THE INFLUENCE OF INFORMATION AND COMMUNICATION TECHNOLOGY AND KNOWLEDGE SHARING ON BALANCED OPEN INNOVATION

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Abstract

Open innovation has recently attracted considerable attention in both academic and practical fields. The effects of information and communication technology (ICT) and in- and extra-role knowledge sharing (KS) on open innovation remain unknown. This study aims to fill this research gap. We believe that ICT application facilitates two types of KS that can enhance internal and external research and development (R&D). The balanced open innovation between internal and external R&D is believed to increase the innovation performance of a firm. We plan to collect data from employees in different firms and then analyse these data using multi-level structural equation modelling (MSEM). We expect that the analysis results will confirm our proposed research model and hypotheses.

Keywords: information and communication technology, knowledge sharing, in-role, extra-role, open innovation.

1 INTRODUCTION

Open innovation generally refers to the use of purposive inflows and outflows of knowledge to boost internal innovation and expand the markets for the external use of innovation (Chesbrough 2006). This approach is increasingly important in creating successful business strategies in a competitive, globalised world. However, Bogers (2011) indicated a paradox of open innovation between knowledge sharing and protection of research and development (R&D). Therefore, firms should not only focus on one type of R&D. Both internal and external R&D (sometimes called outsourced R&D) should be carried out to reach a balanced open innovation that we believe can increase the innovation performance.

Given the rapid development of information and communication technology (ICT), the role of such technology in the formation of balanced open innovation must be investigated. Specifically, we investigate how ICT-enabled knowledge sharing (KS) can enhance internal and external R&D. KS refers to the provision or receipt of task information, knowhow, and feedback regarding a product, service or procedure (Cummings 2004 p. 352). This concept has several taxonomies in literature. Explicit and implicit types of knowledge have been identified (Bock et al. 2005; Constant 1994; Lee 2001). Some studies have classified KS into contributing and collecting knowledge according to its direction (Chen & Hung 2010; Foss et al. 2009; He & Wei 2009), whereas other studies have investigated the quality and quantity of KS (Chiu et al. 2006; Wasko & Faraj 2005). These classifications have provided the foundation for KS research.

To understand further the effect of KS on organisational innovation, we must examine the KS concept from the organisational behaviour perspective. The new conceptualisation of in- and extra-role KS has been developed based on the organisational citizenship behaviour (Organ 1988; Smith et al. 1983). In-role KS is based on role requirements, job specification or organisation regulations, whereas extra-role KS goes beyond the above job requirements (e.g., people share more knowledge than required when necessary).

This study aims to investigate how ICT facilitates in- and extra-role KS and how the latters lead to balanced open innovation formation and performance. Based on the knowledge-based perspective (Cuervo-Cazurra & Un 2010), we posit that ICT application affects innovation performance through KS and balanced open innovation. ICT application enhances the in- and extra-role KS amongst firm employees and their partners, which in turn positively affects internal and external R&D. Further, in- and extra-role KS may influence internal and external R&D differentially. An open innovation with balanced internal and external R&D will enhance the new product introduction (NPI) performance. We also propose that ICT competence moderates the relationship between balanced open innovation and NPI performance.

This study is expected to contribute to the IS literature on open innovation. We adopt the organisation citizenship behaviour (Organ 1988; Smith et al. 1983) and knowledge-based perspective (Cuervo-Cazurra & Un 2010) to build the research model. We expect that the empirical confirmation will validate the application of such theories in the IS field. In addition, the unit of analysis of the research model covers both individual and firm levels. The multi-level analysis is also expected to contribute to cross-level research and provide managers with insights on how to leverage the ICT system to facilitate the sharing of knowledge for forming open innovation strategies.

