corner of a supply chain. Interestingly, most of these cases have been merely descriptive as observations of open innovation from the outside. Opinions and takeaways of those who initiated, led, managed, and evaluated projects of open innovation have been overlooked or insufficiently documented in extant cases. These opinions and takeaways will better reveal to us what managers currently think about the concept of open innovation, what they expect to gain from this concept, and what they are concerned about open innovation. Without candid and in-depth communications with

practicing managers, none of the questions above can be well answered. Thus, we decided to have interviews with the practicing managers to explain open innovation practices in the supply chain activities for their better understanding open innovation.

Another gap left unfilled by extant cases was the lack of documentation of open innovation practices within SMEs. The previous section equipped us with documented knowledge of open innovation in larger enterprises. Built upon this understanding, our interviews were designed to get into deeper discussions of open innovation with practicing managers of SMEs. Our findings brought in practical perspectives of open innovation by SMEs with added depth and width. Our coverage of Korean markets presented an international angle that has been rare in extant cases.

We were able to collaborate with a Korean government agency and approached Korean SMEs (less than 500 employees mainly from electrical, electronic, chemical manufacturing sectors) and services (mainly from software development firms), representing technology-intensive and collaboration-prone sectors that are more likely to adopt open innovation. The definition of SME varies by sectors in Korea (see, for example, page 319 of OECD, 2016). We conducted the interviews between May and October 2016 and successfully interviewed 76 Korean SMEs. We talked to managers at various different levels, with 71.1% top-level or middle-level managers, 15.8% low-level managers, and 13.2% researchers at different levels. Among the 76 SMEs in our database, 77.6% were in manufacturing (15.8% in electronics manufacturing, 13.2% in electrical manufacturing, 7.9% in chemical manufacturing, and 40.8% in other manufacturing industry) and 22.4% were in services (18.4% in software and 4.0% in other service industry). 36 firms (47.4%) had less than fifty employees, 28 firms (36.8%) had 50-249 employees, and 12 firms (15.8%) had

250-499 employees. Only 38 firms (50.0%) had actually implemented open innovation in the past three years, among which 28 firms reported little application and 10 firms reported moderate application. No firms had intensively applied open innovation in the last three years. Among the 38 firms that implemented open innovation, one firm claimed no benefits from open innovation while one firm claimed tremendous benefits from open innovation. The remaining firms believed that they gained either little benefits (39.5%) or some benefits (55.3%) from open innovation. Firms with no open innovation experiences (50% in our 76 sample) were asked whether they were aware of open innovation. 60.5% of the firms responded that they were and 39.5% responded that they were not.

Hurdles that have been holding firms back from adopting or more extensively using open innovation were a key part of our interviews. We asked firms in our sample questions about any difficulties or concerns they had in the process of considering or adopting open innovation:

- To those who hadn't adopted open innovation in the past three years, we asked them why they did not attempt to try open innovation.
- To those who adopted open innovation in the past three years, we asked them what difficulties they had when applying open innovation (questions adapted from Yoon et al. 2016).

Interview results were summarized in Figure 2.

Figure 2 Open Innovation Implementation: Concerns and Difficulties

For firms who didn't try open innovation in the past three years, the top three reasons were:

- Uncertainty in partner capability and reliability
- Operations policies and organizational cultures
- Unclear need or inadequate understanding of technology or partner options

Interestingly, risks related to intellectual property only ranked as the fourth highest reasons for not adopting open innovation.

Open innovation involves an external solution partner, where the partner's capability and reliability can be critical for the success of a project. For companies without long term partners,

the exact capacity of an open innovation partner that is new to the deal is essentially asymmetric information, where moral hazard or self-selection issues can be high hurdles for a sourcing company. Reliability not only includes product reliability within the realm of product quality, but also information truthfulness, long term financial reliability and even compliance issues for many industries. For instance, qualifying as a vendor to major companies, such as Samsung, takes a long and rigorous process. Involving external providers to the vendor's product may simply mean going through Samsung's vendor qualification process again.

The compliance concern also directly touches on a company's operations policies. Operations policies are developed to guide strategic and tactical levels of all operations, which inevitably governs external partners and outsourcing needs. Any procedural violations or concerns may make open innovation a taboo. Getting around an existing policy or the necessity to alter operations policies disturbs current operations procedures, which may carry unforeseeable risks. Some organizations and industries carry a long history of openness in technology development and sourcing, while others may not. Software industry has been built upon open source codes where financial industries, due to compliance concerns and traditional values, are less willing to source from outside. The threshold over which a firm may start to engage in open innovation is simply not the same over different industries or different businesses.

