附件一

行政院國家科學委員會補助專題研究計畫

創新持續性之探討：指標衡量及績效評估

計畫類別：■個別型計畫　□整合型計畫
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計畫主持人：陳慧如
共同主持人：無
計畫參與人員：無

成果報告類型(依經費核定清單規定繳交)：完整報告

本計畫除繳交成果報告外，另須繳交以下出國心得報告：
□赴國外出差或研習心得報告
□赴大陸地區出差或研習心得報告
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□國際合作研究計畫國外研究報告

處理方式：除列管計畫及下列情形者外，得立即公開查詢
□涉及專利或其他智慧財產權，□一年■二年後可公開查詢

中　華　民　國　100 年 12 月 25 日

附件二

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估 ■達成目標 □ 未達成目標（請說明，以 100 字為限） □ 實驗失敗 □ 因故實驗中斷 □ 其他原因 說明：
2. 研究成果在學術期刊發表或申請專利等情形： 論文：■ 一篇已被接受且發表 ■一篇審稿中 ■一篇修改中 專利：□已獲得 □申請中 □無 技轉：□已技轉 □洽談中 □無 其他：（以 100 字為限）

How Technology Descendents Use

Strategic Partnering To Improve Their External Learning

Abstract

We propose four hypotheses to examine how strategic partnership affects external learning of technology descendants from emerging markets under the context of Taiwan's flat panel display industry. The study takes patent citation as a trail of knowledge flow, and our empirical evidence show positive pattern of external learning through strategic technology partnership. Particularly, trading type of partnerships characterized by the asymmetric relations brings more impact than other kind of partnerships. Furthermore, a focused approach in extrapolating knowledge from strategic partners seems to be the dominant practice.

Keywords: Strategic alliance, Patent citation, External learning, TFT-LCD, Flat panel display.

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1. Introduction

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

The decade of the 1990s has been characterized by the growth of strategic alliances (Alvarez Gil & de la Fe, 1999), and the majority of such alliance activity and consequent research attention it has spawned is associated fundamentally with the industrialized countries of the Triad (Europe, North American and Japan). While firms from emerging countries increasingly search for external sources of R & D capabilities through technological alliances with 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 both learning and knowledge flow. Namely, one of the partners is technologically much stronger, and the other is in the position of only 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 compared 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 to analyze 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. Although the term strategic technology partnership (Hagedoorn & Schakenraad, 1994) can be used interchangeably with strategic alliance, we use partnership more often in this study, because it does not, as alliance does, connote mutual flow of information and thus allows us directly to address and emphasize asymmetric relationship.

The study takes patent citation as a trail of knowledge flow and evidence of external learning. As new entrants in the flat panel display (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 partnerships with Japanese firms, to obtain the necessary technological capabilities.

We gathered data from 7 Taiwanese FPD firms through three different sources to construct 1726 pair relations of the cited and citing firms between strategic partners during 2000-2006, and we also documented their respective knowledge positions and linkages with one another in the patent citation network. Our empirical results support our hypotheses, after controlling the quality factor of the knowledge, that technology descendants do learn more from their alliance partners than other non-allied firms. Furthermore, when we consider the type of alliance form across all inter-firm knowledge transfer, we discover that designating trading type of partnership reveals a more substantial impact on such transfers. While the result contrasts to the conventional wisdom that holds equity-based structure to be a more effective conduit for external learning, it nevertheless points to the need in future studies to consider contingent industry factors. Our analysis of the attribute of the knowledge flow provides evidence that technology descendants choose a focused approach in extrapolating knowledge from their strategic partners. Additionally, when localization effect is taken into

account, our sample suggests in today's globalization operating environment, technology dominance and competitive dynamic, rather than geographic proximity, facilitate knowledge flow and direct attention to external learning.

The rest of the paper is organized as follows. Section 2 reviews the 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, and Section 5 offers our concluding remarks.

2. Theoretical background

2.1 External Learning

In organizational learning literature, researchers have typically focused on internal learning process (Nonaka, 1994), but 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 to rely on external sources of knowledge as a critical resource for competitive advantage among firms (Hagedoorn, Kranenburg 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 to them within their own organizations.

This leverage of others' capabilities carries particular importance 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 (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 refer to them as *technology descendents*.

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

2.2 Patent Citation as Knowledge Flow

How to track learning? Several prior studies have employed 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 required recognition of any prior art of the technology upon which the new knowledge has been built upon. Therefore patent citations function as indicators of relevant links 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 (2003), in particular, pursue patent citation data to assess different mechanisms of external learning. Citation data has also been used to measure the intensity of inter-firm learning and technological knowledge flow (Mowery et al., 1996; Podolny, Stuart and Hannan, 1996). However, the practice 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 occurs without generating a citation. Despite these and other potential weakness of using patent citations (Desrochers, 1998), researchers, based on a broad survey among inventors (Jaffe, Trajtenberg, Fogarty, 2000) have discovered that direct patent citations are a relatively good indicator of knowledge flows.

2.3 Strategic Partnership as a Conduit for External Learning

A variety of social mechanisms already 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 can range from reducing costs and risks to facilitating strategic coordination among competitors, many prior researchers (Hamel, 1991) have stressed the learning feature of alliance, as it provides a platform for participating firms to access skills and capabilities of the partners.

