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專利表現和研發國際化：以面板產業為例
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成 果 報 告 目 錄

一、摘要

1.1 中文摘要

本研究計畫已圓滿持執行完畢，有一篇論文 “Strategic Partnership and Its Effect on External Learning of Technology Descendents” 已完成並已投稿 2008 Annual Conference of Academy of Management 審稿中。

1.2 英文摘要

On the basis of this research projects, one paper on “Strategic Partnership and Its Effect on External Learning of Technology Descendents” has been submitted to 2008 Annual Conference of Academy of Management.

二、報告內容

已投稿會議論文一篇如下:

Strategic Partnership and Its Effect on External Learning of Technology Descendents

Jennifer Chen[a], Jimmy Lo[a], Show-Ling Jang[b]

Abstract

We propose four hypotheses to examine how strategic partnership affects external learning of technology descendants from emerging markets under the context of a capital and knowledge intensive industry. The study takes patent citation as a trail of knowledge flow; our empirical evidence show positive pattern of external learning through strategic technology partnership, and among which, trading type of partnership reveals a more substantial impact. Furthermore, a focused approach in extrapolating knowledge from strategic partners seems to be the dominant practice.

Keywords: International Alliances, Patenting and Licensing, Emerging Economies.

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1. Introduction

Researchers have attributed interfirm linkages established by indigenous firms with counterparts in the more advance countries to the success of some East Asia developing countries in certain high technology industries (Gilroy, 1993; Hobday, 1995). Previously, these interfirm linkages were largely done through foreign direct investment and/or original equipment manufacturing, and the learning of technology by East Asian latecomer firms took time to realize (Hobday, 1995). Recently, the interfirm linkage has taken a new form: international alliance.

While the decade of the 1990s has been characterized by the growth of strategic alliances (Gil & de la Fe, 1999), the majority of alliance activity and consequently the research attention is fundamentally associated with the industrialized countries of the Triad (Europe, North American and Japan). While firms from emerging countries are increasingly looking for external sources of R & D capabilities through technological alliances within other more advanced international partners (UNCTAD, 2005), the strategic partnerships they engaged in are often of a different nature than those alliances studied among the developed Triad region.

The international partnerships sought by these latecomer firms are asymmetric in terms of learning and knowledge flow. Namely, one of the partners is technologically much stronger, and the other is only in the position of acquiring new capabilities (mostly manufacturing technology). Such strategic alliance, or strategic partnership, could be a viable means to expedite the learning curve, allowing the latecomers to acquire technology and to access to new knowledge more efficiently comparing to other mechanisms previously adopted.

However, with the exception of few recent studies such as the one by Hu and Jaffe (2003), little has been done in analyzing the effectiveness of learning and the pattern of knowledge flow to the firms in the emerging markets. The objective of this study is therefore to explore how strategic partnership affects external learning of technology descendants from emerging markets. While the term strategic technology partnership (Hagedoorn & Schakenraad, 1994) could be used interchangeably with strategic alliance, we use partnership more often in this study, because it

does not connote mutual flow of information as alliance does, and thus allows us to address asymmetric relationship this study intends to portray.

The study takes patent citation as a trail of knowledge flow and evidence of external learning. We gathered data through three different sources to construct pair relations of strategic partners, and also their respective knowledge positions and linkages with one another in the patent citation network. Our empirical results support our hypotheses that technology descendants do learn more from their alliance partners than other non-allied firms, after controlling the quality factor of the knowledge. Furthermore, when considering the type of alliance form on the extent of interfirm knowledge transfer, we discover trading type of partnership shows a more substantial impact. While the result is in contrast to the conventional wisdom that equity-based structure is a more effective conduit for external learning, it points to the need to consider contingent industry factors in future studies. Our analysis on the attribute of the knowledge flow provides evidence that technology descendants take a focused approach in extrapolating knowledge from their partners. Additionally, when considering localization effect, our sample suggests in today's globalization operating environment, geographic proximity does not facilitate knowledge flow, rather, technology dominance and competitive dynamic are what direct the attention for external learning.

The rest of the paper is organized as follows. Section 2 provides a review of related literature on external learning, knowledge flow and strategic partnership, and further sets up our four hypotheses. Section 3 describes the general background of our empirical context, as well as our source of data, model and measurements. Section 4 discusses the results of our empirical analysis, while section 5 contains our concluding remarks.

