

THE IMPACTS OF OPEN INNOVATIONS ON ORGANIZATIONAL PERFORMANCE: A PERSPECTIVE BASED ON INFORMATION TECHNOLOGY AND KNOWLEDGE ECOLOGY

Completed Research Paper

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Abstract

Open innovation is a paradigm related to knowledge sourcing. It argues that firms should take advantage of both external and internal ideas for innovation in organizations. The purpose of this research is to investigate how different knowledge management strategies and IT capabilities may have effects on the implementation of open innovation and whether the adoption of open innovation may affect organizational performance. We have developed a research model and a questionnaire survey was conducted in Taiwan and Japan to collect matched-pair responses from 213 companies. Our research results indicate the following: (1) IT capabilities are found to have direct effects on open innovation; (2) Organizations with higher level of knowledge interaction and collaboration have higher level of open innovation implementation; (3) Higher level of open innovation leads to higher organizational performance; (4) Inbound open innovation and outbound open innovation have different effects on organizational performance in different economic contexts.

Keywords: Knowledge management, IT capability, Organizational performance, Open innovation

Introduction

Innovation is critical to the financial growth and the competitiveness of a company. The incredible success of Apple's iPhone and iPad has proven the great value of product innovation. The foundation for innovation is up-to-date knowledge and the ability to manage corporate knowledge effectively. As Drucker (1999) stated that knowledge would replace tangible assets, such as equipment, capital, material, or labor as the key production factor; knowledge workers are replacing traditional labor to become an important enabler of organizational value. As such, how to manage knowledge assets effectively has become a critical issue to organizations in the Internet age.

Recent trends in the rapid proliferation of information technologies (IT) and virtual communities on the Internet have changed the way knowledge can be managed and innovation can be created. In particular, more and more companies are taking advantage of the open platform available on the Internet. Previous studies have shown that knowledge management can help enhance the creativity of an organization, which in turn can improve the performance of the organization (Lee and Choi 2003). In the other, knowledge management can also increase the agility of the company (Peng et al. 2006; 2010).

Many models have been proposed to manage valuable organizational knowledge. Early research on knowledge management (KM) focused on the process of creating and sharing knowledge in organizations (e.g. Nonaka 1994, Davenport and Prusak 1998). A well-known model is the knowledge creation cycle proposed by Nonaka (1994), which suggests that knowledge creation activities include socialization, externalization, combination, and internalization. An organization should properly manage the process of knowledge creation, storage, retrieval, transfer, and applications through the use of IT (e.g., Markus 2001, Markus et al. 2002). Alavi and Leidner (2001) provided a nice review of the process view of knowledge management.

Another research line adopts the resource-based view that treats knowledge as organizational resources to investigate its effect on organizational capabilities and firm performance (Bharadwaj 2000; Gold et al. 2001). These studies have found significant impacts of KM activities on organizational creativity and firm performance. In addition to the process of knowledge management, the profile of knowledge in an organization called "knowledge ecology" plays an important role in leading to higher creativity and organizational performance. Here, knowledge ecology includes the distribution, interaction, collaboration/competition, and evolution of knowledge in an organization. It can be used to portray the status of knowledge in an organization (Chen et al. 2010). As KM is a continuous and dynamic process, understanding the patterns of knowledge variation and its driving forces may allow us to explore more about the mechanism of how an organization can dynamically manage its knowledge over time to enhance their performance.

A recent innovation paradigm related to knowledge sourcing is called open innovation, a concept proposed by Chesbrough (2003). It indicates that firms should take advantage of both external and internal ideas and knowledge sources for innovation. This is confirmed by the findings in Chen and Liang (2011) that different types of firms should adopt different knowledge evolution strategies. In knowledge ecology, however, what determines the agility and performance of an organization includes not only knowledge evolution strategies, but also other factors such as knowledge distribution and internal knowledge culture, interaction and collaboration among the employees. Therefore, it is valuable to examine how IT and knowledge ecological factors would have effects on open innovation and firm performance.

Toward this end, the purpose of this study is to investigate the role of open innovation in organizations. We intend to answer the following questions: (1) whether the adoption of open innovation can lead to better organizational performance? (2) whether knowledge ecology can lead to higher adoption of open innovation? and (3) whether IT capability can facilitate the adoption of open innovation? For this purpose, we have developed a research model to show the relationship between KM strategy, IT capability, open innovation, and organizational performance and conducted a questionnaire survey of 213 companies in Taiwan and Japan to empirically analyze our research model. The differences between different countries are also examined.

The remainder of this paper is organized as follows. Section 2 provides research background and review of

key literature. Section 3 explains our research model and hypotheses. Section 4 presents the result of quantitative data analysis and section 5 summarizes the conclusions of this research.

Theoretical Background

Major literature reviewed in this section includes open innovation, knowledge ecology, and IT capability in organizations.

