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產業聚落對產業競爭力之影響

The Development of Industrial Clusters towards a Knowledge-based Economy

行政院經濟建設委員會

民國 九十三 年 十二 月

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The Development of Industrial Clusters towards a Knowledge-based Economy

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Executive Summary

The aims of this study are to: (i) explore the factors contributing to the successful formation of industrial clusters and the overall effects of industrial clustering on productivity; (ii) gain an understanding of the organization and networking of industrial clusters; (iii) examine the flow of human resources between clusters in Chinese Taipei, the US and China, focusing on the drivers of the 'brain circulation', along with its contribution to technological innovation; and (iv) highlight the interrelationships that exist between industrial clustering and innovation.

In part (i), drawing on the empirical evidence from the Hsinchu Science-based Industrial Park (HSIP), we find that outsourcing is generally adopted by firms within the clusters since this enables them to access the major markets and to save on R&D costs through production specialization. The experiences of HSIP also support the assertion that entrepreneurship, skilled labor and market access are essential ingredients for the formation of a cluster. In order to determine whether common mechanisms exist to bring together these three ingredients and produce a winning formula, we have attempted to compare the experiences of HSIP to those of Silicon Valley in the US, as well as the experiences of the industrial clusters in Penang and the Kelang Valley in Malaysia, Hamamatsu in Japan, and Shanghai in China.

Our studies have also shown that industrial clustering improves the productivity of individual firms, in part (i). We have been able to gather evidence with statistical robustness to support the role played by Porter externality and Marshall-Romer in industrial clusters. Although these two externalities differ in nature, they can exist simultaneously in a cluster. If firms in a cluster are more productive than those outside the cluster, it naturally follows that firms that locate too distant from the cluster will be driven out of the industry by competition. This, of course, is the main

driving force for agglomeration.

In parts (ii) and (iii) we have looked at the technological linkages between clusters from the viewpoint of networking. Firms can learn from other firms through global production networks within which they operate, collaborating to offer products in the global market, and it is clear that a cluster is an important facilitator for such learning. Clusters form a 'learning region' within which knowledge flows, and is diffused, amongst the firms residing there. Clusters also provide a bridge between different learning regions to facilitate the effective transfer of knowledge. We have made an investigation into the state of human resource development within the HSIP, from which we find that industrial output expanded exponentially between 1990 and 1995, along with the infusion of high-skilled labor from overseas. Furthermore, there has been a slowdown in the rate of the so-called 'reverse brain drain' since 1995, with foreign workers now accounting for a substantial proportion of labor movement. This suggests that the HSIP is becoming increasingly integrated with the global market because high-skilled labor with the park has increasingly shifted away from production toward research and development.

In addition, we have made an inquiry into the intra-cluster division of labor and networking relationships, using the HSIP as an example, and have found that the most prevalent modes of interaction between firms in the HSIP are subcontracting and outsourcing of components and parts, which implies a vertical disintegration of production within the HSIP, and that the duration of subcontracting contracts increases positively with the distance between the partners. Moreover, the potential impacts of industrial clustering on entrepreneurship have been examined and the results have revealed some positive correlations. Industries that are more geographically concentrated are found to be more receptive to new entrants, implying that industrial clustering may help facilitate labor pooling since industrial clustering reduces the costs of hiring and discharging workers. The empirical research is in line with the theoretical expectation, indicating that successful industrial clusters are important to the incubation of entrepreneurship. In part (iv), we suggest that industrial clustering occurs not only in high-tech industries, but also in the so-called traditional industries. It appears that innovation and growth are the two most important elements in the formation of an industrial cluster. Innovation provides the dynamics for competition and restructuring. Innovation also underlines the benefits of knowledge sharing, which is the basic reason for firms to co-locate with one another. Meanwhile, growth is important both in terms of inducing new entry and facilitating a division of labor within the industry. Growth in most cases is demand-driven and therefore the link (or access) to the major market is the key to the formation of an industrial cluster.

Finally, the whole research report is finished with the conclusions and policy recommendations. In terms of policy recommendations, we suggest that industrial clustering can be a useful policy for national economic development of various scales. However, there is no one-size-fit-all formula for successful industrial clustering and an economy should allow its comparative advantage to determine what industries to grow into a cluster. Having said that, investment infrastructures and human resources, building innovation capabilities, linking sources of growth, promoting vertical disintegration and subcontracting, and enhancing productivity can be the key ingredients of industrial cluster policies.

