Asia Pacific Journal of Information Systems
Vol. 26 No. 4 (DECEMBER 2016), 542-560

ISSN 2288-5404 (Print) / ISSN 2288-6818 (Online)
http://dx.doi.org/10.14329/apjis.2016.26.4.542

The Impacts of Technology Transfer on Productivity Growth of Firms based on Malmquist Productivity Index

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A B S T R A C T

This study determines whether or not firms can achieve high productivity growth through external technology acquisition. It also identifies the key factors affecting adopting firms' productivity growth by employing the Malmquist productivity index (MPI) methodology, which features computational ease, low data dependency, and decomposition of productivity growth into technical efficiency change and technical change. Results showed that the effects of productivity growth arising from technology transfer became stronger over time. Moreover, patent transfer guaranteed firms' productivity growth, but no evidence was found that factors such as age and size could increase productivity. Finally, cultural similarity could be another factor conditioning the effectiveness of technology transfer in the productivity of adopting firms.

Keywords: Technology Transfer, Firm Productivity, Malmquist Productivity Index (MPI) Methodology, Barriers to Technology Transfer JEL Classification Code: L2, L24, L25

Ⅰ. Introduction

In the past, most firms focused on independently developing technologies and utilizing them in their own products (Lichtenthaler, 2009). As today's business environment is changing owing to intense global competition, rapid technological progress, and shorter product life cycles (Santoro and Chakrabarti, 2002), there are more pressures to develop new products and business opportunities. Even firms with large financial and technological resources cannot readily conduct R&D activity solely due to the high costs and time limits (Lin et al., 2002).

Technology transfer has been recognized as an attractive alternative for firms lacking internal resources to develop technologies (Tsai and Chang,

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2008; Zahra et al., 2005) and a popular strategy for growth (Hagedoorn and Schakenraad, 1994). This is because technology transfer provides adopters with benefits like reduced R&D time, costs and risks; further strengthened internal technological capabilities; and easy access to the novel technology (Tsai and Wang, 2008; Zahra, 1996). For instance, small firms (e.g., new ventures) can radically develop new products and services, upgrade existing ones, or quickly enhance their own capacities, thanks to acquisition of required technologies from outsides (Zahra and Bogner, 1999). Large firms also depend more on external sources for technological innovations (Tsai and Wang, 2009). In fact, over 15,000 licensing transactions occurred with a total value of over $320 billion worldwide during the period 1985 - 1997, which implies that on average, approximately 1,150 technology transactions arose worth $25 billion per year (Arora et al., 2001; Kim and Vonortas, 2006).

Technology transfer has not been one of the hottest research topics among information systems researchers. However, as long as the transferred technology is information technology, we can say that information technology transfer has been already widely discussed in information systems literatures. The examples are information technology assessment and adoption issues (Davis, 1989; Huff and Munro, 1985), and new information technology implementation issues (Benbasat et al., 1987; Cooper and Zmud, 1990). Therefore, we can say that technology transfer may not be the research topic out of information systems area.

Korean manufacturers have made the best use of technology transfer to acquire advanced technologies and know-how (Lin, 2003) during the economic catching-up from an agrarian society to one of the most highly developed countries in the world. Notably, Korea has several peculiar characteristics in terms of technology transfer. First, Korea possesses highly educated human resources, which enable it not only to assimilate, adapt, and modify technologies acquired from external sources, but also to generate new technologies, because of Koreans' dedication to education (Choi, 2009). Second, there was the strong support of the governments to create a favorable business climate. The Korean governments made various plans related to technology transfer. A key example is the Technology Transfer Promotion Act, which is the Korean version of the Bayh-Dole Act (Lee and Lee, 2008). After that, to promote technology transfer from public sectors, the Korean governments revised the Patent Law and the Technology Transfer Promotion Act in December 2001 (Eom and Lee, 2008). Finally, Korea is in a suitable cultural environment for international inter-firm technology transfer because the Korean cultural environment reflects a mixture of Eastern and Western culture (Licht, 2004).

Researchers have studied how technology transfer influences firms. These studies can be categorized into three streams: 1) the relationship between technology transfer and innovation (Ahuja and Katila, 2001; Tsai and Wang, 2009), 2) the relationship between technology transfer and in-house R&D (Hu et al., 2005), and 3) the relationship between technology transfer and the financial or market performance (Han and Lee, 2012; Lichtenthaler, 2009; Tsai and Wang, 2008). However, only a few studies focused on the last issue (Tsai and Wang, 2008). For example, based on transaction cost theory, Han and Lee (2012) utilized event study methodology to investigate the impact of technology transfer on firms' market value in Korea.