Open Innovation as External-driven Evolution

Open innovation is a concept proposed by Henry Chesbrough. In his book, the concept is defined to include user innovation, cumulative innovation, know-how trading, mass innovation and distributed innovation. Firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology. The boundaries between a firm and its environment become more permeable; innovations can easily transfer inward and outward. The central idea behind open innovation is that in a world of widely distributed knowledge, companies cannot afford to rely entirely on their own research, but should instead buy or license processes or inventions (i.e. patents) from other companies. In addition, internal inventions not being used in a firm's business should be taken outside the company (e.g., through licensing, joint ventures, spin-offs) (Chesbrough 2003).

Open innovation includes insourcing of new ideas and technology from outside (called *inbound open innovation*) and outsourcing ideas and technology to outside organizations (called *outbound open innovation*). These two options have different implications, however. Inbound open innovation helps the organization to create products and services to the market, while outbound open innovation brings in financial resources or other benefits through helping other organizations develop new products or services.

The idea of open innovation is boosted by the recent trends in social networking and crowd wisdom that promotes the use of virtually unlimited knowledge sources on the Internet to develop valuable ideas in product design, research and development, customer services, and many others. As the traditional wisdom says "two heads are better than one," the more open an innovation system is, it is more likely that the system can perform better.

On the other hand, adopting open innovation is not without concerns (e.g., Turban et al. 2011). A particular issue is the cost involved in a large number of potentially low-quality ideas. In an open platform, ideas may come from participants with different levels of expertise and hence it is hard to assure the quality. Another key issue is the security and property right issue. Ideas and knowledge obtained from open platforms may not belong to the organization alone. It is often not copyrighted, nor patented. Based on the resource-based theory, organizations can better sustain their competitive advantages, if the knowledge is scarce and non-imitable (Barney 1991; Conner and Prahalad 1996). The knowledge obtained from open sources does not meet these guidelines. Therefore, whether to adopt open innovation and how to adopt open innovation are interesting issues for research.

Ecological View of Knowledge Management

Research in knowledge management can be traced to early work in the sociology of knowledge around the 1970's and technical work in knowledge-based expert systems in the 1980's (Berger and Luckmann 1967). In a review on knowledge management and knowledge management systems, Alavi and Leidner (2001) examine how KM has attracted significant attention in organizations, and consider previous KM research from a process view, including activities such as creation, storage, retrieval, transfer, and application of knowledge.

A quite different view was proposed recently to examine organizational knowledge from the ecological view (Chen et al. 2010). Ecology is a science used to analyze the relationship among members (species) of a community and their interaction with its environment. Traditionally, ecology is defined as "the scientific study on the interactions that determine the distribution and abundance of organisms" (Krebs 1978; McGlade 1999).

Knowledge ecology of an organization includes a combination of knowledge communities, organizational

resources, and external environment. Different types of knowledge owned by different divisions or employees are viewed as different knowledge communities (or populations). These knowledge communities build on top of organizational resources (including staff, process, structure, and culture) and maintain a balance with the external environment to maximize its interests through four ecological mechanisms: distribution, interaction, competition, and evolution, called the DICE model (Chen et al. 2010). Figure 1 illustrates the concept of knowledge ecology in an organization. Knowledge distribution portrays the snapshot of the knowledge community at a given time. It can be used to understand the static structure of knowledge community. Knowledge interaction conveys the information flow across different knowledge populations to support the penetration of knowledge flow. The interactions among knowledge populations are similar to knowledge sharing in traditional KM research. Due to the resource constraints in an organization, different knowledge populations will need to compete in order to grow. Different competition culture causes different behaviour of knowledge interactions. It can be collaborative or conflictive competition culture in an organization. Knowledge evolution provides a dynamic view of knowledge ecology. It is a strategy that a knowledge population uses to cope with the pressure of environmental variation. Knowledge evolution will lead in a new type of knowledge population and take effect on knowledge distribution. This ecological model of knowledge provides a comprehensive view to explore knowledge management in an organization.

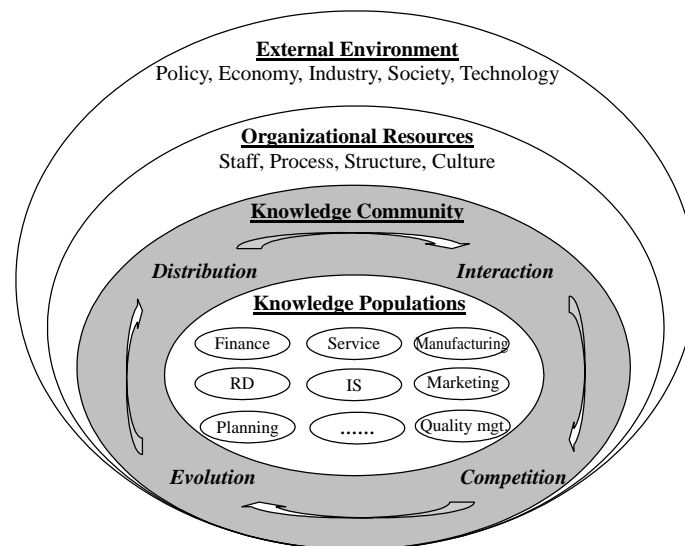


Figure 1. Conceptual Illustration of Knowledge Ecology in an Organization (Chen et al. 2010)

Information Technology in Organizations

As open innovation focuses on how organizations could enhance their innovation capability by interacting with other organizations, IT is often considered an important enabler. For example, Rai and Tand (2010) investigated the organizational IT capabilities by IT integration and IT reconfiguration, and organizational processes by alignment and flexibility. They found that IT capabilities could enhance organizational process capabilities, and lead to increasing competitive performance.