2 LITERATURE REVIEW

2.1 In- and extra-role behaviour and knowledge sharing

Katz (1964) highlighted the distinction between extra- and in-role behaviour. These types of behaviour have been investigated in previous studies. For example, O'Reilly and Chatman (1986) performed a factor analysis with self-reported data to measure in-role performance. Other studies have

attempted to discover the dimensions of extra-role behaviour (also called organisational citizenship behaviour) (Organ 1988; Smith et al. 1983). Williams and Anderson (1991) used supervisor-reported data to distinguish extra-role activities from in-role activities and found that in-role behaviour positively affects extra-role behaviour.

The distinction between in-role and extra-role behaviour is well-accepted in organisational behaviour literature. Given that the sharing of knowledge beyond the required amount is considered an extra-role behaviour (Organ 1988; Smith et al. 1983), the sharing of required knowledge can be regarded as a type of in-role behaviour. Researchers have identified two types of information sharing behaviour amongst supply chain partners, namely, template-based and proactive information sharing (Du et al. 2012).

KS can affect group or organisational performance. For example, the sharing of task-relevant information amongst individuals may significantly improve the performance of such a group, especially the accuracy of its judgement (Henry 1995). Information sharing also has a mediating effect between functional diversity and unit performance (Bunderson & Sutcliffe 2002). Moreover, the willingness of team members to share information affects the KS within the team, which in turn significantly predicts their team performance (Lee et al. 2010). Other studies have confirmed that KS through information technology and transactive memory systems can enhance team performance (Choi et al. 2010). KS also influences factors at the firm level. For example, KS positively affects the success of cooperative outsourcing projects (Lee 2001). However, the relationship between KS, especially in- and extra-role KS, and balanced open innovation remains unclear, which needs to be investigated in this study.

2.2 Open innovation

Introduced over the recent decades, open innovation is a new strategy that concerns the development of internal and external innovation (Chesbrough 2006). This strategy is vital to create new ideas for the products and services of a company. Previously, firms only focus on internal R&D to enhance their performance by establishing new product lines or value-added features. However, Enkel et al. (2009) found that inter-organisational innovation collaboration was prevalent and suggested that those firms that refused to participate in such collaboration would suffer from serious competitive disadvantages. Terwiesch and Xu (2008) suggested that by applying open innovation, firms could enhance their innovation capacity by tapping into the network of knowledge that transcended organisational boundaries. Kirschbaum (2005) claimed that managers should promote open innovation as a critical factor of their firms to accelerate the development of a collaborative culture and mutual benefits. He also referred to open innovation as the practice of utilising innovative knowledge to create value.

Open innovation greatly benefits from KS behaviours that enhance the inter-unit cooperation, mutual learning, idea generation, and knowledge repository enrichment in firms (Zander & Sölvell 2000). Svetlik et al. (2007) found that the enjoyment of helping others, the self-efficacy of knowledge and the support from the top management were all crucial in KS processes, and that the willingness to donate and collect knowledge could enhance the innovation capability of firms from internal and external sources. Dyer and Nobeoka (2000) investigated the case of Toyota and found that creating a high-performance knowledge sharing network could facilitate the transfer of explicit and tacit knowledge and enhance firm innovation. Dodgson et al. (2006) also investigated the information technology, KS and innovation in P&G, a famous multinational corporation, and found that information technology had a crucial role in facilitating communications amongst stakeholders, suppliers and customers. The knowledge of the firm was then integrated into its innovation process, which was supported by an advanced information technology. Previous studies have provided a foundation for this study to investigate ICT, in- and extra-role KS and open innovation.

3 MODEL AND HYPOTHESES DEVELOPMENT

This study investigates the effects of ICT and KS (including in- and extra role) on the balanced open innovation. We believe that the ICT application of a firm enhances both the in- and extra-role KS amongst its employees and with its partners. Two types of KS are proposed to increase internal and external R&D. The balanced open innovation between internal and external R&D are believed to enhance NPI performance. The ICT competence is believed to moderate the relationship between the above relationship. The research model is shown in Figure 1, and the hypotheses are developed as follows.

