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Zhiyi Wang  
*National University of Singapore, Singapore, wangi@nus.edu.sg*

Lusi Yang  
*National University of Singapore, Singapore, yanglusi@comp.nus.edu.sg*

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WHEN SHOULD FIRMS BE “OPEN”? THE MODERATING ROLE OF IT COMPETENCY IN INTER-ORGANIZATIONAL OPEN INNOVATION COLLABORATION

Zhiyi Wang, Department of Information Systems, National University of Singapore, Singapore, wangzhiyi@nus.edu.sg
Lusi Yang, Department of Information Systems, National University of Singapore, Singapore, yanglusi@comp.nus.edu.sg

Abstract

Open innovation has gained momentum in recent years. Prior research has shown the critical role of openness in understanding the inter-organizational collaboration process. However, existing studies largely focus on search openness instead of the openness in actual collaboration. In addition, it remains unclear how the new emerged organizational competencies on information technology will shift the role of openness in collaboration. In this study, we investigate the role of collaboration openness in open innovation collaboration and explore the moderating role of information technology competencies. Drawing on the theory of inter-organizational relationship and resource-based view, we examine the conditions under which firms should be “open” in the actual collaboration. We develop hypotheses on network uncertainty, collaboration openness and open innovation performance. The model also incorporates the moderating effects of competitive IT capability and IT intensity. The proposed hypotheses will be tested using firm-level survey and objective data. We also discuss our research method and expected implications.

Keywords: Open Innovation, Openness, Uncertainty, Competitive IT Capability, IT Intensity.
1 INTRODUCTION

Open innovation has become a popular managerial practice in recent years. Only the internal work in terms of management and R&D is not sufficient to satisfy the expectations and requirements of firms. Firms become “open” to collaborate with others in the form of outsourcing, evolutionary search and open innovation. Among various practices of open strategies, open innovation has attracted salient attention because of its frequent failures in terms of management and inter-organizational collaboration (Lichtenthaler 2011). Compared with other strategies, open innovation requires firms to consider their partners more carefully and share more internal knowledge. And the objective of open innovation is usually acquisition of new ideas, patents and products with higher market expectation (Vanhaverbeke et al. 2008). Thus, firms need to internally guarantee the “open” spirit of employees and externally share and explore new knowledge (Lichtenthaler 2011; Wang & Hahn 2015). Since both the requirements and expectations of open innovation are higher than other open form strategies, difficulties and failures are common in its practice. Some academic attention has been garnered to the investigation of how to leverage open innovation practice effectively.

In this study, we focus on one specific type of open innovation practice – inter-organizational open innovation collaboration. This type of open innovation is usually enacted in the form of collaborative projects between firms (Cui et al. 2014). In prior research, the most frequently investigated aspect in open innovation is “openness”, which refers to how “open” the firms are in the open innovation process. Based upon the open innovation literature (Laursen & Salter 2006; Trott & Hartmann 2009), search openness, which is the effort in seeking different collaborators, is the key component of openness to be examined. It represents the extent of openness when firms search for new ideas/partners (Cui et al. 2014). However, open innovation projects deal with multiple dimensions involving not only the process of seeking partners but also firms’ engagement in collaboration process. There is a lack of understanding in previous literature about how the openness in actual collaboration play a role in the entire process. In knowledge intensive collaboration between firms such as open innovation projects, how the knowledge and resources are utilized and governed has significant implications on understanding inter-firm collaboration. In this study, we propose the concept of collaboration openness as the extent of knowledge and resource sharing in open innovation and investigate how it relates to various factors in open innovation projects. Therefore, our first research question is how collaboration openness is affected by environmental factors and how it affects open innovation project performance.