Unclear need or inadequate understanding of technology or partner options is another major issue our interviews identified. Many SMEs wanted to give open innovation a try, but they did not know what open innovation technology could be employed and where to find open innovation partners, the so called "I don't know what I don't know". We believe this issue generally challenges a SME

more than it does to a larger company. SMEs are often underdeveloped in its ability to keep track of technology offerings in the market. Owners of SMEs overwhelm themselves by daily errands of their businesses. Searching the market for potential technological solutions takes dedicated personnel, which to most of SMEs can be a luxury given their thinly stretched capacities. Similarly, sourcing the right vendor to offer open innovation solutions suffers from the same dilemma.

Risks related to intellectual property threatens any openness of processes. People would think this shall be one of the top concerns for adopting open innovation. Interestingly, risks associated with open innovation (e.g., intellectual property and other legal issues) were common barriers towards open innovation initiatives, but it did not make it to the top three obstacles. The three concerns discussed previously were more bothersome thoughts among our interviewees. Intellectual property concerns turned out to be an important but none vital obstacle. This contradicted the common belief that intellectual property issues shall be a top, if not the number one concern, for adopting open innovation. Some other concerns that scored very closely to risks related to intellectual property were legal issues and administration burdens.

For firms who adopted open innovation in the past three years, the top three difficulties were:

- Difficulties in communication regarding tech
- Additional time and cost for open innovation
- Uncertainty in partner capability and reliability

In sharp contrast to our results among those who did not adopt open innovation, opinions within firms already using open innovation were much more in agreement. The top three blue bars (reasons not to adopt open innovation) staggered with discernible length differences, while the top

three green bars (difficulties with adopting open innovation) were almost identical in length. All other difficulties fell far behind the top three reasons. Noticeably, risks related to intellectual property didn't even make it to the top five difficulties. This apparently showed that intellectual property concerns were much minor a concern once a firm got over the initial hurdle of open innovation adoption. Uncertainty in partner capability and reliability was the only common factor for both with open innovation and without open innovation firms. The other two factors for without open innovation firms dropped out of the top three difficulties for firms already adopted open innovation.

Open innovation includes external solution providers to deal with a specific issue within a sourcing firm. Once included, the provider would have to get to know the issue in greater detail. Passing screening and being selected as the provider didn't mean the provider already had adequate understanding of the issue or the demanded technological specificity. The sourcing firm would have to further disclose more information and communicate effectively with the provider. Our interviews revealed that this communication often got derailed or distracted by pre-assumptions. What the sourcing firm already knew for years would only be new to the solution provider. This often took lengthy communication before knowledge or information playground could be leveled between the two parties. On the other hand, the provider, running as a business, was more inclined to present a standard cookie-cutter solution as much as possible, for both cost and profit reasons. The provider took in a different story than what the real needs would be from the sourcing firm, again, thanks to the provider's own pre-assumptions. Then, technological details of the solution instinctive to the provider imposed a steep learning curve on the sourcing firm. Improvements in communication efficacy shall generate great benefits for open innovation adopters.

Additional time and cost for open innovation only came naturally with sourcing externally of a solution. Work procedures, knowledge backgrounds, previous experience, operations policies, and even software system differences etc. all challenged a firm to work with an open innovation provider. It might be surprising that uncertainty in partner capability and reliability ranked so high as top difficulties. A well-known theory in industrial organization economics is the idea of incomplete contract. No contract can achieve the goal of plugging all possible loopholes. Despite as thorough as possible initial screening, once things got started, the sourcing firm again got into another round of learning about its partner's capability and reliability. Discrepancy between reality and initial understanding often could not be avoided. Back to the same asymmetric information theory discussed above, the true type (the real capability and reliability in this case) of the solution provider got revealed through deeper interactions. What was only signaled (real capability and reliability) during the screening process became fully revealed. This constitutes a classic example of how asymmetric game with incomplete information plays out in reality. Similar to the concerns of those who didn't adopt open innovation, how information, such as need and technological specificities, can be better communicated before and after screening shall come to the core discussions of open innovation adoption.

Our interview results were encouraging for open innovation in that many SMEs not only believed in the concept, but they also saw many areas where open innovation could be applied. Figure 3 demonstrates how uniformly firms with and without open innovation initiatives viewed the concept.

Figure 3 Open Innovation in Supply Chain System: Experience and Perceived Areas of Implementation

The ranks of potential supply chain areas of open innovation application indicated by companies without OI implementation were almost identical to those by companies with OI experience as shown in Table 2.

Table 2 The ranks of potential areas of open innovation application in supply chain

Ranks	With OI	Without OI
R&D	1	1
Product Development	2	2
IT Management	3	3
Manufacturing Management	3	3
Distribution/Logistics Management	4	5
Inventory Management	4	5
Supplier Management	4	4

Ranks only diverged on distribution/logistics management and inventory management. Knowing our interviewing firms came from both manufacturing (77.6%) and services (22.4%) engaging in a wide array of different businesses, this level of uniformity was far from anticipated. We have several readings about the results. First, open innovation or not, firms differed in their reasons and difficulties, but they generally saw open innovation as a concept of value. All these SMEs clearly identified where the concept could be applied. There did not seem to be a lack of awareness or seem to be any confusion of the value of open innovation.