中文摘要

本研究主要的目的有四：（一）探討產業聚落形成的因素與產業聚落對生產力的影響；（二）瞭解產業聚落的組織與網路連結 (networking)；（三）研究人才於台灣、美國及中國產業聚落之間流動（brain circulation）的因素以及其對技術創新的貢獻；（四）突顯產業聚落與創新之間的關係。

在第（一）部份中，利用新竹科學園區（以下簡稱竹科）廠商的資料進行實證分析，本研究發現委外代工（outsourcing）的模式多半存在於聚落內的廠商。廠商藉由委外代工的模式進入主要市場並透過專業化生產節省各項投資費用。透過竹科的經驗，所謂企業家精神、專業人力與市場進入(market access)是形成產業聚落的基本要素的說法也因此獲得支持。為進一步釐清各產業聚落是否有相同的形成與發展之機制，本研究嘗試針對美國的矽谷、馬來西亞的檳城、巴生谷（Kelang Valley）、日本的濱松以及中國上海的經驗，與竹科做一比較。本研究肯定以上所強調的企業家精神、專業人力與市場進入為形成產業聚落的三要素，但目前為止並未發掘維繫產業聚落持續發展的共同因素。

第（一）部份的研究亦指出，產業聚落可強化聚落內個別廠商的生產力。此證據具有統計穩健性（statistical robustness）的意義，驗證 Porter 與 Marshall-Romer 外部性在產業聚落所扮演的角色。雖然上述二外部性本質上不同，但他們可同時存在於一個聚落中。若在聚落內的廠商較座落於聚落外的具有生產力，距離聚落太遠的廠商將因競爭力不足而被淘汰，此乃造成聚落的主因。

其次，在第（二）與第（三）部分中，本研究透過網路連結的角度，觀察不同聚落之間的技術連結。藉由全球化的生產網路，廠商之間可以相互學習，合作進軍全球市場。因此，產業聚落的形成可促使區域內廠商之間的互相學習，由於知識可在聚落內快速流動擴散，產業聚落本身可視為一個提供廠商相互學習的地區 (learning region)。此外，藉由連結不同的學習地區，產業聚落可使知識的傳播更有效率。本研究透過對竹科人力資源發展狀況的調查，發現在 1990 年到 1995 年之間，隨著海外高素質人力的投入，工業產出呈現驚人的成長。唯自 1995 年起，人力資源回流的速度減緩，外籍人力反而成為

勞力移入的大宗。這意味隨著園區內高素質專業勞力的流動已由生產面轉為研發面，竹科已逐漸與全球市場融合。

本研究進一步以竹科為對象，研究聚落間分工與網路連結的關係，結果發現竹科最常見廠商互動的模式為零組件的外包（subcontracting）與委外代工，這代表竹科生產體系呈現垂直分散（vertical disintegration）的現象。而外包契約期間的長短則隨著廠商間的距離增加。我們並檢驗產業聚落對企業家精神的潛在影響，研究結果發現兩著之間存在著正向的相關。地理分布愈集中的產業，愈能接納新進入市場的廠商，顯示由於產業聚落可降低聘僱與資遣勞工的成本，並可加速勞動力匯集（labor pooling）。實證研究與理論預期的結果相同，顯見產業聚落對企業家精神的形成之重要性。

在第（四）部分，我們認為產業聚落不僅存在於高科技產業，並可見於所謂的傳統產業中。創新和成長似乎是形成產業聚落最主要的兩個因素。創新帶動競爭並促使產業重整。創新也突顯知識分享的好處，而知識分享是廠商聚集的基本原因。就誘導新廠商進入市場與加速產業內分工而言，成長具有主要的地位。由於大部分的成長因需求而產生，因此，與主要市場的連結成為產業聚落的關鍵。

最後，就政策建議而言，我們認為發展產業聚落可當作國家經濟政策的一環。然而就分析產業聚落成功的案例可知，形成產業聚落並無一體適用的公式，主要是由該國產業的比較利益決定。但大體而言，吸引投資的公共建設、人力資源、建立創新能力、成長資源的連結，促進生產環節的垂直分散與外包達到生產力的提升，乃為推動產業聚落政策的要項。

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Chapter 1 Industrial Clusters and Industry Competitiveness

1.1 Background

In a knowledge-based economy, the ability to innovate continuously underlines the competitiveness of a nation, and industrial clusters are known to be conducive to the establishment of such an ability. A cluster is a congregation of interrelated industries and institutions that create complementary linkages in the exploration and application of knowledge. Industrial clusters can be as small as a city, or as large as a cross-country network. Industrial clusters have several policy implications, including (1) regional development policy is an essential part of the industrial policy, (2) inter-governmental cooperation is key to the effectiveness of such a policy, and (3) cross-country policy coordination is beneficial to the flows of capital and human resources towards the formation of an industrial cluster. It is now well understood that industrial cluster contributes to the enhancement of national competitiveness because a cluster provides complementary inputs to production, intensifies competition to enhance productivity, and shorten the response time to technological innovations and market changes.

