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Innovation Initiative within Foreign Subsidiaries in South Korea: Determinants and Outcomes

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Abstract:

Innovation is the process through which new products or processes are introduced within the firm; it represents the end of a process of knowledge sourcing and transformation, as well as the beginning of a process of exploitation which may result in an improvement in the performance of the innovating firm. In this paper, we investigate the drivers of innovation initiative in foreign subsidiaries located in South Korea, balancing internal and external drivers to innovation, before investigating its outcome on innovation output and performance of the subsidiary, as well as the level of intra-MNC knowledge sharing with the HQ or other units of the MNC. Findings demonstrate that the external technological environment in South Korea, and MNC internal embeddedness are conducing to subsidiary initiative, and that innovation arising in South Korea is shared with other units of the MNC.

Keywords: MNC, foreign subsidiary, innovation initiative, internal embeddedness, external embeddedness, performance

Innovation Initiative within Foreign Subsidiaries in South Korea: Determinants and Outcomes

INTRODUCTION

Innovation is the process through which new products or processes are introduced within the firm; it represents the end of a process of knowledge sourcing and transformation, as well as the beginning of a process of exploitation which may result in an improvement in the performance of the innovating firm (Roper and Love, 2008). Within the context of the multinational corporation (MNC), localized subsidiary innovation (innovation initiative) refers to the extent to which subsidiaries develop and adopt new product, processes or administrative systems locally (Mu et al., 2007; Ghoshal and Bartlett, 1988).

The perspectives of organizational learning and knowledge (Cohen & Levinthal, 1990), and inter-firm networks (Forsgren, 2008) explain how subsidiaries have a local network of relationships that provides access to local knowledge. Authors have emphasized the importance of local resources for MNE innovation (Almeida, 1996; Pearce, 1999). In this paper, both approaches are therefore considered. The literature first described how ownership-specific advantages were developed at the corporate HQ levels, and leveraged overseas through knowledge transfer. It is recognized now, however, that subsidiaries themselves can contribute significantly to the knowledge base of the MNC, creating ownership advantages through operations in dynamic host environments. Thus, foreign subsidiaries play a very important role by acquiring and creating valuable knowledge in their host country, in time, contributing back to the knowledge base of the entire MNEs (Zhao and Luo, 2005; Almeida and Phene, 2004; Birkinshaw and Hood, 2001; Cantwell and Piscitello, 1999).

There are few studies, however, on the specific case of South Korea, even though inward FDI have increased dramatically since the late 1990s (UNCTAD, 2008). One of the aim and contribution of this paper is to fill this gap and investigate how subsidiaries located in South Korea learn from their operations in this environment and in turn, contribute to the MNC.

Subsidiaries evolve through accumulation of resources and specialized capabilities (Frost, 2001; Birkinshaw & Hood, 1998), and their role within the multinational network evolves as a result of the headquarters' assignment, subsidiary choice, local environment determinism, these three mechanisms interact to determine the subsidiary's role at any given point in time (Birkinshaw & Hood, 1999: 775). Therefore, it is acknowledged that innovation initiative by foreign subsidiaries in South Korea will in part

be determined by the dynamics of internal embeddedness, that is their level of interaction with other units of the MNC.

Following earlier work (Cassiman and Veugelers, 2002; Roper et al., 2006), we consider how foreign subsidiaries source knowledge (both internally within their MNCs networks or externally within the host economy) to develop innovation initiative, transforming this knowledge into new products and processes, and finally exploiting this to achieve higher performance as business entities but also in terms of contributing, in turn, back to the MNCs network. Roper and Love (2006) refer to the process as *innovation value chain*. Thus, another contribution of this paper is to assess the benefits of innovation initiatives to both the subsidiary itself and the rest of the multinational network. The aim is to investigate the outcome of such innovation for output, performance, as well as reverse transfer to either the HQ or other units of the firm.

The paper begins with a literature review to explore the background to the development and drivers of innovation initiative, together with the implication of such activities for the subsidiaries and the host economy as well as the multinational network. In the second part of the paper, the methodology is discussed. Using data from the Korean Innovation Survey, a three-way least square model is presented to provide answers to the hypotheses. The final section discusses the results and draws conclusions, with a focus on the dynamics of South Korea for building innovatory capacities amongst MNCs.