Second, SMEs revealed where they needed the most help through open innovation. They disclosed what had been deficient within their own organization, which propelled them to seek external assistance. R&D, thanks to its capital intensive and long-term return nature, often stayed out of reach for SMEs. They wanted to R&D help to upgrade their technological capabilities and escalate their businesses to a different level. This help apparently had to come from the outside, which enlisted open innovation as a conceivable source. Product development and IT management in many cases entailed some efforts in R&D. New product development and developing/implementing an IT system have basically involved engaging in something new and/or bringing in not-readily-available knowledge or capacities. SMEs' struggle along the lines of survival spared them not so much extra time or resources in product development or IT management. We believe open innovation possessed more potential to thrive in these areas.

Third, among all areas, direct supply chain functions ranked low for open innovation application. Nevertheless, firms that had experience of improving supply chain functions through open innovation evaluated such practices to be either very successful (40%) or somewhat successful

(60%). Furthermore, when asked to select the potential areas for open innovation application, respondents (whether or not they have implemented open innovation in the past three years) were more optimistic about achieving successful open innovation in supply chain systems, especially in information technology management and manufacturing management.

Fourth, we believe the uniformity could be a result of cross-referencing and access to similar influences. SMEs learned from similar sources that influenced them to think alike. For example, a conversation we had recently with an agricultural produce vendor was quite revealing. The CEO was discussing how he formulated his future strategies based on what he learned from other industry friends and common literature. When we brought in the ideas of a new capital structure and technology solutions, he was pleasantly surprised as our suggestions moved him out of his own “box” of thoughts. He is now working with us on openly sourcing solutions to implement his new strategies. Open innovation may be promising in many areas that are yet to be popular in current practices. We would encourage practitioners and researchers to look beyond the top three areas of applications. Shifting the attention to diverging areas, such as distribution/logistics and inventory, may be more fruitful. Future research may even want to look into unmentioned areas of existing literature.

5. Conclusion

Open innovation offers a management paradigm in which a firm can benefit from collaborative activities with external entities to achieve better innovation sustainability. Yet, the current status and recognition of open innovation in the supply chain of SMEs has been unclear in current literature. Concerns or difficulties with open innovation among practitioners, especially SME

practitioners, were less documented. How open innovation may be more promising along supply chains were almost unexplored.

This study reviewed and summarized existing cases of open innovation applications and supplemented the summary with our own interviews of 76 Korean SMEs in both manufacturing and service sectors to better understand the current status of applications. Current case studies revealed that, despite the lack of a relevant systematic study, the application of open innovation on supply chain systems has been observed and reported across a wide range of industries. Our study suggested a relatively high level of awareness of open innovation in SMEs, but a relatively low level of implementation of open innovation.

We further investigated adoption concerns and/or difficulties of open innovation. We found that communication was considered as one of the main difficulties during the implementation of open innovation but was not the major concern when deciding whether or not to adopt open innovation. Risks associated with open innovation, however, were common barriers towards open innovation initiatives but were not reported as the major obstacles during the implementation of open innovation.

Areas within a supply chain that possessed the greatest potential for supply chain management of SMEs were also identified through our interviews. Supply chain functions (e.g., inventory management, distribution/logistics management, manufacturing management, information technology management) were found to be less likely the target area for open innovation than areas

such as R&D or product development. Nonetheless, in general, many respondents believed that supply chain functions would be promising areas for the open innovation application.

This study contributes to the current literature of open innovation by examining to what extent open innovation has been embraced by SMEs, what concerns and difficulties the SMEs had with adopting or implementing open innovation, and what areas of a supply chain were perceived to be the most promising for the open innovation implementation. To the best of our knowledge, it is the first attempt to evaluate the current status and recognition of open innovation in the spectrum of supply chain functions of SMEs. Supply chain functions, such as inventory management, distribution/logistics management, manufacturing management, and information technology, were perceived as good potentials to benefit from open innovation. Our insights from interviewing Korean SMEs added a refreshing international perspective to existing studies.

In closing, this research is subject to a few limitations. First, the interview respondents were restricted to several industry sectors and, therefore, it may need a caution to generalize our findings to other industry sectors and regions. Also, the small sample size imposes another potential limitation. More analysis in other countries and industry sectors can further help validate this study. Second, we addressed the research questions by studying literature cases and conducting interviews. Interviews with managers and researchers at different levels could provide more meaningful implications regarding the practices of open innovation in the supply chain system. Third, this is the first attempt to evaluate the influence of open innovation on the supply chain functions and we limited our scope of investigation to SMEs. Thus, studying the large-scale enterprises can be an immediate extension. Fourth, in this study, firms were asked about their

experience in implementing open innovation to improve supply chain functions of inventory management, distribution/logistics management, manufacturing management, and information technology. Although these supply chain functions were the focus of this research, it would also be interesting to examine whether other supply chain functions can benefit from open innovation in a future study.

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