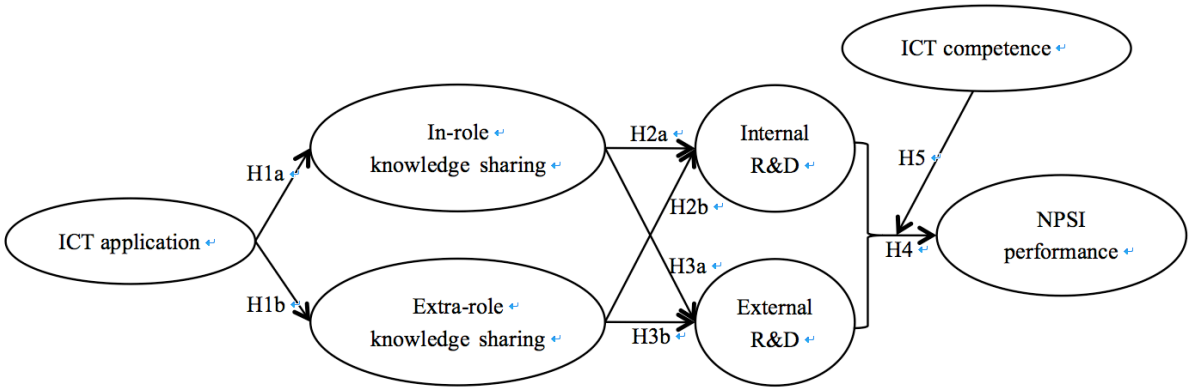

Figure 1. The research model

The ICT application in a firm is necessary for the horizontal integration of geographically dispersed operations, which will subsequently facilitate KS within the firm. Researchers argue that ICT application can enhance KS within the organisation and amongst its supply chain partners (Lee & Whang 2000). Supply chain management technology can be considered a form of information sharing support technology. Previous studies find that ERP systems can boost KS under simple business conditions (Welker et al. 2008) and generate a tremendous amount of information (Huang et al. 2004). The ICT-enabled knowledge base and management provide a foundation for both in- and extra-role KS amongst the members and partners of a firm.

ICT applications can also help firms create a climate that is conducive to KS with some shared vision. Community members with a shared language and vision are more likely to exchange information in online communities (Chiu et al. 2006). A shared vision with supply chain partners also influences information sharing (Li & Lin 2006). Previous studies find that a sense of partnership within the supply chain can promote template-based directly and proactive information sharing indirectly (Du et al. 2012). We believe that a favourable organisational culture facilitated by ICT will encourage employees to share knowledge in both in- and extra-role perspectives.

H1a: The ICT application of a firm positively affects its in-role KS.

H1b: The ICT application of a firm positively affects its extra-role KS.

In- and extra-role KS has key roles in innovative firms. In-role KS prepares the necessary knowledge base and cultivates an innovative atmosphere for internal R&D, whereas extra-role KS helps build trust and foster cooperation and innovation within a firm, which are crucial facilitators of internal R&D. People can also make creative suggestions or recommend innovative modifications even when they are not required to do so. The knowledge-based perspective indicates that the knowledge resources of a firm are positively associated with its R&D (Cuervo-Cazurra & Un 2010). In addition, both in- and extra-role KS can give employees an impression that their firms are supportive of KS and innovation. Previous studies also suggest that the perceived organisational support is positively related to employee innovation (Eisenberger et al. 1990). Therefore, we hypothesise the following:

H2a: The in-role KS of a firm positively affects its internal R&D.

H2b: The extra-role KS of a firm positively affects its internal R&D.