THEORETICAL CONSIDERATIONS

The literature first described how ownership-specific advantages were developed at the corporate HQ levels, and leveraged overseas through knowledge transfer. It is recognized now, however, that subsidiaries themselves can contribute significantly to the knowledge base of the multinational firm, creating ownership advantages through operations in dynamic host environments. Thus, foreign subsidiaries play a very important role by acquiring and creating valuable knowledge in their host country, and in time, contributing back to the knowledge base of the entire MNEs (Cantwell and Piscitello, 1999; Birkinshaw and Hood, 2001; Almeida and Phene, 2004; Zhao and Luo, 2005) and to the MNC competitive advantages.

Subsidiaries evolve through accumulation of resources and specialized capabilities (Birkinshaw & Hood, 1998). Overall, subsidiaries roles evolve as a result of the headquarters' assignment, subsidiary choice and local environment determinism; these three mechanisms interact to determine the subsidiary's role at any given point in time (Birkinshaw & Hood, 1999: 775). Given that market knowledge and commitment increase with the length of operation in the host market, external embeddedness contributes to the ability of

the subsidiary to become competence creating (Cantwell and Mudambi, 2005), and in particular its ability to accumulate innovation capabilities (Frost, 2001).

Foreign subsidiaries can source knowledge either internally from the HQ or other units of the multinational network (Forsgren, 2008) or within the host country environment. Externally, there are various channels through which a foreign subsidiary can source knowledge: either through in-house R&D, through foreign linkages to customers or backward linkages to suppliers or business partners (Jindra et al., 2009), through collaboration with business partners or through linkages to universities and public research centers (Santangelo, 2009). If internal knowledge sourcing is strong, this may discourage other means of knowledge sourcing (from Roper and Love, 2008).

Developing and conducting innovation activities is not a sufficient mean in itself. The underlying assumption is that the company benefits, and in the case of the MNC, not just the subsidiary but the overall multinational network. The ability of the subsidiary to transform knowledge is dependent upon the subsidiary characteristics, its resource-base and capabilities. The first step is how foreign subsidiaries source knowledge both internally within their MNCs network and externally within the host economy (Cassiman and Veugelers, 2002; Roper et al., 2006). This allows the subsidiary to develop innovation initiative, transforming this knowledge into new products and processes. In the final step, the firm can exploit such activities through higher performance and, in turn, through contributing to the knowledge base and competitive advantages of the MNC network. Roper and Love (2006) refer to the process as *innovation value chain*. In the next section, a series of hypotheses are built first around the creation of innovation initiative, and second around the impact of such initiatives within subsidiaries.

Localized Subsidiary Innovation Initiative

Role of Local Embeddedness

Local embeddedness refers to the extent to which a subsidiary has established relationships with local institutions such as suppliers, customers, and research institutions (Mu et al., 2007: 82). Through network of ties as conduits for information flows, subsidiaries are exposed to new developments in the host market. Gaining access to knowledge in diverse environments requires a physical presence because local knowledge is typically *sticky* and tacit (Szulanski, 1996). This is why foreign subsidiaries can become key agents of learning and innovation.

Research suggests that innovation is enhanced when a firm is connected to many others and has diverse contacts (Power et al., 1996). The combination of weak and strong ties in the environment strengthens

exchange of knowledge and promotes trusts amongst business partners, leading to combination of expertise (Anderson et al. 2002; 2005; Yamin and Otto, 2004; Forsgren et al., 2005). The strongly embedded subsidiary is the one that 'maintains frequent and significant interactions with local organizations' (Håkanson & Nobel, 2001: 398), which enables for the development of local competences (Andersson et al., 2001), and in particular of local innovation initiatives. Thus, we posit that:

Hypothesis 1: There is a positive relationship between subsidiaries' local embeddedness (with local business partners and institutions) and subsidiaries' localized innovation initiative.

Role of Internal Embeddedness

From the evolutionary perspective, productivity of knowledge creation is determined by dynamics between constituents of the system. Technology transfer and acquisition from various sources are constrained or facilitated by competition and coordination within the networked system of knowledge creation (Kogut 2000: 408-9). MNCs are created from a network of different geographically dispersed organizations which are related to each other through interpersonal ties. The MNC is viewed as a social community with ability to integrate, combine and create knowledge leading to the creation of competitive advantages (Ambos et al, 2006). Knowledge exchanges and intra-unit relationships strengthen the competence advantage of the subsidiary (Kostova, 1999), providing support for the creation of innovation initiatives.