Most extant studies of interorganizational knowledge flow or interorganizational learning (Colombo et al, 2006; Rothaermel & Deeds, 2004) are set in a context where there is a comparable knowledge base among alliance participants exists, and thereby permits the possibility that the participants might reap the benefits of complementary skills. In analyzing factors that influence the extent of interfirm knowledge transfer, Mowery, Oxley & Silverman (1996) claimed the presence of alliance facilitates the overlap of partner firms' technological resources. 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, which lead to situations where there are learning opportunities for both partners. However, partners might not always on equal footing. As firms from emerging countries, for example, are increasingly looking for external sources of R & D capabilities through technological alliances with other more advanced international partners (UNCTAD, 2005). This type of partnerships, in terms of learning and knowledge flow, is of an asymmetric nature, that is, one of the alliance partners seeks the alliance for organizational learning, such as manufacturing technology, while the other searches for other kinds of outcomes, such as licensing fees, markets, or other purposes.

This study focuses on the learning effect of technology descendents. In line with the prior argument made by Mowery, Oxley & Silverman (1996) that strategic alliance is a conduit for inter-firm knowledge transfer, we believe the presence of strategic partnership, even in the context of unilateral knowledge flow, has pronounced impact on a 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 compared to that of other firms.

Hypothesis 1: In the presence of strategic partnership, knowledge descendents, 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 does the presence of the alliance affect the extent of knowledge transfer, but also the different forms of alliance themselves may variously impact the knowledge transfer between partners. Some researchers differentiate between equity and contract-based alliance (Chen & Chen, 2002; Das & Teng, 1998). Equity alliance involves equity interest between

the partners, while contract-based alliance involves arm-length contractual transactions. Based on survey data, Chen & Chen (2002) suggested that alliance form, together with knowledge attribute, have an interactive effect on the intensity of knowledge transfer. It has been argued that contract-based alliance is more likely to occur when technology is stand-alone and the knowledge is more explicit (Teece, 1998). The inference then is that the less codifiable and tacit the knowledge, the more likely 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 to observe 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 in the study by Garcia-Canal, et al. (2007) have shown under trading alliance, or unilateral transfer of an existing technology, it is less likely for the alliance structure to be equity-based. However, the consequence of these results on inter-firm knowledge transfer has been mixed. Mowery, Oxley & Silverman (1996) has shown in their empirical work that trading, unilateral based alliances create fewer opportunities for inter-firm knowledge transfer than non-trading, bilateral arrangements; they suggested, in fact, it is more difficult to acquire technological capabilities through market-based mechanisms under trading alliance.

However, Hagedoorn (1993) noticed that the rise of international strategic technology partnerships (although less so in US firms than European and Japanese ones), produced 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. It is 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 this trend. Our second hypothesis therefore tests whether trading alliance transfers explicit knowledge more effectively than non-trading alliance.

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

2.5 Technology Trajectory

Another concern worth probing is the attribute of the knowledge flow between the strategic partners. Does the unilateral learning occur 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. Alternatively, they could reach out to other technology realms that represent a portion of partners' diversified knowledge portfolio.

While knowledge acquisition might generally be broadly directed, when a specific learning target exists, such as alliance partners, the scope of learning would follow 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 trajectory (Fung & Chow, 2002; Jang, Lee & Chen, 2007). 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, 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 and 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 descendents 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 international contexts. Not only is the localization effect still prevalent across countries – citation are more likely to be based on patents from own countries than from other countries, but there is also 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 advanced

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

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.

Insert Figure 1 Here

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3. Methodology

3.1 Empirical context

This study focuses on the flat panel display (FPD) industry, an empirical context that exemplifies rapid shift in market demands and technological fronts (Fuller, Akinwande and Sodini, 2003; Jang, Lo and Chang, 2009), and consequently, fast learning and agile adaptation are essential features for companies that operate in this industry. In contrast with conventional bulky cathode ray tube (CRT) displays, FPD functions as a vital device for modern electronic equipments in the areas of information, communications and entertainment, due in particular to its slim, lightweight form, small foot-stand, and portability. Given the strong demand for notebook PCs, desktop PC monitors, TVs and mobile phones, and a wide range of consumer electronics and industrial products, new entries to the FPD industry are encouraged and strategic partnerships are frequently undertaken under fast-track or catch-up conditions (Fuller et al., 2003; Mathews, 2005).

Like many other technologies, FPD has its evolution in technology itself and also in the development of products and mass-production processes. Most FPD technologies have their roots in the U.S., with RCA first developing Liquid Crystal Display (LCD) for use in the cockpit instrument panel of fighter aircraft in 1968. LCD is one among many various

applications of FPD technology, others including electroluminescent, plasma, and several different means of FPD technology (Polgar, 2003). In 1973, Sharp, a Japan-based producer, acquired RCA's LCD patents and subsequently developed a series of products, such as the world's first electronic pocket calculators, which eventually led to the successful commercialization of the LCD technology. In 1987, Japanese firms for the first time surpassed US companies in the number of FPD patents granted that they received; whereas South Korean assignees received their first FPD patent in 1987 and Taiwanese assignees received theirs in 1994.

Although several competing technologies are available to manufacture FPD products, thin-film transistor liquid crystal display (TFT-LCD) in the early 1990s has outperformed prior twisted nematic/super twisted nematic (TN/STN) LCD on large-size (larger than 10 inches diagonally) applications. Following the perceived market dominance of TFT-LCD, South Korean companies in 1995-96 started to invest heavily in generation-2 (G2) and G3 TFT-LCD mass production. Samsung and LG-Philips LCD (LPL), supported by their well-established semiconductor industry and together with the strategic support of government policy, rapidly eroded the market monopoly position that Japanese firms such as Sharp, NEC, DTI (a joint venture between Toshiba and IBM-Japan), Hitachi, and Matsushita had held in the late1990s (Linden, Hart, Lenway and Murtha, 1998). Taiwanese firms, on the other hand, also prepared around the same period to enter this technology- and capital-intensive industry. However, Taiwanese indigenous firms, as new entrants into the FPD industry, did not have all the core technology required; consequently, they actively engaged in the formation of strategic partnerships, especially with those of Japanese firms (Fuller et al., 2003; Mathews, 2005).