Our study aims to assess if firms can achieve higher productivity growth through external technology acquisition. Specifically, our study is interested in how firms' productivity is affected by the characteristics surrounding technology transfer. Our primary concern is, therefore, to identify key factors that affect firms' productivity growth, as well as to lower the barriers to technology transfer. To do this, we employ Malmquist Productivity Index (MPI) methodology introduced by Fare et al. (1994), which has gained considerable popularity in recent years due to computational easiness, less data-dependency, and decomposition of productivity growth into efficiency change and technical change (Chang and Luh, 2000). MPI methodology can be used to investigate productivity change at both the firm and country levels (Lu and Liu, 2010). Regrettably, studies on the application of MPI to technology transfer fields are very limited.

We investigated the following questions using the MPI methodology: (1) Does the external technology acquisition increase adopter's productivity in Korea? (2) How do barriers to technology transfer have an effect on the recipient firms' productivity? Our study thus will not only complement and extend research on technology transfer, but also provide firms with critical success factors as well as risk-hedging strategies regarding technology transfer.

This paper is organized as follows. Sections 2 and 3 present the theoretical background and literature review. Section 4 briefly explains the methodology of MPI (Malmquist productivity index), and Section 5 describes our dataset. Section 6 presents the empirical results and a discussion of the results, and Section 7 gives a summary of the contributions and limitations.

Ⅱ. Background & Literature Review

2.1. Relationship between Technology Transfer and Firm Productivity

Technology, an important means to achieve competitive advantage, contributes to product quality and differentiation as well as sales growth (Cui et al., 2006). Technology can also reduce production costs and increase manufacturing productivity (Lee et al., 2010). It is normally embodied in people, materials, machines, and tools (Lin, 2003). Firms desiring to gain the requisite technologies from outsides can utilize licensing, contract R&D, M&A, strategic alliances, hiring of specialized personnel, etc. (Van de Vrande et al., 2006). Namely, the strategy of acquiring external technologies is largely divided between disembodied strategy (e.g., licensing, R&D contracting, use of technology consulting agencies) and embodied strategy (e.g., acquisition of firms or take-over, attracting qualified personnel, and equipment purchase).

The crucial factor in raising productivity is technological progress (Wu, 2009), which could be triggered by the technology transfer which has been viewed as an important innovation method over the last several decades by firms (Duysters and Hagedoorn, 2000). Accelerating technology transfer can be an effective way for technology progress. And it lies at the heart of the issue of firms' growth (Kogut and Zander, 1993). If a firm finds it difficult to develop new technologies alone, it can acquire the needed technologies through technology transfer and then quickly approach the technological frontier, and also exploit potential opportunities to enter new markets (Kim, 2005). Thus technology transfer offers the potential for productivity growth to both countries and firms behind the technological frontier (Griffith et al., 2004).

Some researchers have studied the effects of technology transfer on productivity growth. Xu (2000) found that the technology transfer of US multinational enterprises (MNEs) contributes to the productivity growth in developed countries, but not in less developed countries. Branstetter and Chen (2006) demonstrated that technology purchase contributes positively to the productivity growth of Taiwanese firms. According to case studies of Japanese multinational firms, intra-firm technology transfer helps increase productivity (Belderbos et al., 2008). The benefit of international technology transfer often far exceeds the effect of domestic R&D on productivity at the country level (Acharya and Keller, 2009). Acquiring disembodied technology could enjoy higher productivity growth from innovations (Gantumur and Stephan, 2010). Wu (2009), however, suggested that technology transfer is not related to the productivity growth of Chinese manufacturing firms.

2.2. Barriers to Technology Transfer

There may be obstacles of effective knowledge transfer (Simonin, 1999). Szulanski (1996) presented four factors influencing the difficulty of knowledge transfer. The first factor relates to the characteristics of the knowledge transferred, as it were, causal ambiguity. The second and third factors are associated with the characteristics of the source and the recipient, i.e. lack of motivation of the source and lack of absorptive capacity of the recipient. Finally, the fourth factor relates to the contexts in which the transfer takes place, such as an arduous relationship. The model of Szulanski (1996) suggests interesting implications in the relationship between technology transfer and a firm's productivity because productivity growth through technology transfer assumes that technology is successfully transferred from the originator to the adopter.

2.2.1. The Characteristic of the Knowledge Transferred: Causal Ambiguity

Knowledge may be either explicit or tacit (Nonaka, 1994). This dichotomy is based on whether knowledge can be codified and transmitted in a formal or systematic language or not (Simonin, 1999). For example, technological knowledge can be explicit, if it is in the form of a patent, or tacit, if it is in the form of know-how shared among employees (Hagedoorn et al., 2000). While the codified knowledge can be transferred more easily within a firm as well as across organizational and national boundaries, the tacit knowledge is not easy to transmit (Kogut and Zander, 1993) because tacit knowledge, which cannot be easily communicated and shared, is deeply rooted in action, commitment, and involvement in a specific context (Nonaka, 1994).