2. Theoretical background

2.1 External Learning

While in organizational learning literature, researchers have typically focused on internal learning process (Nonaka, 1994), recently, more attention has been put on the use of external resources for exploitative or explorative learning (Ahuja & Lampert, 2001; Hagedoorn & Duysters, 2002). The intensified global competition and rapid technological changes have forced firms to depend not only on internal capabilities for creating and transmitting knowledge, but also on external sources of knowledge as a critical resource for competitive advantage of firms (Hagedoorn, and Osborn, 2003; Garcia-Canal, et. al. 2007). A firm seeks external learning when it obtains existing knowledge from an outside source. External learning, through a wide range of partnership arrangements, allows the knowledge seeking firms to obtain from their partners the technologies, skills and knowledge that are not available within their organizations.

This leverage of others' capabilities is particularly important for new entrants to the market. Researchers have attributed the success of some East Asia developing countries in certain high technology industries to external learning established by indigenous firms with counterparts in the more advance countries (Gilroy, 1993; Hobday, 1995). Since these firms from the developing countries, or from the weaker centers of the industrial technology, acquired opportunities to obtain technological know-how from the larger and more reputable firms in advanced countries, we could consider them as *technology descendents*.

However, the benefits of external learning by technology descendents should not simply be presumed. When the learning is asymmetric between the participating companies, it is possible technological dependence might result, and the knowledge receiving firms might be allowed a limited learning opportunity as Alvarez Gil & de la Fe observed in their comparative case study (1999). Therefore, in order to assess whether external learning indeed takes place, we have to observe the trail of the knowledge flow.

2.2 Patent Citation as Knowledge Flow

How to track learning? Several prior studies have used patent citation as systematic information that captures how knowledge may diffuse across geographical area, technological regions as well as between companies (Jaffe, Trajtenberg, & Henderson, 1993; Jaffe & Trajtenberg, 1999; Thompson & Fox-Kean, 2005). Patent documents contain citations to other patents, as the recognition of any prior art of the technology, from which the new knowledge has been built upon. Therefore patent citations serve the function of indicating a link of relevance between the cited and the citing patents.

Researchers have interpreted the cited patent as a "technological antecedent" of the citing patent (Jaffe, et. al. 1993). Rosenkopf and Almeida (2001) use patent citation data to assess different mechanisms of external learning; patent citation data has also been used to measure the intensity of inter-firm learning and technological knowledge flow (Mowery et al., 1996; Stuart & Podolny, 1996). The usage of patent citation as an indicator of knowledge flow is not without criticism, for example, it is possible that citations appear in form without knowledge flow in substance, or vice versa, knowledge transfer occur without generating a citation. Despite these and other potential weakness of using patent citations (Desrochers, 1998), researchers have found out based on a broad survey among inventors that direct patent citations are a relatively good indicator of knowledge flows (Jaffe, Trajtenberg, Fogarty, 2000).

2.3 Strategic Partnership as a Conduit for External Learning

A variety of mechanisms may be used to access external knowledge, such as the forming of strategic alliances, the hiring of scientists and engineers, and the appropriation of informal networks (for a review, see Almeida, Dokko & Rosenkopf, 2003). Among these mechanisms, strategic alliances have been widely studied. While the motivations for forming strategic alliance could range from reducing costs and risks to facilitating strategic coordination among competitors, many prior researchers have stressed the learning feature of alliance, as it provides a platform for

participating firms to access skills and capabilities of the partners. (Inkpen and Crossan, 1995; Teece & Pisano, 1994; Hamel 1991).

Most extant studies of interorganizational knowledge flow or interorganizational learning are set in a context where there is a comparable knowledge base among alliance participants, and thereby they could reap the benefits of complementary skills (Colombo et al, 2006; Rothaermel & Deeds, 2004). In analyzing factors that influence the extent of interfirm knowledge transfer, Mowery, Oxley & Silverman (1996) found out the presence of alliance facilitates partner firms' technological resources overlap. Furthermore, the empirical results of prior studies addressing the flows among firms based in the advanced economies do support a mutual, symmetrical flow over time (Jaffe, Trajtenberg & Henderson, 1993; Jaffe & Trajtenberg, 1999).