Hypothesis 2: There is a positive relationship between subsidiaries' internal embeddedness and subsidiaries' localized innovation initiative.

Outcomes of Subsidiary Initiative

There exist benefits to the action of competence creation within the subsidiary (Cantwell and Mudambi, 2005), such benefits lie into the evolving position of the subsidiary within the overall multinational network (Forsgren et al., 2005). Through enhanced competences and performance, the subsidiary increases its influence over other parts of the MNC. With innovatory capabilities, the subsidiary can transform knowledge into new products and processes, and demonstrate *innovation output*, such as a larger number of patents. The ability to develop new knowledge is also linked to increased performance by the subsidiary itself.

However, the process through which the subsidiary can enhanced in position within the network as a result of its newly created competences is not automatic. The subsidiary's participation in localised knowledge flows is not exogenously determined but endogenous to the development of the capabilities, bargaining

power and autonomous strategic position of the subsidiary (Mudambi and Navarra 2004). As a result, the subsidiary's increased local embeddedness is likely to be embroiled with tensions, and in some cases, it could be prevented from planning its optimal portfolio of innovation resources. Subsidiaries' ability to act as 'technology vehicle' is beset on its absorption of knowledge but this can be hindered "when they behave completely autonomously and strive for their own interests (Manolopoulos et al. 2005: 262)". Potentially the attempt for devolution from the MNC initiative would be penalised by the restricted access to firm-specific assets within the MNC networks. For instance, it is reported that the knowledge outflows to location erodes bargaining power and thereby rent appropriability of subsidiaries (Mudambi and Navarra 2004: 392).

To overcome such problems, as well as situation when knowledge exchange within the multinational network is encouraged by the headquarters, the subsidiary will tend to strengthen its relationships with the parent company and other units of the MNC and its position within the network by contributing to the knowledge base of the company. Overall, there are positive impacts of innovation initiative in the host economy for the subsidiary itself in terms of performance and innovation output, but also for the whole multinational network. Therefore:

Hypothesis 3: Innovation initiative has a positive impact on the subsidiary's ability to generate innovation output, increase is performance and transfer knowledge to the other units of the MNC.

Framework of Analysis

Figure 1 presents the model to be tested in this paper, and covers the *innovation value chain* from the perspective of the foreign subsidiary in a host economy. It shows the drivers to innovation initiatives as well as the impact of the innovation competence for the subsidiary within the host economy and for the entire multinational network.

Insert Figure 1 Here

METHODOLOGY

Data

We use Korean Innovation Survey (KIS) for manufacturing sectors in 2002 and 2005 to test our hypotheses. KIS 2002 reports firms' innovation activities between 1999 and 2001, while KIS 2005 covers

the period from 2002 to 2004. This data set is prepared by the Science and Technology Policy Institute (STEPI) under the Government of the Republic of Korea. It is part of Community Innovation Survey (CIS) by OECD and administered under the Law on National Statistics in the Korean context. Participating firms are asked about the importance of knowledge sources, acquisition of technology, technological cooperation, purposes and barriers to innovation, as well as general information about innovation.

Although the survey does not provide the evidence of responses (Veugelers & Cassiman, 2004), it is rich in firm-level information, and provides a large number of responses by MNCs located in South Korea. As such, it is a good source of information on innovation activities conducted by foreign subsidiaries in this country. The dataset contains a total of 423 respondent firms with foreign ownership of 20% of more. However, due to the large number of missing responses, we conducted a careful data screening and decided to only include a total of 113 useable observations with complete answers.

Variables and measurement

Endogenous and exogenous variables are presented in Table 1.

Insert Table 1 Here

Innovation initiative

Innovation initiative is measured by the extent to which the replacement of existing old-fashioned products with totally new products has been the reason for new technological innovation. For this question, the KIS survey used a five-point Likert scale, from one (very low) to five (very high). Zero is assigned for not applicable. We consider zero as part of the ordinal scale assuming that not applicable equals the absence of such innovation initiative.

External embeddedness

The international business literature has assumed that technological embeddedness is positively related to the increased scope of new product developments (Andersson, Forsgren, & Holm, 2002). The literature on innovation value chain has suggested identifying external knowledge resources as the first step of innovation activities (Roper, Du, & Love, 2008). This paper therefore specifies innovation initiative as a function of the availability of external knowledge sources. Based on CIS data, we identified four types of external knowledge sources – forward, horizontal, backward, and public knowledge sources (Crespi, Criscuolo, Haskel, & Slaughter, 2007, Roper, Du, & Love, 2008).