AU Optronics (AUO, formed by the merger of Acer Display and Unipac in 2001) , for example, sought technology sources from IBM and Matsushita in 1998; Chi Mei

Optoelectronics (CMO, that later merged into Innolux in 2009, an affiliate of the electric manufacturing service giant HonHai) had contractual relations with Fujitsu in 1998 and 2001; Chunghwa Picture Tubes (CPT, an affiliate with home appliance maker Tatung) linked itself to ADI (Mitsubishi's JV) in 1997 and 1999; HannStar Display (HSD, an affiliate of power wire and cable maker Walsin Lihwa) partnered with Toshiba in 1998 and 2001; Prime View International (PVI, now E-Ink Holdings who produces flexible display panels, an affiliate of paper maker YFY Group) cooperated with Optrex in 2001; Toppoly Optoelectronics (TPO, an affiliate of PC maker Compal, who later merged into Innolux in 2009) allied with Sanyo Electric in 2000; and Quanta Display (QDI, an affiliate of PC-maker Quanta, who later merged into AUO in 2006) contracted with Sharp in 1999.

While the Taiwanese firms' acquisition of manufacturing know-how from their partners was to bypass the technological barrier and gain a foothold, Japanese firms entered into the partnerships for financial and strategic reasons. During the Asia financial crisis in 1997-98, the price of FPD took a dramatic dive caused by major Korean 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 by the significant decrease of capital expenditure, and for a capital-intensive industry such as FPD, the retrench have been detrimental. Therefore, when Taiwanese firms, with ample capital funding, initiated the technology transfer agreements, Japanese firms have regarded Taiwanese firms as complementarities for the more cost-effective production base to fend off the Korean challenge, and consequently transferred their mature technology for large-sized TFT-LCD. Another strategic consideration behind the motivation for Japanese technology transfer to Taiwan was to obtain the additional capital funding that resulted from the royalty fee received and subsequently to invest in more advanced technology. Various Japanese firms have ventured into the low temperature poly silicon (LTPS) TFT-LCD or organic light-emitting

diode (OLED) technologies.

The top four TFT-LCD manufacturers, Samsung and LPL of South Korea, and AUO and CMO of Taiwan, have taken two-thirds of the global market share since 2003. Technology transfer and consolidation ceased in 2006 when the TFT-LCD industry entered into G6 mass-production for very large-sized TV panels. While existing incumbent Japanese, Korean, and Taiwanese makers continue to invest in next-generation TFT-LCD fabrication lines, new entrants from China have become the latest challengers to the industry.

3.2 Data

The objective of this study is to analyze the effect of strategic partnerships on the external learning and capability building of technology descendents such as Taiwanese FPD firms. The patent data for this study is drawn from the online database of the United States Patent and Trademark Office (USPTO), which records all patents filed and granted in the United States.

Table 1 provides a 21-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 that despite most TFT-LCD manufacturing nowadays being clustered in Asia, with Korean and Taiwanese producers holding significant worldwide market share, U.S. and Japanese firms, as evidenced by their patent counts, have maintained their advantages in research capabilities. They focus on providing critical supplies, equipment, and intellectual properties from the upstream as well as in staying in the high margin niche markets. Nevertheless, based on the average growth rate of patenting, it is also evident that both Korean and Taiwanese firms have been actively contributing to generating knowledge in the FPD field.

Insert Table 1 Here

We selected the top 7 Taiwanese FPD patent holders who manufactured based on the TFT-LCD technology, and regarded them as the technology descendents for our discussion of the type of partnership (trading or non-trading partnership) and the learning impact of their technology alliance strategy

We first obtained a primary sample of 1007 patents by collecting all patents filed to USPTO by these 7 focal firms. After reviewing these patents individually, we eliminated those pertaining to CRT technology, which left a sample of patents that related directly to FPD technology. Based on the 955 FPD patents identified during the period of 1994-2006 shown in Table 2, we used Java script to 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 paired relationships of the cited and citing firms. Table 3 displays those regions of citations made in Taiwan's FPD patents granted during 1994-2006.

Insert Table 2 & Table 3 Here

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.[2] After thorough reviews, we obtained 79 strategic partnerships between 7 focal firms and their partners, ranging from equity joint ventures, joint development agreements, R &D contracts, to licensing for the transfer of existing technology.

Table 4 depicts those strategic partnerships undertaken by Taiwanese firms. This table shows the countries of the partners and also classifies the partnership based on whether the

[2] , http://www.digitimes.com.tw, http://www.topology.com.tw/tri/

collaboration structure is of trading or non-trading nature during 1994-2006, as discussed in Section 2.

From 1997 to 1998, there was an upward trend in the number of strategic business alliances for Taiwanese manufacturers due to the fact that they had only recently entered the TFT-LCD industry, and many Japanese manufacturers were transferring technologies to them during that time. Three to four years later, when gradual technical enhancement made it possible for Taiwanese manufacturers to carry out independent R&D projects, they started to learn and expand additional strategic alliances with a wider variety of manufacturers. Gambardella (1992) also found that the stronger the manufacturers' technical competence or absorptive capacity was, the more capable they were of absorbing outside resources. Looking once again at Table 2, we observed that the year 2002 witnessed a gradual increase in the number of patents approved among Taiwanese manufacturers, which further proved that Taiwanese manufacturers indeed enjoyed steady technical progress around 2001 (given that the patent approval process normally takes two to four years). Table 5 also shows that from 2001 on, the strategic business alliances for Taiwanese manufacturers were no longer limited to the U.S. and Japan but extended to Korea, Germany, among other countries.