Causal ambiguity, which is defined by "basic ambiguity concerning the nature of the causal connections between actions and results" (Reed and DeFillippi, 1990), can also relate to the tacitness of knowledge because the greater the causal ambiguity, the more difficult it is to identify elements of the related knowledge (Cummings and Teng, 2003). Hence, the transfer success is influenced by the extent to which it can be verbalized, written, drawn, or otherwise articulated (Cummings and Teng, 2003).

2.2.2. The Characteristics of the Source: Lack of Motivation

A knowledge source may be reluctant to share important knowledge owing to the risk of losing ownership, a privileged position, or superiority (Szulanski, 1996). If a knowledge source is in competition with a knowledge recipient, a source may be unwilling to devote a lot of time and effort in order to support the transfer because knowledge transfer can pose a serious threat (e.g., fostering potential competitors or being inadequately rewarded for sharing hard-won success) (Szulanski, 1996). In contrast, an atmosphere of mutual trust not only contributes to the free exchange of knowledge, but also tends to foster collaboration to pursue mutually compatible interests rather than acting opportunistically (Su et al., 2010).

The relationship between the source and the recipient can be classified as two types, according to the degree of trust: a competitive alliance and a non-competitive alliance. Alliances with competitors (e.g., players within an industry) can be very complicated because of conflicts of interest and custody battles for product and technology; in contrast, alliances with non-competitors (e.g., universities) can often be more beneficial because it enables the creation of inter-organizational synergies through a valuable combination of resources and expertise (Santoro and Gopalakrishnan, 2001). Hence, the source in the competitive alliance may not only be reluctant to share the promised knowledge, but also act more opportunistically.

2.2.3. The Characteristics of the Recipient: Lack of Absorptive Capacity

A knowledge recipient may be unable to effectively utilize the external sources due to a lack of absorptive capacity, which is defined as "the ability to assimilate and replicate new knowledge gained from external sources" (Cohen and Levinthal, 1990; Chen, 2004). A continuous improvement of absorptive capacity is a necessary condition for successfully exploiting or assimilating the external knowledge or technological capabilities. Previous studies have used firms' size and R&D intensity as a proxy for absorptive capacity (Cohen and Levinthal, 1990; Geroski, 2005).

Absorptive capacity, which is largely a function of the pre-existing stock of knowledge, results from a prolonged process of investment and knowledge accumulation within a firm (Szulanski, 1996). It is also path-dependent in that the current level of absorptive capacity is affected by historical participation in specific product markets or a series of R&D activities in the related field. Overall, a high level of absorptive capacity enhances the recipient's ability to effectively utilize the multiple knowledge sources outside its boundary, whereas a low level of absorptive capacity inhibits this (Chen, 2004). Hence, a recipient with higher levels of absorptive capacity is more likely to gain productivity growth from acquiring external technology.

2.2.4. The Characteristics of the Context: Arduous Relationship

A knowledge transfer may require numerous individual exchanges when including the tacit components in the transferred knowledge (Szulanski, 1996). The success of such exchanges depends on the ease of communication and the degree of familiarity between the parties of technology transfer (i.e., the source and the recipient) (Szulanski, 1996). Similar cultures and value systems allow for a smooth working relationship between the parties, and common norms between the parties also aid predictability and understanding between them (Cummings and Teng, 2003).

In contrast, cultural distance between the two parties can create an additional difficulty in knowledge transfer. This not only results in conflicts, misunderstanding, and lack of information circulation, but also reduces flows of information and hinders knowledge acquisition (Park, 2011). Especially, lack of fit with a party's culture leads to poor communication and mutual distrust (Park and Ungson, 2001). That will make it harder to understand the critical competitive advantage offered by the knowledge transferred because cultural distance is positively related to causal ambiguity (Simonin, 1999). For this reason, cultural distance will be a barrier to knowledge transfer.

Ⅲ. Methodology: Malmquist Productivity Index

Our study employs MPI (Malmquist productivity index) methodology to assess the relationship between firms' productivity and technology transfer. The MPI was first introduced by Malmquist (1953) and further developed by Fare et al. (1994). It is a methodology to evaluate the productivity change of a DMU between two time periods on the basis of all the existing DMUs (observations) (Thomas et al., 2009). Zhang (2013) adopted Malmquist index to analyze the efficiency of university technology transfers. At this time, a production frontier is constructed on the basis of all the existing DMUs, and the distance of each of the DMUs from the frontier is estimated using non-parametric programming methods (Fare et al., 1994; Fu and Gong, 2009). In doing so, the MPI can be calculated by using distance functions.