It should be noted that most alliance studies focus on companies of similar level in their technological capabilities, leading to situations where there are learning opportunities for the two partners. However, partners might not always be of equal footing. As firms from emerging countries are increasingly looking for external sources of R & D capabilities through technological alliances within other more advanced international partners (UNCTAD, 2005), this type of partnerships is of an asymmetric nature in terms of learning and knowledge flow, that is, one of the alliance partners is looking to the alliance for organizational learning (such as manufacturing technology), while the other is looking for other kind of outcomes (such as licensing fees).

This study focuses on the learning effect of technology descendents. In line with prior argument made by Mowery, Oxley & Silverman (1996) that strategic alliance as a conduit for interfirm knowledge transfer, we believe the presence of strategic partnership, even in the context of unilateral knowledge flow, has pronounced impact on firm's knowledge accumulation. Our first hypothesis postulates that when technology descendents begin to develop their own knowledge stock, they will reveal a stronger knowledge lineage to their strategic partners comparing that to other firms.

Hypothesis 1: With the presence of strategic partnership, knowledge decedents in the process of building their own knowledge stock, tend to undertake more external learning (as shown in patent citation) from their strategic partners than from other non-allied firms.

2.4 Partnership form and effect on knowledge transfer

Not only the presence of the alliance matter to the extent of knowledge transfer, but also the different forms of alliance would carry varied impacts on transferring knowledge between partners. Some researchers differentiate between equity and contract-based alliance (Chen, 2004; Das & Teng, 1998). Equity involves equity interest between the partners, while contract-based alliance involves arm-length contractual transactions. Based on survey data, Chen (2004) suggested that alliance form, together with knowledge attribute, have an interaction effect on the intensity of knowledge transfer. It has been suggested that contract-based alliance is more likely to occur when technology is stand-alone and the knowledge is more explicit (Teece, 1998) while the less codifiable and tacit the knowledge, the knowledge transfer between partners would take place in an organizational setting, thus an equity linkage is more suitable.

Another way to distinguish different alliance form is by the flow of interaction. Trading alliances involve exchange for monetary payments in the undertakings, such as licensing, and the information flow is relatively unilateral. On the other hand, non-trading alliances are considered as bilateral arrangements, such as equity joint venture and various technology sharing or joint development agreements (Chen & Chen, 2002; Mowery, Oxley & Silverman, 1996). Empirical results have shown under trading alliance, or unilateral transfer of an existing technology, it is less likely for the alliance structure to be equity-based (Garcia-Canal, et al. 2007). The consequence on interfirm knowledge transfer, however, has been mixed. Mowery, Oxley & Silverman (1996) has shown in their empirical work that trading, unilateral based alliances create fewer opportunities for interfirm knowledge transfer comparing to non-trading, bilateral arrangements, and they suggested that it is more difficult to acquire technological capabilities through market-based mechanisms.

However, Hagedoorn (1993) noticed along the rise of international strategic technology partnerships (although less so in US firms than European and Japanese ones), there has been a growing use of non-equity agreements, which seem to be a superior means to undertake technological development in high-technology and fast-evolving sectors. They postulated that the improved enforceability of contracts and intellectual property protection as well as the increasing knowledge and familiarity of firms in conducting international business activity have attributed to trend. Our second hypothesis is therefore set to test whether trading alliance transfer explicit knowledge more effectively.

Hypothesis 2: Trading type of strategic partnership has a stronger effect on the prevalence of knowledge decedents' external learning from their partners than that observed in the non-trading partnership.

2.5 Technology Trajectory

Another question worth probing is the attribute of the knowledge flow between the strategic partners, whether the unilateral learning occurs more likely inside or outside of the core technology domain. In other words, when knowledge descendents learn from their strategic partners, they could focus on the technology trajectory upon which the contractual relationship with their partners is based , or they could span out to other technology realms which are parts of partners' diversified knowledge portfolio.