Insert Table 4 & Table 5 Here

The details of the data construction processes are shown in Figure 2.

Insert Figure 2 Here

3.3 Model

Dependent variable

In this study, the extent of external learning that technology descendents, i.e. 7 Taiwanese FPD firms, have 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 & Silverman (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 citation rate made to $Firm_j$'s patents in all new patents applied by $Firm_i$ during the prescribed period.

$$\mathrm{Creat}_{ijt} = \frac{Citation\ to\ Firm_j's\ patents\ in\ Year_t\ in\ Firm_i's\ patents\ in\ Year_t}{Total\ citations\ in\ Firm_i's\ patents\ in\ Year_t} \quad (1)$$

For example, 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, between $Firm_i$ and $Firm_j$ or the importance of $Firm_j$ being the external learning source to knowledge descendents $Firm_i$.

A note worth considering is that the studies using patent citations as a proxy for knowledge flow should also take into account that different industries have different propensities to codify knowledge, and citation measurement might be more relevant in some industries than others (Lerner, 1994). Industries that are characterized by rapid advancing or cumulative technologies tend to have higher propensity to patent such as the semiconductors industry (Hall & Ziedonis, 2001). Since FPD technology is also characterized as having a high share of codified knowledge that is rapidly communicated through publications (Stolpe,

2002), the FDP industry is an appropriate context to observe knowledge flow via patent citation data.

Independent variables

We use two variables to capture the degree of strategic technology partnership. The first variable, $STP_{ijt,}$ captures the presence of strategic technology partnership. 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 was 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, $TRADE_{ijt,}$ is to distinguish different strategic technology partnership 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 is non-trading, and bilateral in interaction flows, such as equity joint venture and various joint development projects. Similarly, the three-year lag was applied in establishing this variable, $TRADE_{ijt}$.

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 $TECH_{ijt}$ 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 $Year_t$, then we could calculate $TECH_{ijt}$= 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 $Firm_j$ is US, Japan, Korea or Taiwan (for example, Dus for the U.S., and Djp for Japan, etc.), and coded '0' for the other countries. These four countries were selected because of their active involvement in the FPD industry as reflected by their significance on the overall patent shares (see Table 1).

Control variables

This study includes three sets of control variables in the regression model. The first set incorporates year control to assess time effect, i.e. how the elapse of time would affect the level of external learning. We coded '0' for the base year 2000, and '1' for each dummy of year 2001-2006. These dichotomy variables are named as D2001 through D2006. The second set of variables is set for firm-specific control. We coded '0' for Chi-Mei, as the base firm, and '1' for the rest (for example, Dauo for AUO, Dcpt for CPT, etc.). 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 by Freeman (1979) that 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 measure (CT), which computes the frequency of $Firm_j$'s patents being cited in the FPD citation network. Hagedoorn and Duysters (2002) concluded that having more contacts with fellow members within the network enhances the probability of developing new capabilities. We therefore

suggest that the higher the degree centrality, 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 specifications are as follows:

$$Crate_{ijt} = F (STP_{ijt} , TECH_{ijt} , Dcounty_{jt} , Dyear_{t} ,, Dfirm_{i,} , CT_{jt}) \quad \textbf{(2)}$$

$$Crate_{ijt} = F (TRADE_{ijt,}, TECH_{ijt} , Dcounty_{jt} , Dyear_{t} , Dfirm_{i,} , CT_{jt}) \quad \textbf{(3)}$$

We run the above two models separately in two regression models.

4. Empirical Results

Table 6 provides descriptive statistics and correlations for our sample variables. The correlations examined among independent variables are well under 0.5, indicating no sign of collinearity.

Table 7 shows estimates of our two OLS regression models, Model 1 and Model 2, based on equations (2) and (3) with all the independent and control variables. As predicted by Hypothesis 1, our variable STP, the presence of strategic partnership is positive and significant at 0.1 level, suggesting that citations made by technology descendents to their strategic partners are more prevalent than to other non-allied firms. This significance holds even when we take into account the patent quality control variable, CT. In other words, the propensity to cite or to learn from the strategic partners is higher, regardless of the prominent positions of the cited patents of non-partners. Specifically, the estimated coefficient of STP is 0.0029, which shows that everything else being held equal, on the average the strength of the knowledge lineage, or the tendency to cite for the focal firms to allied firms, is 0.29% higher than that to the non-allied firms.

In Hypothesis 2, trading-based partnership supports higher levels of interfirm knowledge transfer than non-trading based partnership. This postulation is confirmed by the estimated coefficient of the variable TRADE which is a positive 0.0032, with the significance at 0.1

level.

Furthermore, Hypothesis 3 stating that a focused and specialized approach in extrapolating external knowledge is also confirmed. All other things being held constant, the estimated coefficient of the variable TECH shows a positive sign, i.e., 0.9236, and appears significant at 0.01 level. This result provides strong evidence that the closeness in technology trajectory facilitates external knowledge flow.

Finally, our empirical evidence supports Hypothesis 4, which suggests an absence of localization effect on knowledge flow. All estimated coefficients of the country variables are significant at 0.01, except for Taiwan, where our focal firms reside. In other words, the diffusion of knowledge is not locally bounded.