1.2 Literature Review

Clusters are defined as "a geographically proximate group of interconnected companies and associated institutions in a particular field linked by commonalities and complementaries. Clusters encompass an array of linked industries and other entities important to competition ...... including governmental and other institutions – such as universities, standard setting agencies, think tanks, vocational training providers and trade associations"

(Porter 1998). The basic reason for clustering is that co-location of firms generates positive externality on productivity. Positive externality is most prominent when firms are "interconnected". What does "interconnected" mean? Does it refer to vertically integrated or horizontally integrated firms, or something else? The literature seems to suggest that both vertically and horizontally integrations are essential elements of a cluster. In the initial writing of Marshall (1890), who first postulated the external benefits of a cluster, the existence of specialized suppliers is considered an important contributor to increasing returns. Most theoretical models on agglomeration build on the foundation of intermediate goods (Venables 1996, 1999). This implies vertical integration is an essential element of cluster. But empirical evidence on this is scanty.

On the other hand, the benefit of cluster must also be associated with the reduction of transaction costs when firms co-locate, including search and information costs, bargaining and decision costs, as well as policing and enforcement costs (Dahlman 1979). Co-location of firms imposes certain constraints on the firm behaviors, leading to an ease of conducting businesses with one another. Co-localized firms realize the unattractive consequence of misbehaving and will refrain from doing so. In a cluster it will be immediately noticed if some firm attempts to overutilize asymmetric information, or pass substandard goods as first class, or create hold-ups in order to exploit the market shortage. Information about such misbehaviors will put the firm on the "black list" which deprives it from the flow of information and trading opportunities. Through this sanction mechanism, co-localized firms therefore create a mutual understanding and trust that reduce malfeasance and facilitate trade. Clusters prevail because trust cuts the costs of identifying, accessing, or exchange products between members in the area (Maskell 2001).

It remains to be explained, however, why a single firm does not arise to replace the cluster of firms if transaction cost is the key benefit of co-location. Marshall (1890) again, offers the explanation based on the advantage of "variety". When parallel but dissimilar firms co-locate in a region, they develop a variety of solutions to the same problem, based on the same information but different perceptions and different sphere of competence. This idiosyncratic and partly tacit way of dealing with things allows firms along the horizontal dimension of a cluster to engage in the process of mutual learning and competing improvement, on which their survival depends (Maskell 2001).

A cluster, therefore, encompasses two dimensions: a vertical dimension along which firms collaborate and perform complementary activities, and a horizontal dimension along which firms compete and perform parallel activities. It is the combination of collaboration and competition that drives the dynamics of clusters. The importance of "competition" in clusters is often neglected as researchers tend to overemphasize the benefits of collaboration and complementarily. In a study of New York City's garment industry, Rantisi (2002) highlights the importance of competition in the innovation activities of the fashion industry. Local rivalry is highly motivating to changes and peer pressure and the desire to stand out in the group can spin innovations.

In addition to specialized suppliers, Marshall (1890) also pointed on two other causes of agglomeration effect: labor pooling and technology spillover. Labor pooling refers to the presence of a labor force suitable for the particular industry in the cluster. Labor pooling reduces the entry barriers to new firms, the exit costs of incompetent firms, and the costs of adjusting the scale of production. Labor pooling also acts as a selection mechanism that stores or even cultivates a work force to support the growth of the industry. Using data on US manufacturing industry, Rosenthal and Strange (2001) found labor market pooling to be the most robust influence on agglomeration. Dumais et al (1997) also found that industries with similar labor mix enjoy the largest benefit from proximity.

Technology spillover is also found empirically to be an important contributing factor to geographic concentration of firms. First, innovative activity itself is substantially more concentrated geographically than overall production, and second, industries that emphasize research and development tend to be more spatially concentrated than those do not (Audretsch and Feldman 1996). Technology spillover does contribute to agglomeration, but its effect diminishes rapidly over distance (Rosenthal and Strange 2001). In other words, you have to be close enough to the knowledge center to benefit from knowledge spillover.