Internal embeddedness

Foreign subsidiaries also have access to intra-MNC knowledge in addition to local external knowledge. KIS data provides the five-point Likert scale about the importance of knowledge sources, from one (very low) to five (very high), and zero for not applicable, i.e., no use of concerned knowledge sources. Using KIS data, we first measure the importance of external technological information by computing the average score of forward information from customers and clients, horizontal information from rival firms in the same market, and backward information from suppliers of intermediate goods and parts. Similarly, the score for public scientific information was computed based on information from universities and public research centers. The distinction between technological and scientific information was justified based on Manolopoulos et al. (2009).

Previous studies about internal knowledge flows within MNC structure measured the perceived importance of intra-MNC knowledge flows, by asking questions like what would be the consequence for other units in the foreign company if they no longer had access to the competencies of subsidiary (Foss & Pedersen, 2003). Similarly, to measure the extent to which the subsidiary is embedded in internal MNC knowledge network, we used firm's response about the importance of knowledge inflows from affiliated firms within the same MNC group.

Innovation output and exogenous variables

Innovation output can be measured by the number of patents filed by the respondents in the period covered by the survey. We are not oblivious to the drawbacks of patents as the indicator of innovation output. Nevertheless, we justify measuring innovation output by patents for the reason that output of innovation activities other than patents are very difficult to observe empirically and that patents are usually filed building on existing knowledge, both visible and invisible (Song & Shin, 2008: 296)

Literature has found relationships between innovation output and internal innovation input. Innovation inputs are often specified by *innovation-related expenditures* and the *number of R&D staff* of the firm in Crespi et al. (2008) and Schmeideberg (2008), among others, which express innovation activities in a form of an innovation production function. KIS provides numeric data for those three variables.

Intra-MNC knowledge sharing and exogenous variables

This paper measures intra-MNC knowledge sharing by using the responses about the importance of technological cooperation with affiliated firms within the same MNC group. Data is based on the five-point Likert scale and zero for the use of intra-MNC knowledge sharing experiences.

We identified various exogenous variables of external technological cooperation with the help of previous empirical studies. The purpose of exploration of variables is to find a reliable instrument for endogenous 'intra-MNC knowledge sharing' variable rather than testing each and every factor of external technological cooperation. Therefore, for practicality, we limited our interest to *appropriability* and *absorptive capacity* of the firm, as those are immediately available at KIS data and considered to be associated with external R&D cooperation in previous studies. The former is measured by the extent to which the possibility of illegal replication of innovation outputs has impeded the firm's innovation process (recorded as a five-point Likert scale, from one (very low) to five (very high)), while the later, absorptive capacity, is proxied by the presence of permanent R&D department and in-house research centers, observed as the binary scale of zero and one.

Subsidiary performance and exogenous variables

Subsidiary performance is measured by sales growth over the surveyed three-year period. The comparison over the three-year period enables to assess changes in performance.

The exogenous variables used to explain performance change are the *industry* and *employment growth rate*. To measure the effect of being in the high-tech industry, a dummy variable is created, by assigning one for high-tech industry and zero for the others. Industry classification is applied based on 2-digit NACE-Rev. 1 classification of OECD (Schmiedeberg, 2008: 1497).

3SLS Model

To test our hypotheses, we used a three-stage least square (3SLS) model. The model assumes three stages: firstly, each endogenous variable is instrumented by relevant exogenous variables so as to generate predicted values that will then replace the endogenous variables in the subsequent equation. The second stage is the estimation of a cross-equation covariance matrix of disturbances from the first stage. Finally, the main equation to explain the ultimate dependent variable is estimated based on the covariance matrix and other exogenous variables.

Before running the model, we test how each endogenous variable can be predetermined based on exogenous variables, using determinants identified in previous empirical studies. A test for cross-correlation does not reveal any problems (see Table 2).

Insert Table 2 Here

Dividing firms into high and low initiative groups, we found that high initiative groups tend to use more locally available external technological and scientific knowledge (Figure 2). Those firms also reported that they found intra-MNC knowledge sharing is very important for innovation activities. Consequently, those high initiative firms filed smaller number of patents in the survey period but achieved significantly higher performance improvement in the given period of time. Nevertheless, this observation does not represent the *ceteris paribus* effect, i.e., possibility of not accounting for the intervention of other characteristics. The more dynamic relationships among endogenous variables should be further examined with an econometric model.