The effect of IT on firm performance has been proven in many published studies. A meta-research that aggregates previous findings has shown significant effects of IT on organizational capabilities, which in turn improves firm performance (Liang et al. 2010). In the theory of technology-mediated organizational change, IT is proven to be a facilitator of organizational change (Allen et al. 2013). The implementation of IT will cause the change of process, structure, and culture in an organization. In addition, the alignment between IS strategy and business strategy is proven to increase business performance. The effect varies across different IS strategies to result in enhancing the efficiency of business processes and interacting with external partners (Sabherwal and Chan 2001).

Research Model and Methodology

Research Model and Hypotheses

The focus of this research is to investigate how information technology and knowledge ecology may affect the adoption of open innovation and organizational performance. Hence, our research model includes four major categories of constructs: IT capability, KM strategy based on knowledge ecology, open innovation adoption, and organizational performance. Hence, we can build a research model, as shown in Figure 2.

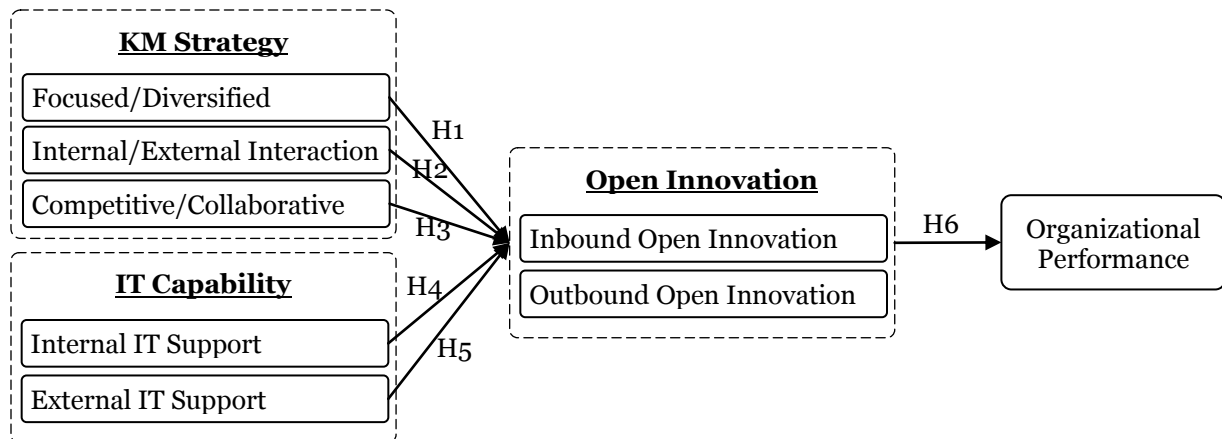


Figure 2. Research Model

The rationale of our research model is elaborated below. First, a critical enabler of open innovation in an organization is its knowledge management capabilities, because innovation activities are knowledge intensive (Alavi and Leidner 2001; Chesbrough 2003). Knowledge management activities are a type of organizational absorptive capability, which can identify, assimilate, and apply external knowledge resource to maintain the competitive advantage. It can also lead to organizational innovation and performance improvement (Roberts et al. 2012). Therefore, we put knowledge management strategy as a precursor of open innovation. We apply the concept of knowledge ecology to portray the knowledge management profile of an organization, which includes knowledge distribution (focused vs. diversified strategies), knowledge interaction (internal vs. external strategies) and knowledge competition (competitive vs. collaborative strategies).

As described in previous section, open innovation has two types: inbound and outbound. Inbound open innovation stands for bringing knowledge and innovative ideas from outside, while outbound innovation stands for licensing internal knowledge and creative ideas to external partners (Gassmann and Enkel 2004; Herstad et al. 2008). The following research hypotheses are posited.

- H1: Higher knowledge diversity can lead to higher level of inbound (H1.1) and outbound (H1.2) open innovation.
- H2: Higher knowledge external interaction can lead to higher level of inbound (H2.1) and outbound (H2.2) open innovation.
- H3: Higher knowledge collaboration can lead to higher level of inbound (H3.1) and outbound (H3.2) open innovation.

The second enabler is IT capabilities. A substantial amount of existing literature has indicated that IT capabilities are important facilitators to organizational processes (e.g., Rai and Tand 2010). From the perspective of technology-mediated organizational change, information technologies/systems can lead to the change of social structure, culture, and performance in an organization (Allen et al. 2013). The perspective was proposed by Volkoff et al. (2007), who argued that IT implemented in an organization will lead to organizational changes through structural conditioning, social interaction, and structural

elaboration/reproduction. Organizational IT can also be used to support organizational learning that would lead to better innovation, higher performance, and more organizational change (Kane and Alavi 2007). Since organizational innovations emerge along with the organizational change, based on the theory of technology-mediated organizational change, we can assume that IT capability will lead to organizational change and adoption of open innovation.