This allows for further decomposition of productivity into changes in efficiency and changes in technology, as it were; the MPI can be decomposed into efficiency change (EC) and technical change (TC) (Chang and Luh, 2000). The efficiency change (EC) is defined as the movement or catch up of the DMU toward the efficiency frontier in a particular time period, and the technical change (TC) is defined as shifts in the efficiency frontier (Thomas et al., 2009). The efficiency change (EC) and technical change (TC) can be interpreted as "catch-up effect" and "innovation effect," respectively (Chang and Luh, 2000).

However, the basic Malmquist productivity index represented does not satisfy the transitivity (or circularity), and thus a global Malmquist productivity change index that is circular and gives a single measure of productivity change was introduced by Pastor and Lovell (2005). This paper measures the productivity change by technology adoption using a global Malmquist productivity index because this new index satisfies the circularity for all periods.

Assuming that for each time period t = 1,...,T, a global production technology is defined as $S^G = \{S^1 \cup \dots \cup S^t\}$. Then the global Malmquist productivity change index is defined on the basis of S^G as follows;

$$M_G(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o^G(x^{t+1}, y^{t+1})}{D_o^G(x^t, y^t)} \tag{1}$$

where $D_0{}^G(x^t, y^t)$ is a distance with inputs x^t and outputs y^t from the global efficiency frontier. The global Malmquist productivity change index can be decomposed into the efficiency change (EC) and technical change as same to conventional Malmquist productivity change index as follows;

$$M_G(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} x \left[\left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_o^G(x^{t+1}, y^{t+1})}{D_o^G(x^t, y^t)}\right) \tag{2}$$

where the ratio outside the brackets measures the efficiency change between years *t* and *t*+1. The geometric mean of the two ratios inside the brackets captures the technical change between the two periods evaluated at x^t and x^{t+1} (Färe et al., 1994), that is,

$$\text{Efficiency change} = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \tag{3}$$

$$\text{Technical change (BPG)} = \left[\left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_o^G(x^{t+1}, y^{t+1})}{D_o^G(x^t, y^t)}\right)\right] \tag{4}$$

If EC (Efficiency Change) is higher than 1, then the efficiency improvement has occurred within the two periods. However, if EC is lower than 1, then it indicates that terminal efficiency has become worse than before. Similarly, if TC (Technical Change) is higher than 1, then the production technology is progressive within two periods. The technology level is depressive if the value of TC is lower than 1 (Liu et al., 2008).

If $x^t = x^{t+1}$ and $y^t = y^{t+1}$ (i.e., no change in inputs and output between the periods), the productivity change index represents no change: $M_o(\cdot) = 1$. This show that the component measures of efficiency change and technical change are mutual, but not necessarily equal to 1 (Färe et al., 1994).

Ⅳ. Data Specification

4.1. Variable Selection

Our study considers a single output and two input variables on the basis of the Cobb-Douglas production function for the purpose of the computation of MPI (Malmquist productivity index). In a similar vein, Lee and Kang (2007) used employees and capital stocks as two input factors and sales as an output factor to utilize MPI methodology. Oh et al. (2009) also utilized three variables that consisted of input variables (i.e., capital stock and labor) and an output variable (i.e., value-added) to estimate the production function and to calculate TFP growth. Finally, Fu et al. (2008) considered two input variables (i.e., labor and capital) and one output variable (i.e., value-added)

Sales (Y) of each firm are used as the output variable, and both capital (K) and labor (L) are used as input variables. Especially, for two input variables, fixed assets are taken as a proxy for capital (K) following a study of Oh et al. (2009), and the number of employees is taken as a proxy for labor (L) according to a study of Fu et al. (2008). In order to exclude inflation effect, the monetary variables need to be divided by the producer price index (PPI). Except for the number of employees, the two variables are deflated by the producer price index[1)] with 2005 as the base year.

4.2. Data Collection

To empirically test the relationship between technology transfer and productivity growth, we gathered technology transfer announcements for Korean firms from 2002 to 2008. We used NAVER (i.e., the most popular Korean portal site) to collect news on technology transfer of Korean firms. The target news sources were edaily, moneytoday, ETnews, Maeil Business News, HanKyung News, and so on. Full text searches were conducted using the keywords: "technology transfer," "technology buy or purchase," "export or import of technology," and "licensing," which yielded more than 4,000 news items. We refined the results by reading the details of the news stories.