While knowledge acquisition might be generally broad in directions, when there exist a specific learning target, such as alliance partners, the scope of learning would likely to be set in a more confined technology trajectory. Prior studies using patent citation have demonstrated that knowledge flow from other industries or other technology classes has a much stronger prevalence than that from the same technology trajetory (Fung & Chow, 2002; Jang, Lee & Chen, 2005). However, in modeling the pattern of patent citation in a single class of flat panel display (FPD) technology, Stolpe (2002) concluded technological closeness of the citing and cited patents are the determinants of citation choice. The finding seems to suggest learning is more confined to the

same knowledge domain, that progress is cumulative and knowledge transfer occurs more likely from the same technology field. In consolidating the seemingly different conclusions, we believe the presence of strategic partnership plays a role in determining the bandwidth of firms' external learning. As firms could be limited contextually in their search for new knowledge (Rosenkopf, Almeida, 2003), knowledge pertaining to the domain of the strategic partnership is more apparent, and firms would tend to concentrate their absorption in such core domain. Therefore, we postulate that:

Hypothesis 3: Technology decedents tend to take a focused, specialized approach in extrapolating knowledge from their advanced partners.

2.6 Localization effect on knowledge transfer

Localization effect[1] refers to the tendency of knowledge spillovers among individuals or firms located in proximity. In the pioneer work by Jaffe et. al.(1993), the researchers were able to demonstrate that the propensity to cite from the same region is much higher, particularly at the state and metropolitan level, indicating the geographic localization of knowledge flows. Such findings have been extended to other international contexts. Not only the localization effect is still prevalent across countries, that it's more likely to cite patents from own countries than from other countries, but also there is a bilateral flow between countries, with notable symmetry between citing and cited intensities (Jaffe & Trajtenberg, 1999). As a result, it becomes commonly assumed that localized citation patterns are evidence of geographically localized knowledge spillovers (Thompson & Fox-Kean, 2005). However, Stolpe (2002) cast doubt on such conjecture. He argued the diffusion of flat panel display (FPD) technology among inventors is not locally bounded, as the probability of citation does not depend on the proximity between inventors. In addition, for the newly industrialized economies, knowledge flow from the same region is much less significant as the majority of their citations made are targeted at patents of the

[1] This is a concept rooted from Marshal's (1920) agglomeration economies model.

advanced economies (Hu & Jaffe, 2003). Therefore, we hypothesize knowledge localization effect does not present in emerging markets:

Hypothesis 4: For technology descendents, external learning from partners of the same area is less evident than the knowledge flow obtained from cross-border partners.

3. Methodology

3.1 Empirical context

This study focuses on the flat panel display (FPD) industry, an empirical context which exemplifies rapid shift in market demands and technological fronts, and thereby fast learning and agile adaptation are essential features for companies operated in this industry. The display technology is a vital interface for modern electronic equipments in the areas of communication, information processing and entertainment. As the intermediate goods, flat panel displays are essential components for mobile phones, computer monitors, and television screens and a wide ranges of industrial and consumer products. Given the rise of the global demand on information and consumer electronic devices and equipments, as well as the ever shrinking product life cycle, strategic partnerships are frequently undertaken by FPD firms as a means to deal with the market and technology dynamic.

Like other technologies, the FPD technology has its evolution in technology itself and also in its centers of activities. The FPD technology has its root in the U.S. , with RCA Corporation being the first company to utilize liquid crystal in making display panel in 1968. In 1973, the Japan-based Sharp Corp. acquired RCA's patent and subsequently developed series of products that applied the liquid crystal display technology. The broad application in making commercialized products under mass production capacity has been since epitomized by the Japanese firms. While there have been several competing technologies available in making display interfaces, in the early 1990s, the development in thin-film transistor liquid crystal display (TFT-LCD) technology has outperformed a prior twisted nematic/super twisted nematic

(TN/STN) LCD technology. As the dominance of TFT-LCD technology established, South Korean companies in 1995 stepped into TFT-LCD manufacturing, and because of their well-grounded DRAM technology together with the strategic support of the public policy, Korean firms have overcome the bottleneck in making mass production. While Korean firms rapidly eroded the market monopoly position taken by the Japanese firms, Taiwanese firms, on the other hand, also prepared to enter this technology-intensive and capital-intensive industry.