In addition to the role of openness in open innovation, how to utilize the organizational resources, especially information technology, to facilitate open innovation, is not well understood in previous literature. Even though organizations adapt their decision based on external environment to obtain expected outcomes (Suarez & Oliva 2005), information technology has provided the potential to shift their conditions and in turn leads to different outcomes. Traditional organizational implications may not be easily generalized when organizational competency of information technology is taken into account. However, even though IS literature has investigated the direct impact of various IT factors on organizational performance in a variety of context, it is still unclear how IT changes organizational decision context and process control (Yang & Hahn 2015). Such a lack of understanding is especially salient in knowledge intensive context such as R&D and innovation, which is closely related to the core competencies of organizations. In this study, we propose the moderating role of organizational IT competencies for the relationships around collaboration openness in open innovation. Thus, our second research question is how IT competencies shift the decision making and performance implication in open innovation.

To address the first research question, we examine two network environmental factors – firm-specific uncertainty and market uncertainty (Beckman et al. 2004), and two aspects of open innovation performance – outcome effectiveness and process efficiency (Pavlou & El Sawy 2006). Using the theory about inter-organizational network, we propose that firm-specific uncertainty will lead to low openness in collaboration, but market openness will drive firms to share more in open innovation. We also argue that collaboration openness is beneficial for final outcome but negatively affects the
collaboration process. These hypotheses create a tension for organizations to make decisions on the condition to be open in knowledge intensive collaboration.

Our second research question intends to understand the role of IT competency and resolve this tension. We focus on two factors that are relevant with the competency to use IT – competitive IT capability and IT intensity – which reflects the understanding of business by IT group (Bhatt et al. 2005) and the extent of deploying IT resources respectively (Chi et al. 2007). Based on the resource-based view, we propose that competitive IT capability enables firms to build inimitable resources and in turn moderates the relationship between uncertainty and collaboration openness. We also propose that IT intensity facilitates knowledge processing tasks and moderate the effects of collaboration openness on project performance.

Our data will be collected from firm-level surveys and a series of available databases. Survey items for measurement are developed by adapting existing items and by combining various sources. Partial Least Square (PLS) and Ordinary Least Square (OLS) will be performed in data analysis. Our study is expected to contribute to open innovation literature by examining the role of collaboration openness in organizational decision making and governance in open innovation process. We also contribute to IS literature on how IT competencies shift the organizational context and then moderate the relationships among uncertainty, collaboration openness and project performance.

2 THEORETICAL BACKGROUND

Open innovation has become a popular phenomenon that have been frequently examined in recent years. In a broad view, Chesbrough (2006) defined open innovation as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation”. This definition covers a series of open innovation business models including technological transaction, inter-firm collaboration, user innovation and technology licensing. Based on this definition, Lichtenhaler (2011) further conceptualized open innovation from two perspectives: in-bound open innovation and out-bound open innovation, which refer to external knowledge exploration (acquisition) and external knowledge exploitation (commercialization) respectively. In our research context, the inter-firm open innovation collaboration is the focal interest. Thus, a relatively narrow definition of open innovation in this context is adopted as “inter-firm collaboration to pool together technological resources to complement and supplement their innovation efforts” (Cui et al. 2014, p. 2). In this research context, firms interact with each other in the form of collaborative projects in idea search, R&D and new product development.

In open innovation research, one of the important factors often examined in the literature is openness (Laursen & Salter 2006). Whether the innovation process is open enough is a key success factor for open innovation project. However, openness is not a single dimension concept and it matters in various aspects. In previous research, search openness has been investigated in terms of the breadth and depth of search (Laursen & Salter 2006). It refers to the activeness and openness in seeking collaborators in open innovation. A firm with higher level of search openness will be more likely to consider different or unfamiliar firms to collaborate. In addition to openness of search, openness could also refer to the extent of knowledge sharing or resource investment during the collaboration. We term this type of openness as “collaboration openness” in the present study to differentiate with search openness. A firm with high level of collaboration openness will be more likely to share knowledge, technology and resources that are related to create new innovations (e.g., patent details or document of ongoing innovation) in the collaboration.

Besides the key factor (i.e. openness) of open innovation, the outcome of open innovation collaboration is also important in both research and practice. In our study context, the open innovation projects usually develop ideas (proposals) or products, so one of the dimension of the performance is the effectiveness of deliverables (Atuahene-Gima & Li 2004). Here we use “outcome effectiveness” to capture whether the outcome (e.g. idea, patent, knowledge and product) are effective or profitable for the firms. In addition, since the collaboration project is similar to an exchange (e.g., outsourcing), whether the process control is efficient is also an important dimension of performance. Thus, “process
**efficiency**” refers to the time, cost and coordination in the collaboration process. We examine the effects of collaboration openness on the two performance outcomes in our first research question.