After collecting the news stories, output and input variables (i.e., the number of employees, fixed assets, and sales) were collected from DART (Data Analysis, Retrieval and Transfer System[2)]). We needed the

1) Source: http://ecos.bok.or.kr/

<Table 1> The Samples' Distribution

Unit[3]: $1,000, %

Item	1	0	-1	Average
Sales	243,211	231,641	212,763	229,205
Employee number	418	398	402	406
R&D intensity	5.36%	4.62%	5.12%	5.03%

Note: 1: one year after technology transfer, 0: the event year occurred in technology transfer,
-1: one year before technology transfer,

Item	Average	Median	STDEV
Age (Founding year ~ Event year)	22	20	14

data for three years (one year before technology transfer, the event year in which technology transfer occurred, and one year after technology transfer: -1, 0, 1) to estimate the productivity change before and after transferring technology. If a firm did not give sufficient information for calculating the MPI, it was eliminated from our study. Additional information for all samples (e.g., the founding year, R&D intensity, etc.) was also gathered from DART. The final sample size, therefore, was 83. However, some information could not be procured for all samples. As a result, the sample size of sub-groups varied according to each standard of classification. The samples' average sales, employee number, R&D intensity, and age distribution are provided in <Table 1>.

Ⅴ. Empirical Findings

5.1. Overall Impact of Technology Transfer

Our study began by estimating the impact of technology transfer on firms' productivity in Korea. To achieve this, we calculated MPI and its two components (i.e., technological change and technical efficiency change) for each of the sample firms under the assumption of CRS (constant returns to scale). <Table 2> presents the aggregate GMPI and components for 83 samples over the first period (-1, 0), second period (0, +1), and whole period (-1, 0, +1), and values for the GMPI and its components indicated geometric means of the sample firms over the given period. While a value of GMPI > 1 indicates a positive productivity growth, a value of GMPI < 1 indicates a productivity decline.

From <Table 2>, we found that there is no regularity of the productivity change by technology transfer. This finding implies that there may be some conditions on productivity growth of adopting firms by technology transfer. We could also observe that all values of both EC and BPCI were higher than 1 in the second period (T2). Judging by these findings, the source of productivity growth is catch-up effect or innovation effect. Hence, firms adopting the needed technologies from the outside can experience productivity growth caused by both the catch-up effect and the innovation effect.

By comparing the annual productivity change of firms after technology transfer, it is possible to identify the general trend in firms' productivity change.

2) http://dart.fss.or.kr/
3) $1 ≒ ,000

<Table 2> Results for Overall Impact of Technology Transfer

Event year	DMU	Period	ECI	BPCI	GMPI
2002	15	T1	0.679	0.824	0.970
		T2	1.111	1.0543	1.006
		T3	0.869	0.932	0.988
2003	15	T1	0.658	0.811	1.074
		T2	1.065	1.032	0.942
		T3	0.837	0.915	1.006
2004	10	T1	0.579	0.761	0.915
		T2	1.232	1.110	1.062
		T3	0.844	0.919	0.986
2005	11	T1	0.565	0.752	1.072
		T2	1.137	1.066	1.057
		T3	0.802	0.895	1.064
2006	10	T1	1.064	0.794	0.998
		T2	1.198	1.094	1.033
		T3	0.8692	0.932	1.015
2007	10	T1	0.784	0.885	0.997
		T2	1.238	1.113	1.082
		T3	0.985	0.993	1.038
2008	12	T1	0.628	0.792	0.910
		T2	1.118	1.057	1.017
		T3	0.838	0.915	0.962
2002~2008	83	T1	0.645	0.803	0.992
		T2	1.146	1.070	1.021
		T3	0.859	0.927	1.006

Note: T1: First period (-1, 0), T2: Second period (0, 1), T3: Whole period (-1, 0, 1)
ECI: Efficiency change index, BPCI: A measure of Technical change index, GMPI: Global Malmquist productivity index

This further comparison can be made on the basis of a year, that is, 2005; the early 2000s (i.e., 2002–2004) are compared with the late 2000s (2006–2008). From <Table 3>, we could find that a value of GMPI over the whole period (T3) was lower than 1 in the early 2000s, but not in the late 2000s. This result implies that the effects of productivity growth arising from technology transfer are increased in the late of 2000s.