As new entrants in the FPD industry, the Taiwanese indigenous firms did not have the core technology available, and therefore, they actively engaged in the formation of strategic partnerships, especially in those with Japanese firms, to obtain the necessary technological capabilities. While the Taiwanese firms' acquisition of manufacturing know-how from their partners is to bypass the technological barrier and gain a foothold, Japanese firms entered into the partnerships are for financial and strategic reasons. During the Asia Financial Crisis from 1997 to 1998, the price of flat panel took a dramatic dive caused by major Korea firms who initiated extreme cut-throat pricing strategy due to the plunge of their currency valuation. The adverse impact of such destructive market pricing on the Japanese firms was reflected on the significant decrease on capital expenditure, and for a capital-intensive industry such as FPD, the retrench could be detrimental. Therefore, when Taiwanese firms initiated the technology transfer agreements with ample capital funding, Japanese firms have regarded Taiwanese firms as complementarities for the more cost-effective production base, and consequently transferred the more mature technology for large-sized TFT-LCD. Another strategic consideration behind the motivation for Japanese technology transfer is to get the additional capital funding resulted from the royalty fee received and to subsequently invest in more advanced technology. Various Japanese firms have ventured into the LTPS (Low Temperature Poly Silicon TFT-FPD) technology, and transferring the more mature technology to Taiwanese firms would provide the necessary capital in developing the next generation of technology.

Table 1 provides a 20-year glimpse of the development of the FPD industry via patent counts and the average growth rate from 1976 to 2006. It should be noted while most TFT-LCD manufacturing is nowadays clustered in Asia, with Korean and Taiwanese manufactures taking up significant worldwide market share[2], US and Japanese firms have maintained their advantages in RD capabilities, as evidenced by their patent counts. They focus on providing critical supplies, equipments and intellectual properties from the upstream as well as in staying in the high margin niche markets. Nevertheless, based on the annual patent growth rate, it is also evident that Korean and Taiwanese firms have been actively putting efforts in generating knowledge in the field. The objective of this study is to analyze the effect of strategic partnerships on the learning and capability building of technology descendents such as Taiwanese FPD firms. These strategic partnerships undertaken by Taiwanese firms are depicted in Table 2. This table shows the countries of the partners and also classifies the partnership based on whether the collaboration structure is of trading or non-trading nature, as discussed in section 2.

Insert Table 1 and Table 2 Here

3.2 Data

The data for this study is drawn from the online database of United States Patent and Trademark Office (USPTO), which keeps track of all patents filed and granted in the United States. Firstly, by collecting all patents filed to USPTO by the focal firms, we obtained a primary sample of 1007 patents, and after reviewing these patents individually, we eliminated those pertaining to CRT technology, leaving a sample of patents which relate directly to FPD technology. Because the majority (98.8%) of these patents was filed after 2000, we therefore took the period between year 2000 to year 2006 as our sample coverage. Based on the 955 patents

[2] The top four TFT-LCD manufactures, Samsung and LG Philips LCD in South Korea, and AU Optronics and Chi-Mei Optronics in Tainan has taken two thirds of the global market share since 2003.

identified during the sample period, we used Java script to further identify the cited patents of these 955 FPD patents, and obtained a sample of 4627 cited patents. From which we were able to configure 1726 pair relationship of the cited and citing firms.

To gather strategic alliance information, we reviewed and cross-checked secondary data from various sources, such as companies' official websites and annual reports as well as two industrial intelligence websites: http://www.topology.com.tw/tri/, http://www.digitimes.com.tw. After thorough reviews, we obtained 79 strategic partnerships ranging from equity joint ventures, joint development agreements, R &D contracts, and licensing for the transfer of existing technology.

3.3 Model

Dependent variable.

In this study, the extent of external learning that technology descendents has conducted is measured by the citation they made to their strategic partners' prior patents. We adopted this measure from the prior work done by Mowery, Oxley & Silvermand (1996), but we modified the base measure to include time factor in order to observe the change of learning pattern over time. When $Firm_i$ absorbs knowledge from its alliance partner, $Firm_j$ during a specific $year_t$, we will see a higher citation rate made to $Firm_j$'s patents in all new patents applied by $Firm_i$ during the prescribed period.

$$Crate_{ijt} = \frac{\text{Citation to } Firm_i\text{'s patents in } Year_t \text{ in } Firm_i\text{'s patents in } Year_t}{\text{Total citations in } Firm_i\text{'s patents in } Year_t}$$

If 10 citations were made to $Firm_j$'s patents by $Firm_i$ in $Year_t$, and $Firm_i$ recorded a total citation of 25 during the period, then $Crate_{ijt}$ equals to 10/25.