In terms of the effect of the control variables, the estimated coefficients of the year control variable, i.e., D2001, D2002, …etc. show consistently negative signs and all estimates appear statistically significant. The magnitudes of these year variables decrease over time, indicating that the learning dynamic of technology descendants diminishes as time evolves. The estimated coefficient of the control variable centrality CT, is positive and significant at 0.05 level, indicating the higher degree of centrality or higher quality of patent's codified knowledge does further induce higher propensity to cite.

Insert Table 6 and Table 7 Here

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5. Conclusions

The present study is set in a context of flat panel display industry (FPD) where the technology intensity is high and fast paced, with the market interplay among the incumbents

and entrants being dynamic. Despite Japanese firms undertook their mass production in the 1980s and have dominated the global FPD market since, Korean firms emerged to challenge aggressively in the mid-1990s. Taiwanese firms, as the late entrants to catch up with global competitors, dexterously sought to overcome technology gaps to attain footholds in the FPD industry. Via rounds of technology transfers and consolidations, Taiwanese FPD firms have taped into the value creation from fabrication establishments, learning economies, process improvement to product outlets.

As late entrants have to quickly build up the required knowledge base to match up with the competitive industrial race, the extent of external learning, or knowledge crossover, becomes an important issue to look at. Extant literature has suggested strategic alliance a means for such external learning. Unilateral trading partnerships in technology licensing, sourcing or export contracts are frequently employed, in particular for the upstream or downstream industry players who want to retain their controls on intangible, firm-specific assets. On the other hand, equity-based or bilateral functional partnerships such as cross-licensing, and collaboration on research and development or on production may most likely be realized when certain preferential financing and technology achieved, aiming at more strategic, longer-term return.

We aimed at examining whether the presence of the alliance would facilitate the extent of external learning and also how the composing factors of alliance may impact the knowledge crossover. Our study configures the citation network of seven Taiwanese 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 during 2000-2006. While our hypotheses are generally supported by the empirical results,

some findings require additional elaboration.

Though different contractual forms would lead to a 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 results show the contrary; it appears that non-equity agreements are a superior means to absorb external knowledge for technology descendents. In explaining the difference, we should consider the industry context. On a firm-level basis, the propensity to use different types of arrangements is associated with industry dynamics; in other words, when considering the appropriate alliance structure, it is necessary to take account of industry factors. A non-trading alliance will impose similar stake of financial risks on both partners. For an industry such as FPD industry, which is extremely capital intensive, the larger and more reputable firms in advanced countries tend to avoid non-trading partnerships and focus on arm-length trading types 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 did not 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 an asymmetric partnership relationship. Further studies could elaborate the framework established in our study to examine other new entrants, such as China a strong new contender in the FPD industry, or other industry, such as the photovoltaic (solar energy) industry. Given the rapidly evolving technological environment, with firms actively catching up and further venturing ahead into new frontiers, we believe the issue of knowledge flow in the context of technology descendants will become only more relevant for both managerial and academic concerns.

Table 1: The number and growth rate of global FPD patents granted, 1976-2006

Region of assignees	Year granted	1976~1980	1981~1985	1986~1990	1991~1995	1996~2000	2000~2006	Total (Share)
U. S.	**Patents**	**278**	**254**	**407**	**649**	**1,525**	**2,244**	**5,357**
	Growth rate	n/a	-8.6%	60.2%	59.5%	135.0%	47.1%	(24.6%)
Japan	**Patents**	**135**	**206**	**479**	**1,011**	**2,647**	**5,738**	**10,216**
	Growth rate	n/a	52.6%	132.5%	111.1%	161.8%	116.8%	(46.9%)
South Korea	**Patents**	**0**	**0**	**2**	**110**	**514**	**2,524**	**3,150**
	Growth rate	n/a	n/a	n/a	5400.0%	367.3%	391.1%	(14.5%)
Taiwan	**Patents**	**0**	**0**	**5**	**54**	**196**	**1,168**	**1,423**
	Growth rate	n/a	n/a	n/a	980.0%	263.0%	495.9%	(6.5%)
Others	**Patents**	**96**	**94**	**122**	**111**	**225**	**986**	**1,634**
	Growth rate	n/a	-2.1%	29.8%	-9.0%	102.7%	338.2%	(7.5%)
Sub-total	**Patents**	**509**	**554**	**1,015**	**1,935**	**5,107**	**12,660**	**21,780**
	Growth rate	n/a	8.8%	83.2%	90.6%	163.9%	147.9%	(100%)

n/a: not available

Table 2: The number of Taiwan's FPD patents granted and their citations, 1994-2006

Firm (founded)	Year granted	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
AUO (1996)	**patents**	0	0	0	0	0	0	**4**	6	21	49	79	108	167	**434**
	citations	0	0	0	0	0	0	8	20	106	201	316	459	946	2,056
CMO (1998)	**patents**	0	0	0	0	0	0	**1**	3	12	11	30	26	32	**115**
	citations	0	0	0	0	0	0	9	14	67	35	114	143	179	561
CPT (1971)	**patents**	**1**	2	0	1	0	0	1	3	3	2	10	27	32	**82**
	citations	7	41	0	16	0	0	6	16	5	17	45	155	156	464
HannStar (1998)	**patents**	0	0	0	0	0	0	0	**1**	18	26	43	30	34	**152**
	citations	0	0	0	0	0	0	0	3	157	102	201	119	190	772
PrimeView (1992)	**patents**	0	0	**3**	2	0	2	2	0	0	1	5	7	12	**34**
	citations	0	0	63	10	0	9	13	0	0	2	35	27	43	202
Quanta (1999)	**patents**	0	0	0	0	0	0	0	0	**1**	1	3	10	19	**34**
	citations	0	0	0	0	0	0	0	0	2	2	13	30	75	122
TPO (1999)	**patents**	0	0	0	0	0	0	0	0	0	**1**	24	27	52	**104**
	citations	0	0	0	0	0	0	0	0	0	2	88	107	253	450
Sub-total	**patents**	1	2	3	3	0	2	8	13	55	91	194	235	348	**955**
	citations	7	41	63	26	0	9	36	53	337	361	812	1,040	1,842	4,627