Organizational IT can be divided into two categories in existing literature: internal business support IT and external business support IT (Sabherwal and Chan 2001). They may have different effects on organizational innovation. Hence, we hypothesize internal and external IT capabilities to be two enablers of open innovation.

H4: The internal IT support strategy can facilitate inbound (H4.1) and outbound (H4.2) open innovation in an organization.

H5: The external IT support strategy can facilitate inbound (H5.1) and outbound (H5.2) open innovation in an organization.

Finally, open innovation adoption is assumed to affect organizational performance (Chesbrough 2003). Because the most immediate impact of innovation is on organizational research and development, we use the research and development (R&D) performance to represent the organizational performance in this study (Kusunoki et al. 1998).

H6: The adoption of inbound (H6.1) and outbound (H6.2) open innovation will lead to better organizational performance.

Operational Definitions of Research Constructs

The constructs defined previously are operationalized for the empirical study, and the measurements as described below. All the items are measured on a Likert's 7-point scale.

Knowledge Management Strategy

Three constructs were chosen to measure the KM strategy of an organization (Chen et al. 2010). First, we measure knowledge distribution in an organization. It represents whether the knowledge management profile of an organization is focused or diversified. Higher knowledge diversity means higher knowledge richness and complexity. We measure whether an organization spends its resource on a relatively narrow knowledge domain or a variety of different knowledge areas. We also measure whether key knowledge is stored and maintained in a few divisions or distributed in many divisions. Measurements of this construct include: (1) How many departments in your company have carried out document management mechanisms? (2) How many departments in your company have applied information technology to manage the documents? (3) How many departments in your company have carried out knowledge management mechanisms? (4) How many departments in your company have attached importance to acquiring new knowledge? (5) How many departments in your company have esteemed knowledge assets as the source of competitive capabilities? (6) Overall, every department in your company attaches importance to the knowledge assets and carries out knowledge management. (7) Overall, every department in your company has paid the same attention to knowledge management.

Second, we measure the degree of external knowledge interaction. This construct measures whether major knowledge is developed internally or obtained from outside sources. Four items were used to measure this construct: (1) How frequent does your company share/interchange its knowledge with other research institutes? (2) How frequent does your company share/interchange its knowledge with other collaborative companies in the supply chain? (3) How frequent does the members in your company share/interchange their knowledge with other experts outside? (4) Overall, our company has interacted with other organizations frequently and got lots of valuable knowledge from outside.

Third, we measure the level of knowledge collaboration in an organization. This construct assesses whether the general knowledge management culture is collaborative (i.e., people are more willing to share and help each other) or competitive. We used seven items for measuring this construct: (1) How about the knowledge sharing situation among the members in your organization? (2) How about the knowledge

sharing experience among the members in your organization? (3) How about the effects of knowledge sharing among the members on problem solving in your organization? (4) How about the standpoint of your organization that the members ask for others' help when it is necessary? (5) How about the standpoint of the members in your organization that problem solving is achieved by knowledge sharing? (6) Overall, all the members in your organization are pleased to share knowledge with others. (7) Overall, the culture of your organization encourages the members to cooperate with others.

Information Technology Capability

In this research, information technology/information system (IT/IS) capabilities are a major construct that we expect to have significant influences on open innovation adoption. The IT capabilities were measured by IT applications at different levels of organizational functions, including internal business support and external business support. The internal support IT was measured by six items (Sabherwal and Chan 2001). They are: (1) Our IS improve the efficiency of our day-to-day business operations. (2) Our IS support effective coordination across functions (e.g., marketing, manufacturing) and product lines. (3) Our IS provide us with the facts and figures we need to support our day-to-day decision making. (4) Our IS enable us to develop detailed analyses of our present business situation. (5) Our IS provide sufficiently detailed information to support prudent decision making. (6) Our IS support detailed analyses of major business decisions.

The external support IT was assessed by three items (Rai and Tang 2010). They are: (1) Our platform provides seamless connection between our suppliers' systems and our systems (e.g., forecasting, production, manufacturing, shipment, etc.). (2) Our platform has the capability to exchange real time information with our suppliers. (3) Our platform easily aggregates relevant information from our suppliers' databases.

Open Innovation

This construct measures the level of open innovation adoption in an organization. Two different types of open innovation are defined: inbound open innovation and outbound open innovation. The inbound open innovation indicates the inflow of innovative ideas and knowledge from external bodies, while the outbound one is the outflow of an organization's innovative ideas and knowledge to external bodies (Gassmann and Enkel 2004; Herstad et al. 2008). The inbound open innovation was measured by five items. They are: (1) Due to the globalization, it is easy to access international innovative resource in your company. (2) The external innovative resource is attached importance in your company. (3) It is aggressive in your company to acquire the external innovative resource. (4) It is aggressive in your company to acquire new advanced machineries/equipment to improve the quality of products/service significantly. (5) It is aggressive in your company to purchase or license patents, inventions, and any other type of knowledge from other organizations. The outbound open innovation was assessed by six measurements, including: (1) Our company would provide innovation suggestions to other collaborative organizations. (2) Our company would cooperate with other organizations to develop new products or service. (3) Our company would cooperate with other suppliers to develop new products or service. (4) Our company would cooperate with other research institutes to develop new products or service. (5) Our company would cooperate with other universities to develop new products or service. (6) Our company would cooperate with customers or consumers to develop new products or service.