Insert Figure 2 Here

In the 3SLS model, our main interest is, as discussed earlier, to explain the simultaneous relationships between four endogenous variables, namely, innovation initiative, innovation output, the role of intra-MNC knowledge sharing in respondents' innovation activities, and performance change. The iteration command of STATA for 3SLS provided the estimation of Table 3. Hausman Test was performed in order to confirm endogeneity of variables so as to argue that 3SLS estimation is more efficient than estimation based on simple OLS. We conducted Breusch-Pagan Test and found heterogeneity at the 95% significance level, while heterogeneity was not detected when we relax the significance level to 90%. The evidence of mild heterogeneity means that there may be omitted endogenous variables in this model. For the test of over-identification, we computed the Sargan score and found that this model was not over-identified at the 95% level, i.e., the number of endogenous variables used in this model is adequate. Therefore, we report the 3SLS result as it is, although the model needs to be improved in a way that better handles heterogeneity issues.

Insert Table 3 Here

Our data set is a pooled cross-section data from year 2002 and year 2005, as this method is successful when testing a pooled cross section data (Wooldridge, 2009). To make sure that there are no statistically significant structural breaks between the two years, we perform the Chow Test based on a simple multiple

regression. The results show that all equations are significant at the 95% significance level except for equation 3 on intra-MNC knowledge sharing, with a slightly lower significance level of 90%.

We start by checking relationships between endogenous variables and related exogenous variables. Equation 1 shows the effect of knowledge sources on innovation initiative of subsidiaries. Coefficients for intra-MNC information and external technology turned out to be positive and statistically significant at the 90% level and 95% level respectively. The effect of external scientific knowledge on innovation initiative was not significant. This empirical result can be compared with Manolopolous et al. (2009)'s finding that firms tend to consider external technological knowledge valuable, even if what actually contributes to performance change is external scientific knowledge from public research centers

Equation 2 is significant at the 95% level, and all explanatory variables turned out to be significant except for innovation expenditures. With a level of 90%, the size of innovation expenditure is potentially positively related to innovation output. As predicted, the number of R&D staff turns out to positively affect innovation output of the subsidiary.

P-value of Equation 3 is 0.055 and therefore the equation could be accepted at the 90% significance level. The equation shows that high appropriability concerns prevents the subsidiary from sharing knowledge with other units of the MNC, as predicted. The presence of permanent innovation and research departments play no significant role on intra-MNC knowledge sharing. This could be due to the fact that the number of patents filed absorbs most effects related to a firm's internal innovation capacity.

Finally, we derive Equation 4 that investigates the ultimate effects of exogenous and endogenous variables on the performance change of subsidiaries. The two control variables – being in a high-tech industry and employment growth – are both significant and have a positive effect on sales growth (our proxy for performance change). Innovation initiative is negatively associated with performance change.

DISCUSSION AND CONCLUSIONS

Our first and second hypotheses related to the factors conducing to the innovation initiative at the level of the subsidiary. We find a clear relationship between the level of knowledge received from other units of the multinational network and the innovation initiative of foreign subsidiaries. Results for the external embeddedness, however, point to differences between the external scientific knowledge environment and the external technological knowledge environment. Foreign subsidiaries positively benefit from public research centers within South Korea. Our third hypothesis was related to the impact of innovation initiative within the subsidiary.

By combining results of the equations, we find clear associations among endogenous variables (see Figure 3). Innovation initiative is positively associated with innovation output. Innovation initiative then raises the profile of intra-MNC knowledge sharing in subsidiaries' innovation activities. This empirical result means that innovation initiative is a common cause for innovation output and intra-MNC knowledge sharing.

Insert Figure 3 Here

Patents filed, our endogenous variable for innovation output, has no effect on intra-MNC knowledge sharing. This could be because the subsidiary's accumulation of internal knowledge reduces the relative importance of intra-MNC knowledge. Innovation output can potentially operate as a mediator on the indirect relationships between initiative and intra-MNC knowledge sharing: p-value for patent filed in Equation 3 is 0.152, so we may not rule out the positive role of innovation output in this model.