The citation rate $Crate_{ijt}$ indicates the strength of knowledge lineage, or the importance of $Firm_j$ being the external learning source to knowledge descendents $Firm_i$.

A note worth considering is that studies using patent citations as a proxy for knowledge flow should also take into account that different industries have different propensities to codify

knowledge (Lerner, 1994), and citation measurement might be more relevant in some industries versus the others. Industries that are characterized by rapid advancing or cumulative technologies tend to have higher propensity to patent such as the semiconductor industry (Hall & Ziedonis, 2001). As FPD technology is also characterized as having high share of codified knowledge that it is rapidly communicated through publications (Stolpe, 2002), this industry is considered an appropriate context to observe knowledge flow via patent citation data.

Independent variables.

We use two variables to capture the impact of strategic technology partnership (STP). The first variable, $DSTP_{ijt,}$ captures the presence of STP. We coded '1' if $Firm_i$ engaged in STP with $Firm_j$ in $Year_t$ and the following three years, and '0', if the cited company $Firm_j$ did not have any partnering relationship with $Firm_i$. A three-year lag was applied because it is assumed that learning might not occur immediately nor occur only during the period when the alliance established. Rather, the knowledge diffusion accompanied by the presence of alliance would require some time to take place, before the impact on citation rate could be observed.

The second variable, $Dform_{ijt,}$ is to distinguish different STP forms. We coded '1" if the partnership is of a trading nature, involving the unilateral transfer of an existing technology and payment in exchange. A '0' was coded if the partnership non-trading, and bilateral in interaction flows, such as equity joint venture and various joint development projects. Similarly, the three-year lag was applied.

The knowledge attribute refers to the technology domain reflected in technology descendents' citing patents. It is measured by the ratio of having cited and citing patents being in the same technology class. In other words, this variable $Sclass_{ijt}$ is the proportion that citing patents of $Firm_i$ and cited patents of $Firm_j$ stay within the same technology trajectory relative to the rest of $Firm_i$'s citations during a specified period. For example, assuming that 10 patents of $Firm_j$ were being cited by $Firm_i$, and among which six cited patents pertain to the same

technology class as the citing patents; if we further know that $Firm_i$ made a total of 25 citations during $Time_t$, then we could calculate $Sclass_{ijt}$= 1/25 +1/25+1/25……+1/25 = 6 /25.

To assess the effect of strategic partners' geographic origin on knowledge flow, we also set up several country dummy variables. We coded '1' if the nationality of the cited Fim_j is US, Japan, Korea or Taiwan, and coded '0' for the other countries. These four countries were selected because of their active involvement in the FPD industry as reflected on their significance on the overall patent shares (see table 1).

Control variables

This study includes three sets of control variables. The first set incorporates year control to assess time effect, how the elapse of time would affect the level of external learning. We coded '0' for the base year 2000, and '1' for 2001-2006. The second set of variables is set for firm control. We coded '0' for Chi-Mei, one of our seven focal firms, and '1' for the rest. Lastly, the propensity to cite could either be influenced by the presence of strategic alliance, or by the quality of the cited patents despite the lack of any partnership relationship. Therefore, it is important to distinguish those patents of leading positions as they are prone to receive higher citations. By adopting the concept of degree centrality which reflects the degree of firms holding prominent positions in the knowledge network (Spencer, 2003), we compute via the use of UCNET network software an elaborate centrality (Ct) measure, which computes the frequency of $Firm_j$'s patents being cited. The higher the value, the higher the citation made to the particular patent, and thus an indication of the importance, or quality of patent's codified knowledge.

In summary, our model specification is as follows:

$$Crate_{ijt} = F (DSTP_{ijt} , Dform_{ijt,} , Sclass_{ijt} , Dcounty_{jt} , Dyear_{t} , Dfirm_{i,} Ct_{jt})$$

We run the two variables $DSTP_{ijt}$, $Dform_{ijt}$ separately in two regression models.