5.2. Barriers to Technology Transfer

5.2.1. The Characteristic of the Knowledge Transferred: Causal Ambiguity

An intra-group comparison was suggested to analyze the impact of transferred knowledge according to its characteristic (i.e., causal ambiguity). We divided the samples into two sub-groups: patent and

<Table 3> Results for the Impact of Technology Transfer According to the Time

Event Year	DMU	Period	EC	BPCI	GMPI
2002 - 2004	35	T1	0.645	0.803	0.993
		T2	1.122	1.059	0.995
		T3	0.851	0.922	0.994
2006 - 2008	32	T1	0.674	0.821	0.964
		T2	1.179	1.086	1.042
		T3	0.892	0.944	1.002

Note: T1: First period (-1, 0), T2: Second period (0, 1), T3: Whole period (-1, 0, 1)
ECI: Efficiency change index, BPCI: A measure of Technical change index, GMPI: Global Malmquist productivity index

<Table 4> Results for the Characteristic of the Transferred Knowledge

No	Classification	DMU	Period	EC	BPCI	GMPI
1	Know-how	27	T1	0.694	0.833	1.009
			T2	1.122	1.059	0.970
			T3	0.882	0.940	0.990
2	Patent	39	T1	0.582	0.763	1.002
			T2	1.146	1.071	1.035
			T3	0.817	0.904	1.018

Note: T1: First period (-1, 0), T2: Second period (0, 1), T3: Whole period (-1, 0, 1)
ECI: Efficiency change index, BPCI: A measure of Technical change index, GMPI: Global Malmquist productivity index

know-how. The GMPI and its components are presented in <Table 4>. From <Table 4>, we found that productivity growth arising from patent transfer was identified in both the first period (T1) and second period (T2), while productivity growth arising from know-how transfer was only identified in the first period (T1), in view of the fact that a value of GMPI > 1 indicates positive productivity growth. In the whole period (T3), firms' productivity growth was due only to patent transfer. This result implies that firms' productivity growth is affected more by patent transfer than by know-how transfer.

Our study empirically shows that patent transfer guarantees firms' productivity growth due to a lower barrier. A possible interpretation of this finding is the ease of the transfer. A patent is a relatively more articulated form than know-how. Articulated knowledge such as a patent is likely to be quite straightforward to transfer, because it does not demand a strong social bond between the source and the recipient (Bresman et al., 2010). As a result, it is likely to require lower interaction between the two parties or little regard for personal interaction in order to be effectively transferred (Bresman et al., 2010). The extent to which technological knowledge can be articulated would be positively related to the transfer (Bresman et al., 2010). Another interpretation is the limited competition. As patents can easily restrict the use of third parties, thanks to the monopoly power granted by IPRs, they are able to make the limited competition in an industry. In such circumstances, firms can make a higher profit in view of the fact that a low competition level generally leads to higher profits .

<Table 5> Results for the Characteristic of the Source

No	Classification	DMU	Period	EC	BPCI	GMPI
1	Non-competitive alliances	19	T1	0.659	0.812	1.022
			T2	1.134	1.065	1.010
			T3	0.865	0.930	1.016
2	Competitive alliances	21	T1	0.557	0.746	0.952
			T2	1.166	1.080	1.071
			T3	0.806	0.898	1.009

Note: T1: First period (-1, 0), T2: Second period (0, 1), T3: Whole period (-1, 0, 1)
ECI: Efficiency change index, BPCI: A measure of Technical change index, GMPI: Global Malmquist productivity index

5.2.2. The Characteristic of the Source: Lack of Motivation

Our study carried out an intra-group comparison to investigate the impact of the source's characteristic (i.e., lack of motivation). We classified samples as two sub-groups: competitive alliances and non-competitive alliances. The test results for the two relationships are reported in <Table 5>. From <Table 5>, we could ascertain the firms' productivity growth in both competitive and non-competitive alliances because of GMPI values for both groups were greater than 1, which means the positive productivity growth for both groups. Hence, our study failed to suggest the empirical evidence for firms' productivity deteriorates caused by low levels of the source's motivation.

However, close scrutiny would reveal that when sourcing technologies through a competitive alliance, firms can experience temporal productivity deterioration. This finding implies that competitive alliances can result in productivity decrease unlike non-competitive alliances, which is very interesting but could, to some extent, be expected. While competitors have employed the "market-pull" efficiently, with the market research (e.g., market analysis, competitive analysis, market target determination, etc.) that facilitates the conversion of new technologies into marketable new products, the private sector, on the other hand, has extensively used market research as a significant source of information (Tran and Kocaoglu, 2009). Moreover, competitors' reward system is based largely on commercial activity instead of scientific publications (Bozeman, 2000). It is possible, therefore, that competitive alliances under these circumstances may have a good effect on the firms' productivity for the purpose of technology transfer. However, if considering non-competitive alliances for the purpose of technology transfer, firms need to think very deeply about these issues.