Our findings are consistent with those of Yamin and Otto (2004) but not with those of Mudambi and Navarra (2004). Whether or not local external and MNC internal knowledge assets are complementary can be interpreted as successful intra-MNC coordination for subsidiaries to carry out dispersed innovation activities, while substitutive relations could indicate either limited mandate of subsidiaries due to the centralized mode of MNC governance or the absence of intra-MNC coordination mechanism (Grant, 1996). In this case, one can question whether foreign subsidiaries in South Korea are actively involved in coordination with their headquarters or other units of MNC regarding their innovation initiative.

Performance change measured by sales growth is negatively associated with innovation initiative. Innovation initiative may result in the creation and accumulation of internal knowledge, as supported by the positive relationships between innovation initiative and innovation output. Figure 3 shows that innovation output does not mediate the indirect effect of innovation initiative on performance change. This could be explained by the fact that firms have binary priorities of short-term and long-term goals and the allocation of managerial time on either goal is reflected in the timeframe of realized performance change (Liu, 2008).

Innovation initiative and innovation output are related to long-term goals that can differ from sales growth, which tends to be a short-term goal. This can explain why our data fails to observe the link between innovation initiative to performance change through innovation output. Intra-MNC knowledge does generate a mediating effect in the negative association between innovation initiative and sales growth. It could be because intra-MNC knowledge sharing helps innovative subsidiaries to better balance short-term and long-term goals.

To conclude, this study has provided a useful insight into the innovation initiative of foreign subsidiary in the South Korean context. Few studies have considered the evolving role of foreign subsidiaries in Korea, their ability to develop innovation initiatives, the drivers behind such initiatives and their potential to contribute knowledge to the multinational network. This is because MNCs only started investing substantially in South Korea since the late 1990s. By now, however, foreign subsidiaries have developed competences, and have started benefitting from the technological knowledge of their host economy.

The main limitation of the study lies in the use of the Korean Innovation Survey data, as this does restrict the number of variables that can be included in the model. Because there is no access to the name of the firms that take part in the study, it is not possible to add to the existing dataset. Additionally, the large number of missing values lowers the overall number of cases included in the model (although over 423 firms took part in the survey, only 113 cases could be used in the analysis).