Table 3: Region of citations made by Taiwan's FPD patents granted, 1994-2006

Region of citations made by	U. S.	Japan	South Korea	Taiwan	Others	Total
AUO (1996)	25.5%	47.5%	14.2%	7.9%	4.9%	100.0%
CMO (1998)	22.8%	58.3%	11.7%	3.4%	3.8%	100.0%
CPT (1971)	30.3%	43.1%	16.9%	5.2%	4.5%	100.0%
HannStar (1998)	26.1%	40.6%	18.4%	10.8%	4.1%	100.0%
PrimeView (1992)	35.9%	49.1%	4.5%	4.0%	6.5%	100.0%
Quanta (1999)	28.9%	45.6%	15.8%	7.0%	2.7%	100.0%
TPO (1999)	23.2%	54.8%	10.4%	6.3%	5.3%	100.0%
Average	**27.5%**	**48.4%**	**13.1%**	**6.4%**	**4.5%**	**100.0%**

Table 4: Strategic partnerships made by Taiwan's FPD firms, 1994-2006

Strategic partnership made by	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Total
AUO (1996)	0	0	**1**	0	2	0	1	0	0	4	1	3	3	**15**
CMO (1998)	0	0	0	0	**2**	0	0	4	2	1	0	4	3	**16**
CPT (1971)	**1**	0	0	2	0	1	0	6	2	2	4	3	1	**22**
HannStar (1998)	0	0	0	0	**1**	0	1	2	2	0	1	3	1	**11**
PrimeView (1992)	0	0	0	0	0	0	0	**1**	0	0	0	2	0	**3**
Quanta (1999)	0	0	0	0	0	**1**	0	0	1	0	0	2	1	**5**
TPO (1999)	0	0	0	0	0	0	**1**	1	1	1	2	0	1	**7**
Sub-total	1	0	1	2	5	2	3	14	8	8	8	17	10	**79**

Table 5: Region and type of partnerships made by Taiwan FPD firms, 1994-2006

Region of partnership	Partnership Type	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Sub-total	Total (share)
U. S.	Trading	0	0	0	0	0	0	0	3	0	0	2	4	2	**11**	**15**
	Non-trading	0	0	0	0	1	0	0	0	0	1	0	2	0	4	(19.0%)
Japan	Trading	1	0	0	1	2	2	2	4	4	4	3	1	1	**25**	**44**
	Non-trading	0	0	0	1	1	0	0	5	3	1	1	5	2	19	(55.7%)
South Korea	Trading	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**2**
	Non-trading	0	0	0	0	0	0	0	1	0	0	0	0	1	2	(2.5%)
Taiwan	Trading	0	0	1	0	1	0	1	1	0	1	1	0	0	**6**	**14**
	Non-trading	0	0	0	0	0	0	0	0	1	1	1	3	2	8	(17.7%)
Others	Trading	0	0	0	0	0	0	0	0	0	0	0	2	2	**4**	**4**
	Non-trading	0	0	0	0	0	0	0	0	0	0	0	0	0	0	(5.1%)
Sub-total	Trading	1	0	1	1	3	2	3	8	4	5	6	7	5	**46**	**79**
	Non-trading	0	0	0	1	2	0	0	6	4	3	2	10	5	33	(100%)

Table 6: Descriptive statistics and correlations

	Mean	Std. Dev.	STP	TRADE	TECH	Dus	Djp	Dkr	Dtw	CT
Crate	0.022	0.046								
STP	0.064	0.244	1.000							
TRADE	0.055	0.228	0.943	1.000						
TECH	0.014	0.042	0.005	0.009	1.000					
Dus	0.379	0.485	-0.015	-0.049	-0.038	1.000				
Djp	0.379	0.485	0.032	0.037	0.015	-0.512	1.000			
Dkr	0.089	0.285	-0.142	-0.134	0.119	-0.171	-0.418	1.000		
Dtw	0.062	0.241	0.169	0.191	-0.054	-0.158	-0.387	-0.129	1.000	
CT	0.902	2.502	0.147	0.102	0.140	-0.132	0.277	-0.001	-0.201	1.000

Observations: 1,726

Table 7: Regression Result

	Crate	
	Model 1	**Model 2**
STP	0.0029*	
	(0.0016)	
TRADE		0.0032*
		(0.0017)
TECH	0.9236***	0.9235***
	(0.0160)	(0.0160)
Dus	0.0021***	0.0021***
	(0.0008)	(0.0008)
Djp	0.0025***	0.0026***
	(0.0009)	(0.0009)
Dkr	0.0056***	0.0056***
	(0.0019)	(0.0019)
Dtw	0.0011	0.0010
	(0.0011)	(0.0011)
CT	0.0009**	0.0009**
	(0.0004)	(0.0004)