4. Empirical Results

Table 3 provides descriptive statistics for our sample variables. Correlation table is not

presented because all correlations under examined are well under 0.5, indicating no sign of collinearity among variables. Table 4. shows estimates of our OLS regression models with all the independent and control variables. As predicted by our hypothesis 1, our variable DSTP, the presence of strategic partnership, is positive and significant at 0.1 level, indicating that citations made by knowledge decedents to their strategic partners are more prevalent than those to other non-allied firms. This significance holds even after we control for the prominent positions of the cited patents in the knowledge network.

Hypothesis 2 is confirmed. Trading-based partnership support higher levels of interfirm knowledge transfer than non-trading based partnership, as the variable Dform is positive and significant at 0.1 level. Hypothesis 3 stating that a focused and specialized approach in extrapolating external knowledge is also confirm, as Sclass shows a positive sign and appears significant at 0.01 level. Finally, hypothesis 4 which suggests an absence of localization effect on knowledge flow is supported by our empirical evidences. All the country variables are significant at 0.01, except for Taiwan, where our focal firms reside.

Our year control variable show consistently negative signs and all estimates appear statistically significant. It seems at the first sight that the learning dynamic diminishes as time evolves. The control variable centrality Ct, is positive and significant at 0.05 level, indicating the quality of patent does induce higher propensity to cite.

Insert Table 3 and Table 4 Here

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5. Conclusions

This study configures the citation network of seven focal FPD firms (knowledge descendants) and based on the cited and citing pairs constructed, we attempt to analyze to what extent the presence of strategic partnership, the type of such partnership arrangement, the

embedded technology trajectory, and the geographical origin of the strategic partners would determine the learning trail of these knowledge descendent firms. While our hypotheses are generally supported by the empirical results, some findings require additional elaboration.

While different contractual forms would lead to different degree of technology transfer, from tacit experience sharing to codified procedure setting up, conventional wisdom suggests that equity-based or non-trading bilateral structure is a more effective conduit for learning. Our result related to hypothesis 2 shows the contrary. It appears that non-equity agreements are a superior means to absorb external knowledge. On a firm-level basis, the propensity to use different types of arrangements is associated with industry-specific factors. Therefore, when considering the appropriate alliance structure, it is necessary to take into account of industry factors. Because non-trading alliance will impose similar stake of financial risks on both partners, for an industry such as FPD industry being extremely capital intensive, the larger and more reputable firms in advanced countries would tend to avoid nont-trading partnership and focus on arm-length trading type of contractual relationship. Thus, the learning effect from trading type of partnership is more pronounced.

Additionally, when considering localization effect, our sample suggests in today's globalization operating environment, geographic proximity (Taiwan) does not facilitate knowledge flow, rather, technology dominance (US, Japan)and competitive dynamic (Korea) are what direct the attention for external learning. One of the shortages of this study is that while we account for firm control, we didn't further include firm-specifc factors to explain different propensity of firms in learning and alliance engagement, which could be a topic for future exploration.

Nevertheless, to the best of our knowledge, this study is one of the first to address the extent of external learning under asymmetric partnership relationship. Given the rapidly evolving technological environment, with firms actively catching up and further venturing into new frontiers, we believe the issue of knowledge flow in the context of technology descendants would

only become more relevant for both managerial and academic concerns.

Table 1 Patent counts and growth rate of FPD industry: 1976-2006

	1976~1980	1981~1985	1986~1990	1991~1995	1996~2000	2000~2006
U.S.	278	254	407	649	1525	2244
		(-8.63%)	(60.24%)	(59.46%)	(134.98%)	(47.15%)
Japan	135	206	479	1011	2647	5738
		(52.59%)	(132.52%)	(111.06%)	(161.82%)	(116.77%)
Korea	0	0	2	110	514	2524
		(0.00%)	(0.00%)	(5400.00%)	(367.27%)	(391.05%)
Taiwan	0	0	5	54	196	1168
		(0.00%)	(0.00%)	(980.00%)	(262.96%)	(495.92%)
Others	96	94	122	111	225	986
		(-2.08%)	(29.79%)	(-9.02%)	(102.70%)	338.22%)
Total	509	554	1015	1935	5107	12660
		(8.84%)	(83.21%)	(90.64%)	(163.93%)	(147.90%)