Organizational Performance

Organizational performance is the outcome of an organization's operations. In this research, we measure the research and development performance to stand for the organizational performance (Kusunoki et al. 1998). We applied five items for this construct: (1) The efficiency of R&D investment of our firm is much better than the competitors. (2) The transfer from R&D to production of our firm is much better than the competitors. (3) The commercialization of R&D of our firm is much better than the competitors. (4) The production cost of similar products of our firm is much lower than the competitors. (5) The improving capability of products of our firms is much better than the competitors.

Data Analysis

Data Collection and Analysis Method

We hired two professional marketing research companies to conduct the questionnaire survey in Taiwan and Japan. Our survey included 8 latent constructs and 43 measurement items. Questionnaires in Chinese and Japanese were distributed in respective countries. To avoid the common method bias, we collected two independent responses from each company. Their averages were used to represent the sample company. The Taiwanese data were collected by the Trendgo research Co., Ltd, and the Japanese data were collected by the NTT Resonant, Inc. The resulting effective sample includes 93 companies in Taiwan, and 120 companies in Japan.

The data were analyzed by partial least square (PLS) analysis due to inadequate sample sizes for covariance based structural equation modeling (SEM). Barrett (2007) suggested SEM should have at least 200 samples, and the sample size less than 100 is untenable (Kline 2011). Mitchell (1993) also suggested the number of samples should be 10 to 20 times of the measurements in SEM analysis. Since our sample size did not meet the requirements for covariance-based SEM, we chose to use SmartPLS, a PLS software to analyze our data (Ringle et al. 2005). PLS was chosen because it has minimal restrictions on the measurement scales, sample size and residual distribution (Chin and Newsted 1999) and is a popular tool for model analysis in information systems and other business areas. We used PLS to evaluate the measurement model for reliability and validity first, and analyze the structural relationships among the constructs to test research hypotheses. The collected data are analyzed at two different levels: one is the overall level and the other is at the country level.

Analysis Results of All Data

The reliability was examined by composite reliability values with the acceptance threshold being 0.7. Convergent validity was evaluated by the average variance extracted (AVE). The AVE of each research construct should exceed 0.5 (Fornell and Larcker 1981). Discriminant validity was evaluated by two tests. First, the correlations among the constructs are all below the 0.85 threshold (Kline 2011). Second, the square root of the AVE of a construct is larger than the correlations between the construct and other constructs (Fornell and Larcker 1981).

Tables 1 and 2 show the reliability and validity analysis results of the overall data. It indicates that our data pass the commonly used criteria for evaluating data reliability and validity, which means the collected data are in good quality for estimating the model.

Table 1. Survey Quality Criteria of All Data

	AVE	Composite Reliability	R Square	Cronbach's Alpha	Communality	Redundancy
Knowledge Diversity	0.762	0.957		0.948	0.762	
Knowledge Interaction	0.761	0.927		0.895	0.761	
Knowledge Collaboration	0.791	0.964		0.956	0.791	
Internal IT Support	0.873	0.976		0.971	0.873	
External IT Support	0.932	0.976		0.963	0.932	
Inbound Open Innovation	0.841	0.963	0.731	0.952	0.841	0.111
Outbound Open Innovation	0.792	0.958	0.686	0.947	0.792	0.315
Organizational Performance	0.843	0.964	0.696	0.953	0.843	0.460

Table 2. Latent Variable Correlations of All Data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Knowledge Diversity (1)	0.873							
Knowledge Interaction (2)	0.712	0.872						
Knowledge Collaboration (3)	0.667	0.672	0.889					
Internal IT Support (4)	0.615	0.653	0.681	0.934				
External IT Support (5)	0.500	0.567	0.551	0.752	0.965			
Inbound Open Innovation (6)	0.624	0.706	0.742	0.792	0.669	0.917		
Outbound Open Innovation (7)	0.575	0.698	0.669	0.723	0.730	0.821	0.890	
Organizational Performance (8)	0.560	0.671	0.687	0.743	0.659	0.804	0.786	0.918

Note: The values on the diagonal are the square root of AVEs.

In our PLS analysis, the significance of the structural paths was assessed by 500 bootstrap runs. The path analysis results are presented in Table 3 and the path diagram is shown in Figure 3. In Figure 3, the solid lines indicate significant relationship that have t-statistics larger than 1.96. The number on the solid line is path coefficient that indicates the magnitude of direct influences of predictors on the predicted constructs. Dashed lines mean insignificant correlation in the PLS analysis.