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Figure 1

Determinants and Outcomes of Subsidiary Initiative

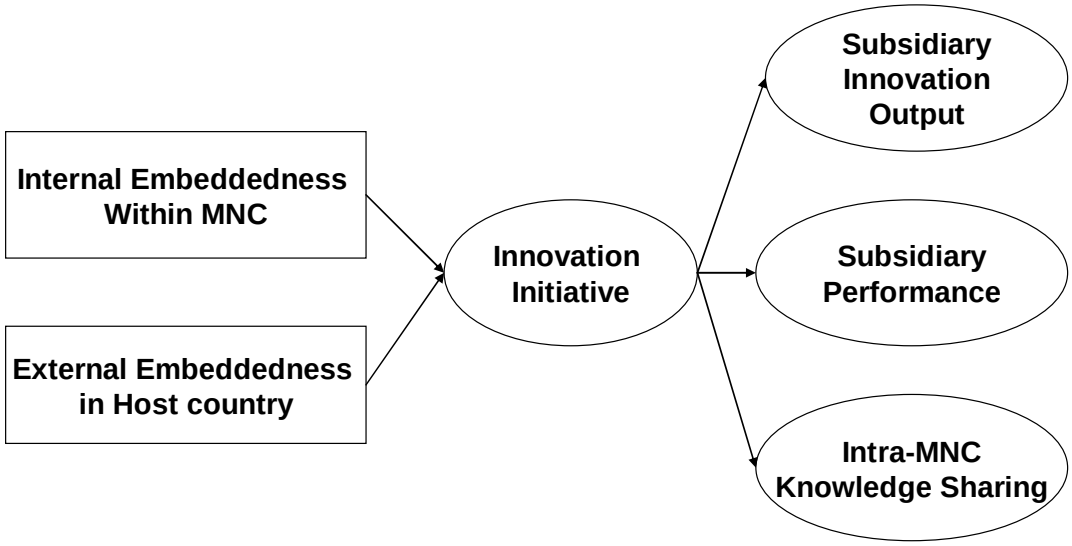


Table 1 Variables, measurements and descriptive statistics

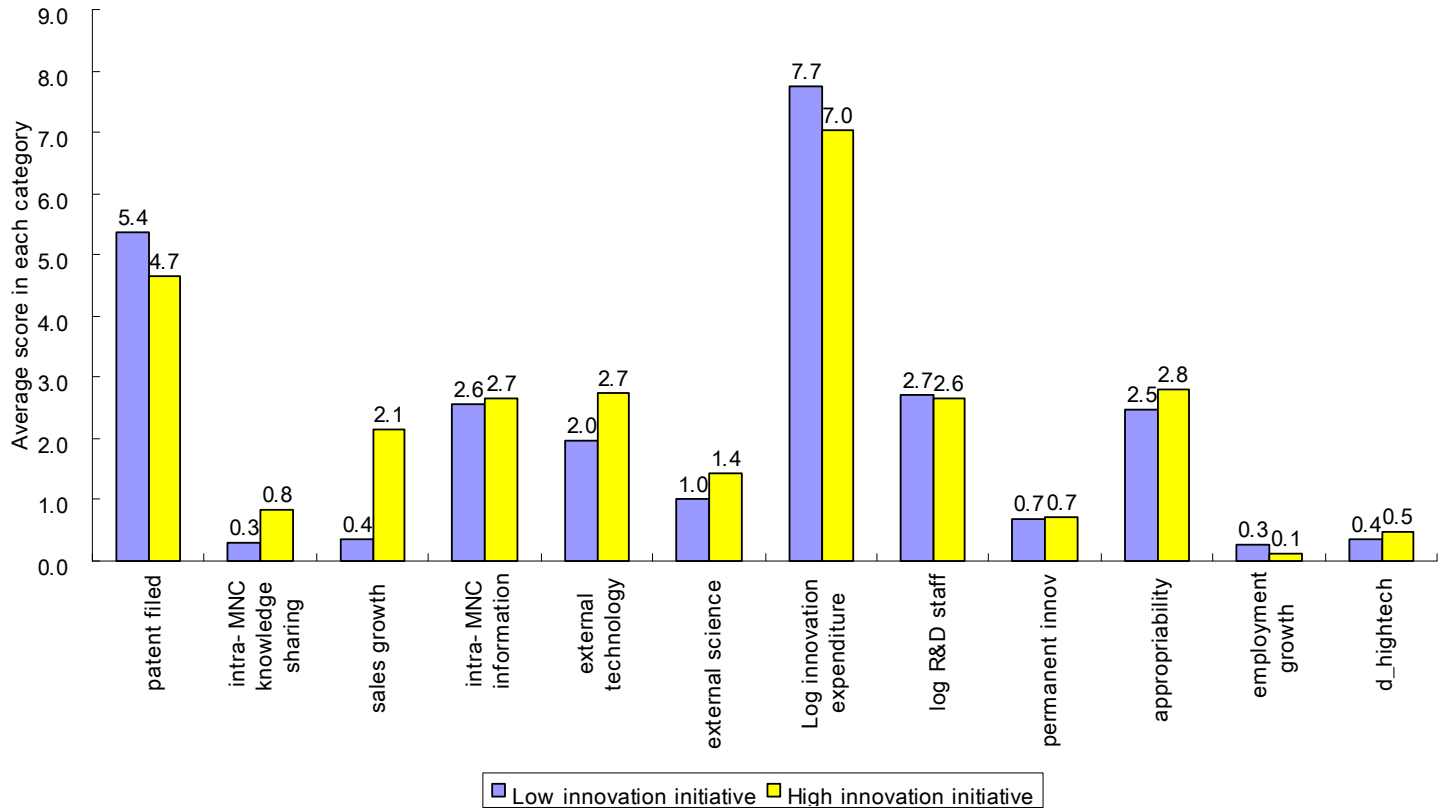
Short name	Definition	Mean	Standard deviation	Min	Max
Endogenous Variables					
Innovation initiative	Innovation aiming at new product development to replace existing products	3.124	1.753	0	5
Innovation output	Number of patents filed	11.965	32.897	0	205
Intra-MNC knowledge sharing	Importance of intra-MNC knowledge sharing	0.991	1.740	0	5
Sales growth	Sales growth over the past three years	0.347	0.643	-0.774	4.563
Exogenous Variables					
Intra-MNC information	Importance of knowledge from other units of MNC	2.912	1.845	0	5
External technology	Importance of knowledge from public research centre	2.582	1.351	0	4.750
External science	Importance of knowledge from public or private institutes and universities	1.422	1.138	0	3.667
Log innovation expenditure	Innovation expenditures	7.247	2.561	1.792	13.816
Log R&D staff	Number of R&D staff	2.955	1.259	0	6.907
Permanent innovation	Presence of permanent R&D department as an indicator of independent knowledge utilization capacity	0.956	0.207	0	1
Appropriability	Concerns about failing to appropriate rents from innovation output	2.708	1.314	1	5
Employment growth	Employment growth over the past three years	0.070	0.245	-0.610	1.133
Hightech	Whether or not the industry classification is a high-technology by OECD definition	0.434	0.498	0	1