Source: USPTO, compilation by this study

Table 2 Strategic Partnerships Engaged by Focal Firms

TA: Trading type alliance

NTA: Non-trading type alliance

Years	**U.S.**		**Japan**		**Korea**		**Taiwan**		**Others**	
	T.A.	**N.T.A**	**T.A.**	**N.T.A**	**T.A.**	**N.T.A**	**T.A.**	**N.T.A**	**T.A.**	**N.T.A**
1994	0	0	1	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	1	0	0	0
1997	0	0	1	1	0	0	0	0	0	0
1998	0	1	2	1	0	0	1	0	0	0
1999	0	0	2	0	0	0	0	0	0	0
2000	0	0	2	0	0	0	1	0	0	0
2001	3	0	4	5	0	1	1	0	0	0
2002	0	0	4	3	0	0	0	1	0	0
2003	0	1	4	1	0	0	1	1	0	0
2004	2	0	3	1	0	0	1	1	0	0
2005	4	2	1	5	0	0	0	3	2	0
2006	2	0	1	2	0	1	0	2	2	0
Total	11	4	25	19	0	2	6	8	4	0

Table 3 Variable statistic summary

Variable	Obs	Mean	Std. Dev.	Min	Max
Crate	1726	0.0217	0.0459	0.0011	0.5
DSTP	1726	0.0637	0.2443	0	1
Dform	1726	0.0550	0.2281	0	1
sclass	1726	0.0144	0.0421	0	0.5
Dus	1726	0.3789	0.4853	0	1
Djp	1726	0.3789	0.4853	0	1
Dkr	1726	0.0892	0.2851	0	1
Dtw	1726	0.0620	0.2412	0	1
D2001	1726	0.0238	0.1523	0	1
D2002	1726	0.0886	0.2843	0	1
D2003	1726	0.1008	0.3012	0	1
D2004	1726	0.2039	0.4030	0	1
D2005	1726	0.2254	0.4180	0	1
D2006	1726	0.3424	0.4747	0	1
Dauo	1726	0.3720	0.4835	0	1
Dcpt	1726	0.0997	0.2996	0	1
Dhsd	1726	0.1958	0.3970	0	1
Dpvi	1726	0.0371	0.1890	0	1
Dqdi	1726	0.0359	0.1861	0	1
Dtpo	1726	0.1147	0.3188	0	1
sclass	1726	0.0144	0.0421	0	0.5
Ct	1726	0.9021	2.5015	0	22.981

Table 4 Results on OLS Regression.

Y=Crate

Variable	Estimates	S.D.	Estimates	S.D.
DSTP	0.0029*	0.0016		
Dform			0.0032*	0.0017
Sclass	0.9236***	0.0160	0.9235***	0.0160
Dus	0.0021***	0.0008	0.0021***	0.0008
Djp	0.0025***	0.0009	0.0026***	0.0009
Dkr	0.0056***	0.0019	0.0056***	0.0019
Dtw	0.0011	0.0011	0.0010	0.0011
D2001	-0.0284*	0.0157	-0.0284*	0.0157
D2002	-0.0364**	0.0151	-0.0364**	0.0151
D2003	-0.0409***	0.0149	-0.0408***	0.0149
D2004	-0.0445***	0.0148	-0.0444***	0.0148
D2005	-0.0447***	0.0148	-0.0446***	0.0148
D2006	-0.0466***	0.0148	-0.0465***	0.0148
Dauo	-0.0016	0.0013	-0.0016	0.0013
Dcpt	0.0081***	0.0029	0.0081***	0.0029
Dhsd	-0.0020*	0.0012	-0.0021*	0.0012
Dpvi	0.0054	0.0038	0.0055	0.0038
Dqdi	0.0100***	0.0031	0.0100***	0.0031
Dtpo	0.0016	0.0013	0.0016	0.0013
Ct	0.0009**	0.0004	0.0009**	0.0004
_cons	0.0473***	0.0147	0.0472***	0.0147
N		1726		
Adjusted-R^2		0.8805		

* $p < 0.1$.

** $p < 0.05$

** $p < 0.01$

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