Table 3. Path Analysis Results (Mean, STDEV, t-Values)

	Research Hypothesis	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	t-statistics (O/STERR)
H1.1	Knowledge Diversity → Inbound Open Innovation	-0.001	-0.001	0.059	0.059	0.018
H1.2	Knowledge Diversity → Outbound Open Innovation	-0.032	-0.028	0.075	0.075	0.427
H2.1	Knowledge Interaction → Inbound Open Innovation	0.203	0.202	0.061	0.061	3.325
H2.2	Knowledge Interaction → Outbound Open Innovation	0.286	0.285	0.062	0.062	4.617
H3.1	Knowledge Collaboration → Inbound Open Innovation	0.283	0.280	0.064	0.064	4.413
H3.2	Knowledge Collaboration → Outbound Open Innovation	0.196	0.192	0.067	0.067	2.917
H4.1	Internal IT Support → Inbound Open Innovation	0.387	0.387	0.073	0.073	5.336
H4.2	Internal IT Support → Outbound Open Innovation	0.150	0.149	0.064	0.064	2.349
H5.1	External IT Support → Inbound Open Innovation	0.107	0.110	0.054	0.054	1.986
H5.2	External IT Support → Outbound Open Innovation	0.363	0.367	0.058	0.058	6.251
H6.1	Inbound Open Innovation → Organizational Performance	0.487	0.483	0.065	0.065	7.449
H6.2	Outbound Open Innovation → Organizational Performance	0.387	0.391	0.065	0.065	5.955

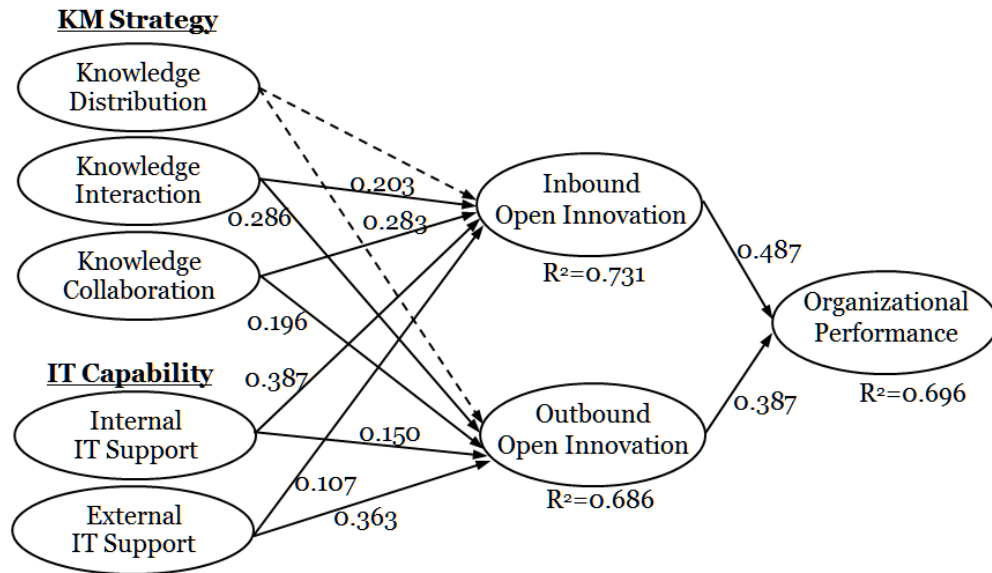


Figure 3. Path Analysis Results of All Data

As we can see that most hypotheses are supported by the result, except H1.1 and H1.2. The paths in Figure 3 indicate that: (1) knowledge interaction and knowledge collaboration have positive effects on open innovations, (2) both internal and external IT support can facilitate the adoption level of open innovation, and (3) higher level of open innovation leads to better organizational performance. Especially, the inbound open innovation is more important than the outbound one. This result has confirmed our understanding about the importance of open innovation in today's business operation.

Country Difference Between Taiwan and Japan

Organizational innovation may differ in different countries due to different social and economic contexts. The national innovative capacity is a factor used to represent a country's ability to produce and commercialize a stream of innovations (Furman et al. 2002). It contains both political and economic entity, and can be used to portray the difference among countries' innovative potentials. Different countries with dissimilar economic contexts could have different levels of national innovative capacity (Porter and Stern 2001). Therefore, we further examine whether country difference exists in the adoption of open innovation. Similar analysis was applied to Taiwanese and Japanese companies separately. The reliability and validity test results of Taiwan and Japan met commonly used criteria (due to page limitations, the results are excluded in the paper.) After the same procedures for structural modeling, their resulting models are shown in Figure 4 and 5.

Because different levels of economic maturity affect business strategy (Porter and Stern 2001); it is interesting to investigate the effect of economic maturity in our research model. We compare the path coefficients of the two models. The statistics for the test were computed using the following equation (Keil et al., 2000). The result of path coefficient comparisons is shown in Table 4.