In addition to related background in open innovation, in this study, we also investigate the role of IT in shaping organizational collaboration. We consider organizational IT competency, which refers to organization’s ability to use IT in their operations (Pérez-López & Alegre 2012). Among various competencies of utilizing IT, we identify two key competencies: competitive IT capability – the business knowledge of IT members (Bharadwaj 2000) and IT intensity – the extent of IT deployment within organization (Mahmood & Mann 1993). These two competencies capture not only the amount of IT invested in a firm but also the alignment between IT and business operation. The resource-based view suggests that these IT competencies could cultivate unique resources and facilitate knowledge management within firms (Mata et al. 1995). In the present study, we intend to explore the role of IT competencies in shifting organizational decision and governance context by proposing the moderating effects of these two IT attributes in open innovation process.

### 3 HYPOTHESES DEVELOPMENT

#### 3.1 Uncertainty and Openness

The theory of inter-organizational networks addresses how the inter-organizational relationships are formed in the environment. In a network, firms build connections and collaborations based upon uncertainty as well as their positions in the network. We examine the role of uncertainty to suggest the condition of “open”. Firms try to build ties like strategic alliance with other firms in response to uncertainty (Pfeffer & Salancik 2003; Thompson 1967). This is also the case for open innovation projects since firms want to acquire external knowledge from other firms to address the uncertainty. However, faced with different types of uncertainty, firms tend to adjust their strategies accordingly, which is likely to affect their openness in the collaboration process (Liu et al. 2015; Yang et al. 2015). We adopt the two types of uncertainty from Beckman et al. (2004): firm-specific uncertainty and market-based uncertainty. Firm-specific uncertainty refers to the uncertainty faced by an individual firm (e.g. entry, acquisition, turnover and technical uncertainty), while market uncertainty refers to the uncertainty by a set of firms in a network (e.g. demand uncertainty, competition, input cost uncertainty (McGrath 1997)) (Beckman et al. 2004).

When firm-specific uncertainty is high, firms should be more diversified since it is non-systematic risk for firms (Brealey et al. 2014). Through the diversification, firms acquire additional information and new knowledge through weak ties, and try to maintain legitimacy by signaling to new partners (Baum & Ingram 2002; Beckman et al. 2004). Thus, in open innovation collaboration, the way to benefit from diversification is to collaborate with a different firm or a new partner. By increasing search openness, firms will be more likely to initiate an open innovation project with a different or unfamiliar firm (Cui et al. 2014). However, such a propensity in collaboration usually leads to a low level of mutual trust and strong bargaining power between firms. Although firms may have the possibilities to access new knowledge, the extent of knowledge sharing would be undermined by such weak and distant collaboration ties. In addition, openness in the collaborative process (i.e. collaboration openness) is related to both knowledge sharing and external knowledge exploration. When a firm is facing specific uncertainty, although it wants to search harder to collaborate with distant firms, the main objective is to explore the new knowledge for solving its own problems instead of sharing internal resources. Firms may be reluctant to share their unique information when they have specific uncertainties since such openness will expose detailed problems to their partners and expand the uncertainty (Enkel et al. 2009). Thus, although it is possible that firms are more likely to conduct open innovation with diverse partners, we argue that firm-specific uncertainty has a negative impact on the openness in collaboration due to the lack of trust and objective of exploring new knowledge. Hence, we propose:

*Hypothesis 1a: Firm-specific uncertainty is negatively associated with collaboration openness.*
On the contrary, for market uncertainty, a set of firms face similar environment uncertainty which is difficult to control at firm level. In such context, exploitation is likely to be adopted to reduce uncertainty. It is often difficult for the set of firms to find other new partners because of the collective uncertainty in the environment. Thus, firms tend to rely on existing relationships and to interact with similar ones (Beckman et al. 2004; Larson 1992). Such a collaboration pattern, although may not enable firms to benefit from diverse and weak ties, could lead to strong collaboration ties with trust and reciprocity among firms (Yang 2015). The extent of knowledge sharing of a firm in collaboration is thus expected to be greater with such partners. In addition, when there is market uncertainty, firms do want to share more knowledge for collective problem solving and uncertainty reduction. Since the market risk is hard to be controlled by a single firm, firms would like to invest more knowledge and resources in the collaboration to reduce the uncertainty first (Yang & Mao 2014). They are less likely to worry about the exposure of uncertainty as the market uncertainty has been usually recognized publicly. Thus, they want to push the depth of collaboration in open innovation to come up with new ideas or products which could help them get rid of uncertainty. Hence, we propose:

*Hypothesis 1b: Market uncertainty is positively associated with collaboration openness.*

### 3.2 The Moderating Role of Competitive IT Capability

Competitive IT capability, as one of the IT capabilities proposed by Bhatt et al. (2005), refers to the extent to which IT employees understand the business process of the firm and are familiar with business managers. It goes beyond the IT usage and captures how IT units are aligned with the business units. This IT capability has been argued as an important source of competitive advantage of firms (Mata et al. 1995). It implies the trust and communication between IT group and business units, and it is difficult to be observed and imitated. Thus, it is regarded as an inimitable resource for building absorptive capacity and competitive advantage (Bhatt et al. 2005; Cohen & Levinthal 1990). We propose that competitive IT capability will shift the behavior of firms under different network uncertainty, thus moderating the relationship between uncertainty and collaboration openness.

When facing greater firm-specific uncertainty, firms would like to share less in open innovation collaboration. However, if a firm has relatively higher level of competitive IT capability, it facilitates the cultivation of competitive advantages that could not be easily imitated by other firms (Teece et al. 1997). Such IT-enabled competency creates more opportunities to assimilate new knowledge and transfer knowledge within the firm. It also helps them quickly understand what they need when facing uncertainty (Sambamurthty & Zmud 1997). Thus, the load of exploring new knowledge is mitigated by competitive IT capability, driving firms to focus more on improving the collaboration outcome instead of only seeking external knowledge. Then they will have more rooms to share their internal knowledge. In addition, firms with competitive IT capability are able to build trust, workflow and communication effectively between IT and business units, which can balance their concern from the firm-specific uncertainty (Peteraf 1993). With greater competitive IT capability, they are less likely to concern about the uncertainty and the exposure of uncertainty. Thus, their reduced intention to share internal knowledge will be mitigated by the capability. We propose:

*Hypothesis 2a: The negative effect of firm-specific uncertainty on collaboration openness will be mitigated with greater competitive IT capability.*

When firms face greater market uncertainty, their objective is not to explore new partners but to solve the problems. However, firms with higher competitive IT capability tend to possess competitive advantages in the network and are likely to be involved in seeking partners for reducing uncertainty. These firms have greater ability to integrate new resources through information technology and their own capabilities are less likely to be replicated by other firms (Teece et al. 1997). Such competitive IT capability enables firms to share a great amount of internal resources to their partners without losing existing advantages (Bhatt et al. 2005). Thus, based on the resource-based view, firms with such inimitable resources (i.e., competitive IT capability) will be able to share internal resources without concerning about their existing advantages (Makadok 2001). Hence, we propose:

*Hypothesis 2b: The positive effect of market uncertainty on collaboration openness will be strengthened with greater competitive IT capability.*
3.3 Openness and Performance

In this section, we focus on how openness affects open innovation performance. Specifically, we build hypotheses on collaboration openness to investigate the role of openness in actual collaboration. As aforementioned, the performance of open innovation project is characterized by two dimensions: outcome effectiveness and process efficiency. We then propose the relationship between collaboration openness and these two collaboration outcomes.