Table 2 Correlation matrix of variables

(N=113)

		1	2	3	4	5	6	7	8	9	10	11	12	13
1	Innovation initiative	1.0000												
2	Intra MNC information	-0.0269	1.0000											
3	External science	0.1570	-0.1054	1.0000										
4	External technology	0.2755	0.0047	0.4373	1.0000									
5	Innovation output (patents)	0.0061	0.1282	0.2109	0.1042	1.0000								
6	Log innovation expenditure	-0.0499	0.2457	0.0465	-0.0679	0.3439	1.0000							
7	Log R&D staff	0.0447	0.1422	0.3334	0.1107	0.4906	0.5178	1.0000						
8	Intra-MNC knowledge sharing	0.1204	0.2307	0.0695	0.1883	-0.0649	0.1218	0.1822	1.0000					
9	Appropriability	0.1476	-0.0329	0.1448	0.0978	0.0016	-0.0483	-0.1221	0.0067	1.0000				
10	Permanent innovation	-0.0833	-0.1510	0.1054	-0.1148	0.0747	0.1716	0.2199	-0.0508	-0.1467	1.0000			
11	Sales growth	0.0443	0.0244	-0.0787	-0.0760	0.1325	0.1903	0.2691	0.2888	-0.1122	0.0635	1.0000		
12	Employment growth	-0.0068	-0.0406	-0.1250	-0.1054	0.0172	0.0639	0.1285	0.1469	0.1215	0.0649	0.4546	1.0000	
13	High tech industry	-0.0212	0.1200	0.0682	0.0364	-0.0852	-0.0088	-0.0515	0.0354	-0.0231	0.0146	0.0573	-0.1664	1.0000

Figure 2 Comparison of high and low levels of innovation initiative



Note: High initiative is innovation initiative>=3, and low initiative is innovation initiative<=2.

Table 3 Results of 3SLS model

	No. of observations	"R-sq"	Chi2	p	
Equation 1	113	0.059	10.390	0.016	**
Equation 2	113	-0.019	39.380	0.000	***
Equation 3	113	-0.475	9.260	0.055	*
Equation 4	113	-6.852	143.340	0.000	***
	Coefficient	Std. error	z	p>|z|	
Equation 1					
innovation initiative					
intra MNC information	0.098	0.058	1.680	0.093	*
external science	0.078	0.099	0.780	0.433	
external technology	0.249	0.106	2.360	0.019	**
Constant	2.087	0.359	5.810	0.000	
Equation 2					
patent filed					
innovation initiative	9.669	5.597	1.730	0.084	*
log innovation expenditure	1.798	1.122	1.600	0.109	√
log R&D staff	10.293	2.411	4.270	0.000	***
Constant	-32.005	14.622	-2.190	0.029	
Equation 3					
intra-MNC knowledge sharing					
innovation initiative	0.731	0.359	2.040	0.041	**
patent filed	0.015	0.010	1.430	0.152	√
Appropriability	-0.086	0.061	-1.410	0.160	√
permanent innov	-0.202	0.341	-0.590	0.554	
Constant	-1.047	1.172	-0.890	0.372	
Equation 4					
sales growth					
innovation initiative	-0.764	0.288	-2.650	0.008	***
patent filed	-0.002	0.008	-0.270	0.786	
employment growth	1.115	0.277	4.020	0.000	***
intra MNC knowledge sharing	0.778	0.150	5.180	0.000	***
D_high tech	0.192	0.114	1.690	0.091	*
Constant	1.825	0.895	2.040	0.041	
Hausman test	chi2(15)= 30.05		Prob>chi2 =0.0117		**
Breusch-Pagan test	chi2(1)=3.86		Prob > chi2=0.0495		**
Sargan score	chi2(3)=6.41		Prob > chi2=0.92		
Chow test	F(4, 93) =0.98		Prob > F =0.4203		

Note: * = *p < 0.1*, ** = *p < 0.05*, *** = *p < 0.01*

Figure 3 Relationships between internal and external sources and intra-MNC knowledge sharing