We also believe that in- and extra-role KS enhances external R&D. In-role KS reinforces the basic communications between the employees of a firm and its partners, which will provide access to diverse knowledge domains (Ahuja & Katila 2001). In-role KS provides the foundation for external R&D, while extra-role KS infuses more innovative ideas into the R&D process. The extra-role KS among firm employees or with firm partners is not limited by any rigid regulations. The concepts that are collected from extra-role KS tend to generate more ideas for innovation (Laursen & Salter 2006). In addition, a favourable KS helps build stable relationships amongst the employees of a firm and with its partners, thus motivating them to cooperate further in the outsourcing of innovative projects. Therefore, we hypothesise the following:

H3a: The in-role KS of a firm positively affects its external R&D.

H3b: The extra-role KS of a firm positively affects its external R&D.

In addition to the importance of internal R&D from the traditional perspective, R&D outsourcing, the major format of external R&D, has also been considered an important instrument of firm innovation (Grimpe & Kaiser 2010; Howells et al. 2008). Although recent studies on high-technology industries confirmed the positive relationship between R&D outsourcing and firm performance (Han & Bae 2014), Grimpe and Kaiser (2010) discovered a U-shaped relationship between the outsourcing and innovation performance of innovative German firms, indicating that the 'gains' from R&D outsourcing should be balanced with its 'pains.' However, internal and outsourced R&D are not mutually exclusive. Grimpe and Kaiser (2010) found that internal R&D had a complementary effect on outsourced R&D. Another study has reported that the absorptive capacity from internal R&D enables further offshore outsourcing, which in turn leads to more positive innovation outcomes (Bertrand & Mol 2013). A literature review shows that research on outsourced R&D is moving toward open innovation, which provides a more balanced view (Hsuan & Mahnke 2011). We believe that the balance between internal and outsourced R&D is important in ensuring innovation performance. Therefore, we hypothesise the following:

H4: The balanced open innovation between the internal and external R&D positively influences NPI performance.

The transfer from innovation strategy to NPI performance may be influenced by ICT competence, which is a core capability that is conferred by organisational information systems and cannot be easily imitated by others. The core competency in an enterprise resource planning system can magnify organisational benefits with better coordination and optimisation (Huang et al. 2004). Previous studies argue that the information system capability of a firm can moderate the relationship between coordination (internal and external) and market and supply-chain intelligence, which in turn influences new product development (Bendoly et al. 2012).

The effects of early supplier integration (Schiele 2010), customer empowerment (Fuchs & Schreier 2011) and consumer co-creation (Hoyer et al. 2010) on new product development have recently attracted considerable research attention. ICT competence can help maintain the link of an organisation with its suppliers and customers, which in turn will facilitate the development of new products and services. Therefore, ICT competence can also enhance the relationship between the balanced open innovation and NPI performance, which brings us to the following hypothesis:

H5: The ICT competence of a firm positively moderates the relationship between the balanced open innovation and NPI performance.

4 METHODOLOGY

4.1 Variable operationalisation

The measurements of the variables in this study are developed based on previous studies. These measurements comprise multiple statements with Likert scales ranging from '1' to '7' for each statement. Among the variables, in- and extra-role KS are designed at the individual level, whereas the other factors, including ICT application, internal and external R&D, ICT competence and NPI performance, are designed at the firm level.

The measures for in- and extra-role KS are developed based on the measures of template-based and proactive information sharing (Du et al. 2012), of which contexts is extended from 'to supply chain partners' to 'to colleagues, customers and suppliers.' We modify the wording of these measures according to the measures of organisational citizenship behaviour (Smith et al. 1983). Four items that address KS on the basis of role requirements, regulations, organisational expectations and avoiding problems are used to measure in-role KS, while another four items that address the readiness and willingness to share knowledge beyond what is required, eagerness to share new knowledge and volunteering to share knowledge to enhance job performance are used to measure extra-role KS.