Collaboration openness is related to the extent of sharing knowledge and resources during collaboration. In the actual collaboration process in open innovation, firms share their knowledge and collaborative work on new ideas, products or patents. These knowledge and resources are usually internal documents or researchers. More investment of knowledge and resources sharing would accelerate knowledge recombination and promote new idea generation during the project. The project team will be able to search from more resources and create more innovative outcomes with more internal knowledge shared with partners (Cassiman & Veugelers 2006). The new innovations are also more likely to be economically successful and generate profits for firms, achieving the effectiveness of project final outcome (Williams & O’Reilly 1998). Thus, we propose:

*Hypothesis 3a: Collaboration openness is positively associated with outcome effectiveness.*

However, more resources shared in the projects will increase the requirement of resource assignment and governance. More strict contracts or coordination are required for the control of large set of unique knowledge and resources. It implies that collaboration openness may lead to difficulties in project management and process control (Harrison et al. 2002). In addition, more resources and knowledge invested in the projects implies that more time are needed to assimilate and recombine them. This may lead to longer project duration and higher governance cost. Moreover, firms need to individually care about whether sharing more will affect the uniqueness of their possessed knowledge, suggesting the necessity for firms to carefully control shared knowledge in collaboration. This may increase the potential or hidden cost in the collaboration project. Thus, different with outcome effectiveness, efficiency of collaboration process will be negatively affected by the additional governance load in collaboration due to more shared resources. We hypothesize:

*Hypothesis 3b: Collaboration openness is negatively associated with process efficiency.*

3.4 The Moderating Role of IT Intensity

IT intensity refers to the extent to which IT is invested, deployed and used in the firm (Boynton et al. 1994). It indicates whether a firm intensively invests resources and utilizes information technology in their operation and production (Ramamurthy & Premkumar 1995). Intensive IT in the firm is usually regarded as an important driver to facilitate organizational process such as search and learning (Bharadwaj 2000). It is more related to actual working context instead of business environment. Thus, organizational process for searching and governing knowledge will be affected by the penetration of information technology (Wang et al. 2016). We therefore propose that IT intensity of the firm will moderate the relationship between collaboration openness and open innovation performance.

As previously discussed, collaboration openness has a positive effect on outcome effectiveness. When IT intensity in the firm is greater, the firm will be more likely to use information technology in the collaboration process. Through the introduction of information technology, it is easier for firms to search for existing knowledge and explore new knowledge (Kane & Alavi 2007). Thus, the shared knowledge is better utilized and recombined with the help of IT. Greater IT intensity suggests that more IT employees, more equipment and better tools will be invested in the collaboration process, leading to effective knowledge assimilation and creation process. In addition, intensive IT usage will introduce effective tools in knowledge intensive works, helping the project team generate the final outcome with economic values (Chi et al. 2007). Taken together, IT intensity is able to make the shared knowledge better utilized for effective outcomes, strengthening the relationship between collaboration openness and outcome effectiveness. We propose:
Hypothesis 4a: The positive effect of collaboration openness on outcome effectiveness will be strengthened with greater IT intensity.

Contrary to outcome effectiveness, process efficiency is negatively affected by collaboration openness. However, with greater IT intensity, the collaboration process will be facilitated with the help of technology. The resources and knowledge shared in the project will be more clear and organized through the usage of project management tools and the involvement of technical members (Zahra & George 2002). The load of managing large-scaled resources will be mitigated with an intensive IT environment. It is thus expected that a lot of knowledge management work could be easily performed by information systems (Chi et al. 2007), significantly reducing time and governance cost in the project. Moreover, the usage of shared knowledge could be tracked by the project management systems, making firms less concerned about the unexpected leakage of their unique knowledge. Taken together, greater IT intensity will effectively reduce the cost in the process control, mitigating the negative effect of collaboration openness on process efficiency. We propose:

Hypothesis 4b: The negative effect of collaboration openness on process efficiency will be mitigated with greater IT intensity.

Figure 1 presents our research model. It covers our hypotheses on the role of collaboration openness and the moderating effects of IT competency.