continued to the right

	Crate	
	Model 1 (cont'd)	**Model 2 (cont'd)**
D2001	-0.0284*	-0.0284*
	(0.0157)	(0.0157)
D2002	-0.0364**	-0.0364**
	(0.0151)	(0.0151)
D2003	-0.0409***	-0.0408***
	(0.0149)	(0.0149)
D2004	-0.0445***	-0.0444***
	(0.0148)	(0.0148)
D2005	-0.0447***	-0.0446***
	(0.0148)	(0.0148)
D2006	-0.0466***	-0.0465***
	(0.0148)	(0.0148)
Dauo	-0.0016	-0.0016
	(0.0013)	(0.0013)
Dcpt	0.0081***	0.0081***
	(0.0029)	(0.0029)
Dhsd	-0.0020*	-0.0021*
	(0.0012)	(0.0012)
Dpvi	0.0054	0.0055
	(0.0038)	(0.0038)
Dqdi	0.0100***	0.0100***
	(0.0031)	(0.0031)
Dtpo	0.0016	0.0016
	(0.0013)	(0.0013)
_cons	0.0473***	0.0472***
	(0.0147)	(0.01547
Observations	1,726	1,726
Adjusted R^2	0.8805	0.8805

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

Figure 1: Hypothetic Model

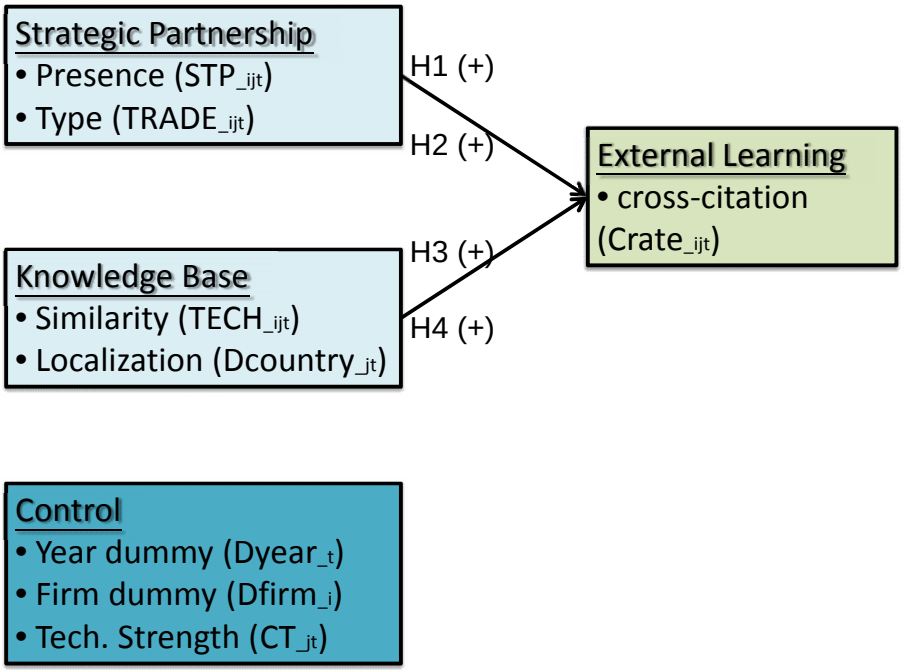
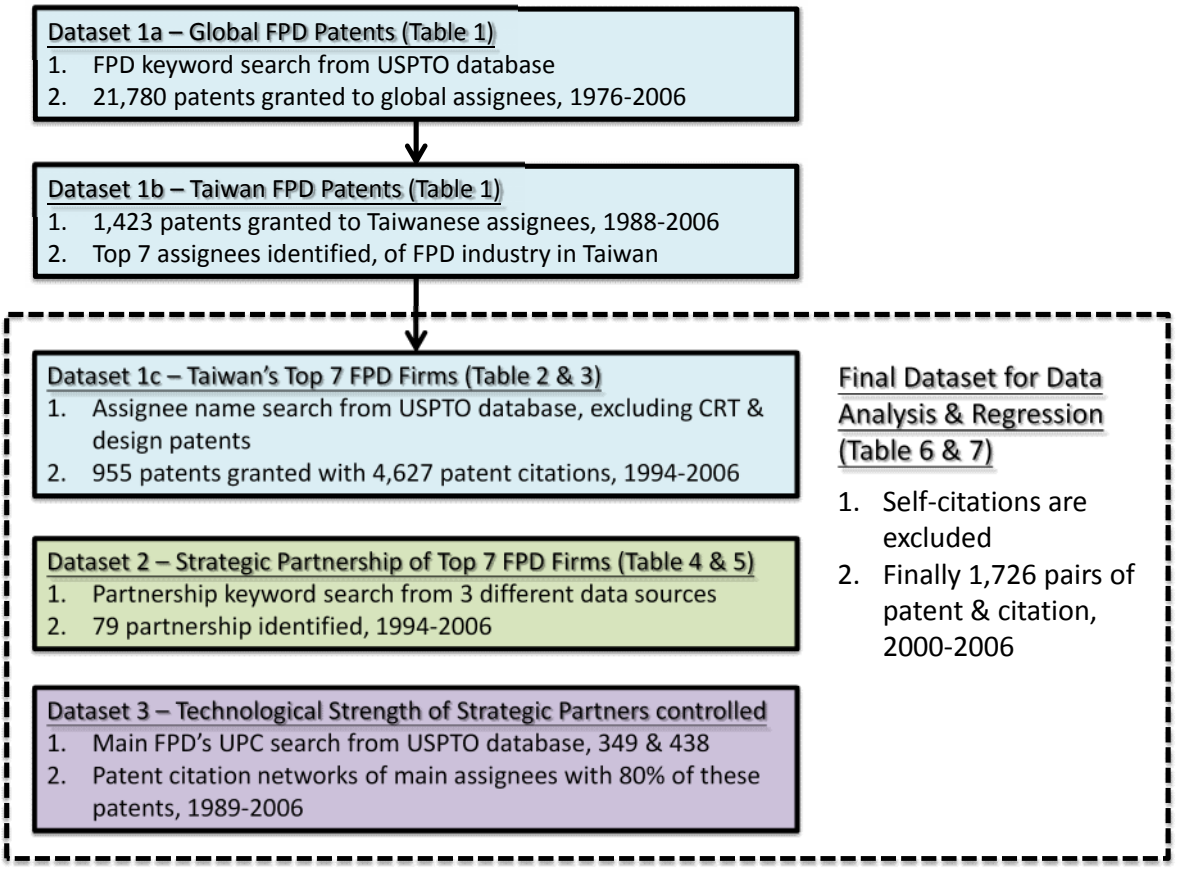