5.2.3. The Characteristic of the Recipient: Absorptive Capacity

To test the impact of the recipient's characteristic (i.e., absorptive capacity), an intra-group comparison was suggested. Our study used firms' size, age, and R&D intensity as the proxy for absorptive capacity. To measure a firm's size, Kim and Vonortas (2006) used sales as a proxy for the size, which can be divided between large and small firms on the basis of sales of US $100 million[4]: "large" if annual sales exceeded $100 million and "small" if annual sales

4) 1 Dollar ≒ 1,000 Korean Won

were less than $100 million (Ragothaman and Korte, 1999). To measure a firm's age, past studies calculated the number of years since the firm was founded (Brown and Kapadia, 2007). Following Garmaise (2008) and Park (2008), firms can be divided into young (firm's age less than 20 years) and old firms (firm's age above or equal to 20 years) using the median age of 20 years. R&D intensity can be categorized into two groups, according to 4%. OECD suggested R&D intensity of 4% as a criterion for classification within either the high-tech industry or low- (or middle-) tech industry. Firms can be divided into high (R&D intensity above or equal to 4%) and low R&D intensity (R&D intensity below 4%).

In much of the literature, R&D intensity as proxy of absorptive capacity has been used to argue that higher R&D intensity firm has high absorptive capacity (Cohen and Levinthal, 1989; Cohen and Levinthal, 1990). Also, proxies such as age (Rao and Drazin, 2002) and size (Geroski, 2005) have been used by the argument that older/larger firms have high absorptive capacity because they have accumulated knowledge and developed routines and processes that facilitate innovation. Accordingly, they can be broadly divided into two sub-groups according to each criterion: high level of absorptive capacity (i.e., large size, old age, high R&D intensity) and low level of absorptive capacity (i.e., small size, young age, low R&D intensity).

The GMPI and its components are presented in <Table 6>. From <Table 6>, we could find that younger/smaller firms or high R&D intensity firms have

<Table 6> Results for the Characteristic of the Recipient

No	Classification		DMU	Period	EC	BPCI	GMPI
1	Size	Large firm	25	T1	0.903	0.950	0.931
				T2	1.127	1.062	1.006
				T3	1.009	1.004	0.968
		Small firm	58	T1	0.557	0.747	1.019
				T2	1.154	1.074	1.027
				T3	0.802	0.896	1.023
2	Age	Young firm	41	T1	0.574	0.758	1.013
				T2	1.218	1.103	1.075
				T3	0.836	0.914	1.043
		Old firm	42	T1	0.722	0.850	0.972
				T2	1.080	1.039	0.971
				T3	0.883	0.940	0.971
3	R&D Intensity	High R&D Intensity	30	T1	0.570	0.755	1.021
				T2	1.218	1.104	1.073
				T3	0.833	0.913	1.047
		Low R&D Intensity	52	T1	0.686	0.828	0.971
				T2	1.109	1.053	0.992
				T3	0.872	0.934	0.981

Note: T1: First period (-1, 0), T2: Second period (0, 1), T3: Whole period (-1, 0, 1)
ECI: Efficiency change index, BPCI: A measure of Technical change index, GMPI: Global Malmquist productivity index

productivity growth because of most values of GMPI > 1. Thus, we couldn't confirm that high absorptive capacity leads to more increased productivity. This finding implies these evidences have been less conclusive.

The majority of the empirical studies have identified absorptive capacity as a knowledge base-more, as the extent of prior knowledge in the company. However, the appropriateness and validity of such proxies for absorptive capacity are questionable, given that the empirical evidence is discordant (Mowaery et al., 1996). For example, Mowery et al. (1996) and Meeus et al. (2001) found that the R&D intensity in affecting innovation was worse proxy of inter-organizational learning. Colin Gray (2006) argued that the attributes of high absorptive capacity firms was higher levels of education, staff development, and propensity to innovate, but not the age of firms. Moreover, proxy such as size is one of the most important organizational factors that affect firms' behavior in response to changes in market environments. Based on structural contingency theory, groups tend to become bureaucratized as size increase, which hampers organizational responsiveness, becomes more rigid in their behavior patterns and diminishes both the volume and diversity of information processing (Nanaka et al., 2000).

As a result, our study couldn't demonstrate that absorptive capacity such as age or size is a necessary condition in increasing productivity. However, we find that only R&D intensity as the proxy of absorptive capacity is important in productivity growth. Namely, if their own absorptive capacity is low, firms must consider a variety of strategies to enhance R&D intensity.