4 RESEARCH DESIGN

To test our research model, we plan to collect both subjective and objective data from firms and related databases. The major data source is from organizational surveys. Firm-level surveys will be sent to science and technology firms in U.S. Firms who receive the questionnaires will be asked to select one recent open innovation collaboration project to answer some detailed information (e.g. time, size, duration, cost, etc.) and the questions to measure our constructs in model. We only focus on the focal firm surveyed in the sampling and investigate their behavior and project outcome. Thus, the unit of analysis is at firm (organization) level, although some variables are related to the collaboration dyad (they are captured from the focal firm perspective). Additional objective data come from a series data sources: stock market price data are used to construct alternative variables for uncertainty; data from InformationWeek are used to compliment IT intensity measures; data from COMPUSTAT and CrunchBase will be extracted to provide additional firm level performance and control variables; NBER patent data are referred as the output of innovation to verify open innovation project outcome and performance.
4.1 Variables

Uncertainty: Survey items on firm-specific uncertainty (5 items) and market uncertainty (4 items) are
developed based on Sawyerr et al. (2003) and Song and Montoya-Weiss (2001). In addition to survey
measures, as suggested by Beckman et al. (2004), uncertainties could be measured by stock market
price of firms. Firm-specific uncertainty is measured by the volatility of the firm’s stock market price
before the project, which is a proxy for uncertainty of focal firm. Market uncertainty is measured by
the mean monthly stock price volatility of all the firms in the same network (the network is defined by
a larger number of firms in similar domains than the respondent firms) before the reported project.

Collaboration Openness: Collaboration openness is measured through instruments from Lawson et
al. (2009) and Im and Rai (2008); (Lawson et al. 2009) about inter-organizational knowledge sharing.
We adapt their items and develop a 4 items construct.

Performance: Outcome effectiveness is measured by survey questions from the focal firm
perspective. We develop 4 items adapted from Pavlou and El Sawy (2006). Firm performance and
patent information after the project reported in the survey are also used for verifying this construct.
Measurement items of process efficiency are also adopted (4 items) from Pavlou and El Sawy (2006).

Competitive IT Capability and IT Intensity: Survey items of competitive IT capability are adapted
from Bhatt et al. (2005) (6 items measurement). IT intensity is measure using both survey item scale
questions (5 items) adapted from and Boynton et al. (1994) as well as objective indicators such as IT
expense, IT equipment and IT training suggested by Ranganathan et al. (2004).

Control Variables: Firm related variables including firm age, firm size, firm performance, R&D
investment (intensity) are included in survey and controlled in testing the hypotheses. In addition,
project specific characteristics including project size, project duration, project complexity, project
uncertainty, inter-firm dependence are controlled for hypotheses for project performance. Additional
data from professional firm level databases will provide richer information and verification on our
survey responses. These control variables and corresponding measures refer the variables used in
Laursen and Salter (2006) and Cui et al. (2014).

4.2 Analysis Approach

We will use Partial Least Square (PLS) to estimate the measurement model and test the hypotheses.
Common method bias will be tested using Harmon’s single factor approach (Podsakoff et al. 2003). In
terms of the limitations of PLS estimation and our usage of secondary data, we will also use OLS
regression to check the robustness of results. Variables will be aggregated by measurement items in
the regression analysis.

5 CONCLUSION REMARKS

This study examines the antecedents and consequences of openness in inter-organizational open
innovation collaboration and the moderating roles of competitive IT capability and IT intensity. The
role of openness is an important topic in the research stream of open innovation. Its different impacts
have been investigated in the literature. In this study, we propose the concept of collaboration
openness and emphasize its importance in open innovation. Based on theory of inter-organizational
relationship and resource-based view, we investigate the conditions under which organizations should
be “open” in open innovation projects. Our hypotheses suggest that firms will choose different level
of collaboration openness under different circumstances and collaboration openness has differential
impacts on project performance. We also propose that firm’s IT competency will reconcile these
tensions. Our hypotheses posit that competitive IT capability and IT intensity will moderate the
relationships among uncertainty, openness and performance. We expect this study contributes to the
literature of open innovation by examining firm’s decision about collaboration openness. We also
expect to contribute to IS literature on IT capability and intensity by investigating how these
competencies shift the relationships around collaboration openness from a resource-based view.
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