The measure for *ICT application* is adapted from (Sher & Lee 2004). This variable is measured by asking whether the company has applied the following modules: employee competence databases, groupware for discussion, expert networks, case-based experience databases, email, document management, online knowledge search, data warehousing, online learning, work flow, decision support systems, enterprise portal sites, tele-conferencing, exogenous professional databases, enterprise resource planning, supply chain management, customer relationship management and other ICT. The percentage of ICT module application will be calculated to measure ICT application. Such a design is to synthetically reflect the extent to which a firm adopts different kinds of ICT application software.

The measures for *internal and external R&D* are both adapted from Cuervo–Cazurra and Un (2010). These measures include two dimensions, namely, the frequency and amount of R&D investment. The frequency of R&D investment is measured in five categories, namely, never, start, stop, vary and always. 'Never' means that the firm has zero R&D expenditures in all of the analysed years. 'Start' means that the firm has zero R&D expenditures in some years at the beginning of the analysed period, but has positive expenditures until the end of the period. 'Stop' indicates that the firm has positive R&D expenditures in some years at the beginning of the analysed period, but has zero expenditures until the end of the period. 'Vary' indicates that the firm has positive R&D expenditures in some years, but has zero expenditures in the other years. 'Always' indicates that the firm has positive R&D expenditures in all of the analysed years. The amount of R&D investment is measured by total R&D expenditures divided by sales and multiplied by 100. The *balanced open innovation* is measured by asking the participating managers to evaluate to what extent they believe that the balance between the internal and external R&D in their companies was achieved.

We measure *ICT competence* by following the measurement for IT capabilities in (Kim et al. 2011). Three dimensions, including ICT personnel expertise, ICT infrastructure support and ICT management capability, are used to measure ICT competence. ICT personnel expertise, which is measured by four items, refers to the level of professional skills or knowledge of ICT staff members. ICT infrastructure support, which is measured by three items, indicates the ability of the ICT infrastructure of a firm to support various system components. ICT management capability, which is measured by four items, refers to the ability of a firm to manage ICT resources to deliver business value.

To measure *NPI performance*, the respondents are asked to compare a typical new product with similar products that are manufactured and sold by their competitors. These products will be compared based on their functionality, features, durability, reliability, conformance quality, aesthetic appeal, customer perception, ease of servicing, unit price, unit cost of manufacturing, customisability

and rapid delivery ability. To make the measurement reliable, the comparison will be conducted between products with similar market size.

4.2 Instrument development and pre-test

A three-step questionnaire validation will be conducted. First, we will invite professors with expertise in the IS and operations management areas to check the questions that we have developed based on previous studies. We will then revise the questionnaire according to their comments. Second, we will ask a group of selected company managers to review the questionnaire, and we will then improve the quality and content validity of the questionnaire as required. Finally, we will administer a pilot test to 50 EMBA students to ensure the reliability of all variables based on their Cronbach's alpha values.

4.3 Data collection

We plan to collect data from 100 companies in Hong Kong, Beijing, Shanghai and Guangzhou. We will randomly select the participating companies from the Directory of the Chinese Manufacturers' Association of Hong Kong and the Yellow Pages of China Telecom in the three mainland cities. We will send a cover letter that outlines the objectives and potential contributions of our research to the selected companies. Each company will be asked to collect the data at the individual level from 10 employees and at the firm level from one operation manager. We will provide those companies with a summary of the results and a small participation incentive for each respondent that participate in either level of data collection. Follow-up telephone calls will be conducted to improve the response rate.

4.4 Data analysis procedure

The reliability of the variables will be checked by calculating their Cronbach's alpha values using SPSS. Their convergent and discriminant validity will then be assessed via confirmatory factor analysis. Multi-level structural equation modelling (MSEM) will then be applied to analyse the data to confirm the research model and hypotheses. Mplus will be used for testing the model.

Acknowledgement

The work described in this paper was supported by a grant from the Research Grants Council of the Hong Kong Special Administration Region, China (Project no, UGC/FDS15/B02/14) and a research grant from Hong Kong Shue Yan University, Hong Kong Special Administration Region, China (Project no, 12035C).

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