5.2.4. The Characteristics of the Context: Arduous Relationship

In order to investigate the impact of the context's characteristics, namely, the arduous relationship, our study carried out an intra-group comparison. We divided the samples into two sub-groups: low cultural distance (i.e., two parties share the same nationality) and high cultural distance (i.e., two parties of different nationality). The GMPI and its components are presented in <Table 7>. From <Table 7>, we could find that all GMPI values for high cultural distance did not exceed 1 in three periods (i.e., T1, T2, T3), but GMPI values for low cultural distance were more than 1 in two periods (i.e., T2, T3), except the first period (i.e., T1). In other words, low cultural distance generates more effective productivity growth compared with high cultural distance.

<Table 7> Results for the Characteristic of the Context

No	Classification	DMU	Period	EC	BPCI	GMPI
1	High cultural distance	36	T1	0.712	0.844	0.982
			T2	1.137	1.066	0.985
			T3	0.900	0.948	0.983
2	Low cultural distance	41	T1	0.597	0.773	0.988
			T2	1.151	1.073	1.048
			T3	0.829	0.911	1.018

Note: T1: First period (-1, 0), T2: Second period (0, 1), T3: Whole period (-1, 0, 1)
ECI: Efficiency change index, BPCI: A measure of Technical change index, GMPI: Global Malmquist productivity index

Therefore, our study found that the productivity didn't increase in an arduous relationship, usually considered as a barrier to technology transfer. Like the theoretical prediction of Szulanski (1996) and Cummings and Teng (2003), a technology transfer may require numerous individual exchanges when including the tacit components in the transferred technology. The success of such exchanges relies on the ease of communication and the degree of familiarity between the two parties. As a result, similar cultures allow for a smooth working relationship and cultural distance will be a barrier to technology transfer.

Ⅵ. Concluding Remarks

Korean firms have established a worldwide reputation in high technology areas such as that of semi-conductor, LCD, TV, cellular phone, telecommunication equipment, automobile, shipbuilding, and so on. Although Korean firms acquired technological competitiveness in many high-tech products, its reliance on foreign core technology has still not been reduced (Chung, 2009). In spite of the negative side, one cannot deny the positive contributions (e.g., catch-up effect or innovation effect) that the foreign technologies have made.

We attempted to analyze whether technology transfer is a medicine or a poison, as it were, in the light of what Korean firms have reaped from technology transfer. To find the answer to this problem, we empirically analyzed ex-post effect within the framework of the impact of technology transfer on a firm's value. We observed firms' productivity change by comparing their performance before and after receiving the promised technologies from the external source. Further, we studied how barriers to technology transfer influence firms' productivity.

We could find some empirical evidences for successful technology transfers. Firms should take more interest in the characteristics of the transferred knowledge (i.e., patent), of the recipient (i.e., absorptive capacity), and of the context (i.e., cultural distance). In other words, firms that wish to increase productivity through technology transfer should foremost consider patents, if they have high levels of absorptive capacity, and foreign sources.

Our findings may provide certain practical implications to both technology recipient firms that desire to achieve sustained growth and technology supplier firms that hope to gain more licensing fees. Moreover, it will provide the recipients with critical success strategies (e.g., selection of the better supplier, risk hedging) for accomplishing technology transfer. The results of our study can also help technology recipients aware of what constitutes ideal portfolios of technology transfer that best meet their particular needs.

Korean experiences as an empirical settings offer good lessons for policy-makers who are directly responsible for promoting technology commercialization and, especially, for developing countries that desire to experience rapid economic growth or scientific developments through technology transfer. They can use our findings to establish a new R&D policy to accelerate technology diffusion in national R&D projects, as well as to move their technical market to a higher level. In particular, our findings will help decision-makers within firms in conducting comprehensive analysis for technology transfer effectiveness because of providing the important information related to firms' productivity growth. Indeed, in the light of the results presented in this study, firms can not only develop detailed criteria for selecting the best supplier, but also determine what the ideal portfolios in external technology acquisition are.

A significant contribution of our study is associated with the introduction of a model of Szulanski (1996) in the Korea context. We attempted to check whether the strategies for external technology acquisition mentioned in the existing studies are applicable to the Korea context, and thereby could show the fine examples of technology transfer practices. Therefore, our study contributes to the academic society by complementing and extending the existing body of research in the area of technology transfer.

As is also true with other studies, our work is not free from limitations. First, the total sample (83 announcements) was relatively small because firms are averse to making public announcements about technology transfer. Second, our study did not consider various types of technology transfer because it was not easy to find announcements for technical partnerships, joint research, R&D contracts, and/or M&A. Our study also did not reflect the characteristic of the transferred technology or make an inter-industry comparison. In the future, we hope it will be possible to extend the subject and the scope of the research on technology transfer. Third, our study investigated only the technology transfer in Korea, and a multi-national comparison might be interesting in future studies.

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Submitted: December, 5, 2016; 1st Revision: January 3, 2017; Accepted: January 3, 2017