$$S_{pooled} = \sqrt{\left\{ \left[\frac{(N_1 - 1)}{(N_1 + N_2 - 2)} \right] \times SE_1^2 + \left[\frac{(N_2 - 1)}{(N_1 + N_2 - 2)} \right] \times SE_2^2 \right\}}$$

$$t = (PC_1 - PC_2) / \left[S_{pooled} \times \sqrt{\left(\frac{1}{N_1} + \frac{1}{N_2} \right)} \right]$$

where Spooled = pooled estimator for the variance

t = t-statistic with $N_1 + N_2 - 2$ degrees of freedom

N_i = sample size of dataset for culture

SE_i = standard error of path in structural model of culture i

PC_i = path coefficient in structural model of culture i

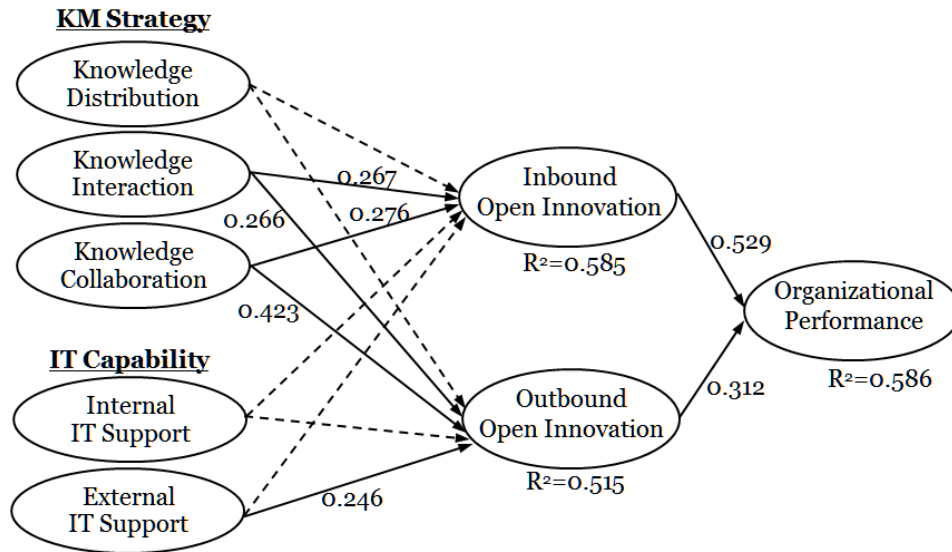


Figure 4. Path Analysis Results of Taiwanese Companies

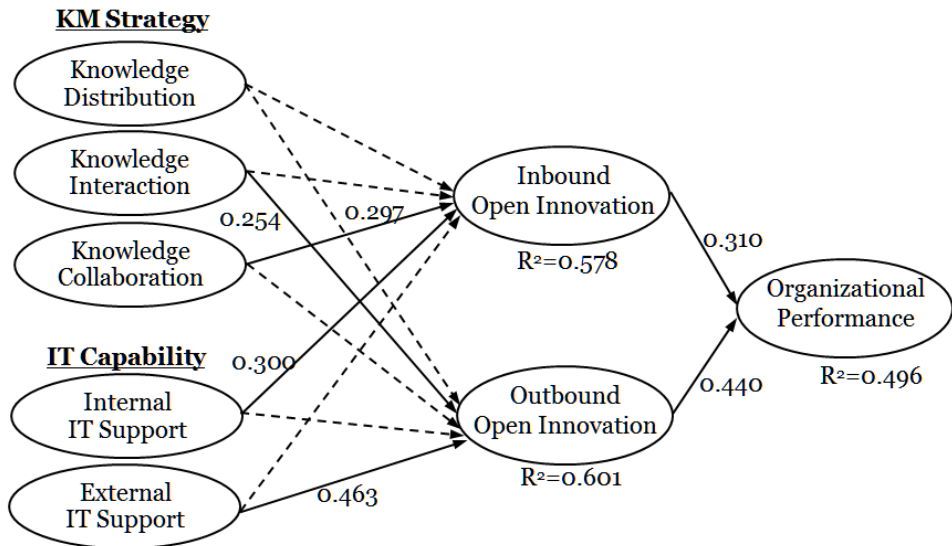


Figure 5. Path Analysis Results of Japanese Companies

Table 4. Path Coefficient Comparison Results between Taiwan and Japan

Hypothesis	Path Coefficient of Taiwan (A)	Path Coefficient of Japan (B)	A-B	t value
H1.1	0.14	0.031	0.109	7.212
H1.2	-0.008	0.025	-0.033	-1.873
H2.1	0.267	0.157	0.11	8.493
H2.2	0.266	0.254	0.012	0.864
H3.1	0.276	0.297	-0.021	-1.540
H3.2	0.423	0.073	0.35	22.695
H4.1	0.209	0.3	-0.091	-5.829
H4.2	-0.056	0.115	-0.171	-13.174
H5.1	0.041	0.151	-0.11	-9.118
H5.2	0.246	0.463	-0.217	-20.833
H6.1	0.529	0.31	0.219	17.308
H6.2	0.312	0.44	-0.128	-10.597

As shown in Table 4, most effect sizes differ significantly, except paths H1.2, H2.2, and H3.1. This indicates that the country effect did exist. Different organizational cultures between Taiwan and Japan had moderated the relationships between KM strategies and open innovations. This is consistent with the observation that the cultural context of different countries is a critical issue to carry out knowledge management strategies (Glisby and Holden 2003). Therefore, in pursuing the success of knowledge management, organizational cultures in different countries should be considered.