Figure 2: Data Construction



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附件四

國科會補助專題研究計畫項下出席國際學術會議心得報告

日期：2011 年 12 月 20 日

計畫編號	NSC 99-2410-H-343 -001 –MY2		
計畫名稱	創新持續性之探討：指標衡量及績效評估		
出國人員 姓名	陳慧如	服務機構 及職稱	南華大學 專任助理教授
會議時間	2011 年 11 月 24 日至 2011 年 11 月 26 日	會議地點	Bali, Indonesia
會議名稱	（中文）第七屆國際第三部門亞太地區雙年會 （英文） The 7th ISTR International Society for Third-Sector Research Asia Pacific Regional Conference		

一、參加會議經過

A. Editorial workshop
- Bernard Enjolras, Editor of Voluntas on “Getting Published in Scientific Journals”
- Brenda Gainer, President of ISTR on other publications reductionist research is not. For a civil society research, passion and commitment of social change (jc note: engagement), and perhaps activism is needed.

B. Community building: experiences from Europe, Northern America, Japan
While could struggle for legitimacy, scholars in the 3rd-sector should consider ourselves as boundary spanner. The nature of inter-, cross-, multi-discipline, is both a blessing and a struggle. With the merging trend, the distinction is not organizational basis, but value basis (belief in making social impact).

C. Attend 3 plenary sessions, 13 presentations, cultural nights, 7 meals
Potential topics / extension for students’ thesis
Carolyn on net benefits on volunteer program mgmt p33,34 I-wei
Dongre on coop mission p41, 12/20 visit.

Margot on older community leader p105, senior people's volunteering, reference on active citizenry, active aging, older people empowerment, relevant to Tsui, Weili
Rosemary, bonding social capital, elder caring network, p85, I-Fen, Weili,

二、與會心得

Potential research topic for myself

- Myth about the conflict between social and commercial goals. Similarly the misunderstand of effectiveness vs efficiency. JC consider the difference is in essence means vs ends, subtle vs concrete, different focus of time dimension at different stage (st vs lt)….. therefore, cannot be separately dealt with.
  e.g. Jersan Hu's parallel operating system, Llainey Smith's argument that the meaning of work would be diminished with profit goal (p112).
  Have we ever argue about innovation vs commercial goals? It is the wrong question to ask: "when there's a conflict, which goes first?"
  Argument from Simon, Bernard, article from Strategy I. Chinese strategy Co-writing with JR.
- Critique or expansion on the article non-market competitors
- SE not to be categorized as social vs commercial goals, but level of engagement. Stakeholder engagement. Not parallel dual-role, because it is mutually beneficial.
- Prior conception of SE--- has to be A+ enterprise bec. Double "taxation", additional costs/exp. With criteria of engagement, now could respect and include in my SE definition those locally-bounded. Preservation of value, cultural heritage, dignity…etc.

To follow up:

1. Carolyn on net benefits on volunteer program mgmt p33,34 I-wei
2. Dongre on coop mission p41, 12/20 visit.
3. Margot on older community leader p105, senior people's volunteering, reference on active citizenry, active aging, older people empowerment, relevant to Tsui and Weili
4. Day 2 panel on business link, ngo-turned S/E
5. Jenny on social impact measure, focus group method. Motivation of study: too much tilt toward $ proxy. "Cannot measure, cannot manage, cannot get fund". TW e-info case.
6. Rosemary, bonding social capital, elder caring network, p85, I-Fen, Weili,
7. NSC proposal.
8. Critique on organizational hostility and blind spots

三、考察參觀活動(無是項活動者略) 無

四、建議

This is a small scale conference, but I found the community exchange and networking has been the best among all conferences I have previously attended.
One interesting situation I observed which I didn't pay attention to previously (but heard of the situation). I noticed colleagues from Taiwan who presented more than one papers at the conference, but besides their presentation time slots, they did not show up for any other sessions nor attend the opening/closing social events. This is a great pity, for presenting paper is only one of the many objectives for attending conferences. Having exchanges with other researchers, developing community bonding, fostering future research/teaching collaborative work would be just, if not more important.

I have in the conference site throughout the whole time and got the chances to talk to many participants. After the conference, I received invitation by a ranked journal editor to undertake a reviewer's role. Additionally, I was recommended by a participant to the Chair of the 2012 ISTR international conference to be held in Italy, and subsequently received their invitation to partake in the program.

I think making interaction and connection during the conference attendance should be more highly recommended by NSC in the future when granting the travel subsidies (in addition to just looking at paper presentation).

五、攜回資料名稱及內容

Conference program, proceedings and abstracts, two published journals from Japan and Singapore, calls for paper announcement for two international conferences to be held in 2012, more than twenty name cards.