The effect of economic maturity is also confirmed, which is consistent with the argument in Porter and Stern (2001). In the World Economic Outlook proposed by IMF (International Monetary Fund)¹ in 2012, Japan has better development of economy than Taiwan. The GDP of Japan is much higher than Taiwan. The comparison results between two countries can be used to explain the different open innovation adoption strategy in different level of economic maturity. The higher economic maturity the country is (i.e. Japan), the firms in the country get more benefits from outbound open innovation (H6.2). For firms in lower development country (i.e. Taiwan), the inbound open innovation will be the key to organizational performance (H6.1).

Summary of Hypotheses Testing Results

Hypothesis H1 is rejected in all three data sets. No significant relationship between knowledge distribution and open innovation is found. The reason is probably due to that knowledge distribution measures the structure of knowledge environment in an organization. That only focuses on the internal organizational knowledge structure (Chen et al. 2010). Both inbound and outbound open innovations require interacting with external organization, but not with internal units. Therefore, internal distribution of knowledge has no significant influence.

Hypothesis H2 is supported in all relationships, except H2.1 in Japan. Higher knowledge interaction in an organization would lead to higher inbound and outbound open innovation. Knowledge interaction stands for the activities of knowledge interchanging. It is reasonable that higher internal knowledge interaction would cause higher inbound and outbound open innovation because the internal culture could extend to the outside world (Herstad et al. 2008). The reason that it has no effect between knowledge interaction

¹ <http://www.imf.org/external/pubs/ft/weo/2012/01/pdf/text.pdf>

and inbound open innovation in Japan is probably due to the nature of centralized management of firms in Japan. In this case, the decision on adopting open innovation is made at the senior management level with little involvement of other members. Another possibility is that inbound open innovation needs resources to bring in outside knowledge. It might be a difficult decision for a Japanese company with a good R&D capability and close culture (Hofstede 2001).

In hypothesis H3, we find significant effects of knowledge collaboration on inbound open innovation in all data set but not for outbound open innovation of Japan data (H3.2). Knowledge collaboration describes a supportive rather than competitive climate of knowledge management in an organization. The reason that a collaborative environment leads to higher inbound open innovation is probably because the supportive environment could increase the absorptive capacity of an organization. That H3.2 was not supported in Japanese data is probably due to the high power distance in Japan that inhibits knowledge collaboration in an organization (Hofstede 2001).

Both internal and external IT support capabilities lead to higher inbound and outbound open innovation. H4 and H5 are supported for the whole data in Figure 3. As Alavi and Leidner (2001) stated that IT can facilitate the flow of knowledge in an organization. Therefore, it is reasonable that IT can also enhance the inbound and outbound innovation processes. However, the IT effect reduces in individual country analysis; only H5.2 (external IT support to outbound open innovation) still holds. A possible reason is that outbound open innovation requires frequent interaction with external entities, which needs strong external IT support.

Hypothesis H6 examines the impact of open innovation on organizational performance. The results are significant in all datasets and have high path coefficients. This implies that higher open innovation will lead to higher organizational performance. In the knowledge era, the intensive competition and short product life cycle force enterprises to cooperate with others to accelerate the R&D process in order to remain competitive. Open innovation provides a strategy to achieve this objective (Chesbrough 2003). Our findings from this cross-country study confirm this argument.

Conclusion

Knowledge and innovation are probably the most important buzzwords in the recent decade. Organizations are advised to adopt knowledge management in order to keep their valuable intangible assets and to take advantage of rich external intellectual resources through open innovation. The underlying driver of these managerial trends is the rapid development and proliferation of information technology, which has changed the rule of competition and enabled a vast amount of innovations within and across organizations.

In this research, we have investigated how different knowledge management strategies and IT capabilities affect the implementation of open innovation and whether the adoption of open innovation affects organizational performance. Our findings have the following implications. First, IT capabilities are found to have direct effects on open innovation. This confirms the general belief that IT is an important competitive weapon for most organizations. Therefore, if a company intends to build competitive advantages based on intellectual properties, enhancing its IT capabilities would be a key success factor. Second, inbound open innovation and outbound open innovation have different effects on organizational performance in different economic contexts. There is no generally applicable strategy for open innovation. Outbound open is helpful to performance improvement for leading companies, while inbound open would be helpful to performance improvement for follower companies. Finally, knowledge distribution does not have significant effect on open innovation, but knowledge interaction and collaboration did have significant positive effects on open innovation. Therefore, building a sharing and collaborative KM culture is helpful to the adoption of open innovation.

Overall, the research has achieved the objective by identifying relationships among IT capability, KM strategy, open innovation, and firm performance. The study is not without limitations, however. A major limitation is that the data collected in different countries are based on convenient telephone interview methods. Although we have hired professional market survey companies in Japan and Taiwan to collect data, their data collection procedures vary due to different local practices. Second, although the study is multi-national, we are not sure whether the findings can be generalized to other significantly different

cultures such as Europe or America, where management practices could be very different from those in Taiwan and Japan. Nonetheless, the quality of the sample for analysis has met commonly accepted criteria and the findings are acceptable from the statistical perspective. The findings provide valuable first-hand insights into IT, KM, open innovation and firm performance, which have not been carefully investigated in previous studies.

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