Knowing the benefits of clusters is not sufficient to understanding how clusters come about. It is noticeable that clusters, whether they are of high-tech or low-tech industries, only exist in certain regions of certain countries. This inevitably leads one to think that some regional advantages give rise to successful clusters. This may be true in the low-tech industry but not in the high-tech industry. After studying high-technology clusters in US, Ireland, India, Israel, and Taiwan, Bresnahan, Gambardella and Saxenian (2001) conclude that the economic factors that give rise to the start of a cluster can be very different from those that keep it going. Agglomeration economies arise almost naturally after a cluster has taken off, but the most difficult part is to get a new cluster started. They identify entrepreneurship, linkage to a major and growing market, and availability of skilled labor as three key ingredients to the formation of a cluster. Among the three factors, market access is the most recognized in the literature. Empirical studies have shown market access to be important determinant of cross-country income distribution (Hummels 1995, Leamer 1997). Recent studies by Hanson (1996,

1997) on the Mexican apparel industry found that prior to trade liberalization in 1986 when Mexico joined WTO, production of apparel was concentrated around Mexico City and largely oriented towards the domestic market. With trade liberalization, there was a substantial relocation of manufacturing activity towards the US border. There is evidence of a negative relationship between relative wages and distance from Mexico City prior to 1988, and of a significant decline of this relationship between 1985 and 1988. Distance matters even although transport cost has been declining due to improvement in technology. Davis and Weinstein (1998), for example, using data for 13 OECD countries and constructing a measure of "idiosyncratic demand" for each 4-digit industry based on demand in each country and its trading partners, distance weighted, found that the elasticity of production with respect to demand to be as high as 1.6. Feenstra, Markusen and Rose (2001) also found a fairly strong home market effect in industries with differentiated products.

While the three ingredients of entrepreneurship, market access, and skilled labor are indispensable, there seem to be various ways of formulating a recipe. This is why various clusters co-exist instead of one cluster monopolizing the entire industry. The variety of recipe is often culture related and this is why culture is an important factor in defining the development path of a cluster (Saxenian 1994). This finding is tantamount to saying that entrepreneurship, market, and technology are three key ingredients to the formation of a cluster, but there are multiple combinations to produce an output. The key is to find a formula that sets out a process of " cumulative causation". Some clusters appeared to arise naturally, out of nature geography advantage. For example, in the beginning of industrial revolution, most textile industry clustered in the area rich in water resources, as water was the most distinctive input to textile production. However, in the high-technology age, nature-endowed inputs become less important and created assets such as skills become more relevant. Examining the experiences of Ireland, India, Israel and Taiwan which have succeeded in developing IT clusters in recent years, market access seems to be the most critical among the three ingredients for success. US was apparently the major and growing market for IT products, and it seems that building a linkage to this market center is a precondition for developing a cluster. In all four cases, an alliance approach was taken. They built a collaborative relationship with multinational firms based on the US to enable a market access, and to benefit from technology spillovers from such an alliance. Even the "specialized suppliers" and "labor pooling" were supplanted by multinational firms.

Contrary to the general belief, putting a university at the center of the cluster can help but it is neither necessary nor sufficient to starting a cluster. There is also no evidence showing that government policy, whether based on protectionist infant industry, national champion, arguments or direct industrial targeting, is useful in jump-starting a cluster (Bresnahan et al. 2001). The success of a cluster can be measured by the growth of the number of firms and by the growth of existing firms. The growing number of firms is important because it is critical to the creation of knowledge simultaneously by variation and by the division of labor (Wallsten 2001). But the growth of firms is equally important because the growing companies are often the sources of increasing returns for the continuous growth of the cluster, in form of training for potential spinouts, development of managerial and technical competencies, and the typical forward and backward linkages.

Although the ingredients to the start of a cluster have been identified, the mechanism that put these ingredients together to work toward building a successful industry is not quite clear. The experience of Silicon Valley has pointed out the important role played by venture capital (Rowen and Toyoda 2002), but the experience in other countries is not as clear-cut. Venture capital also played an apparently important role in Taiwan's high-tech clusters, but the role of venture capital in other APEC members is not as significant. It is also clear that venture capital is important only in the start-up stage of a firm, and traditional capital market has to take over the subsequent role in supporting the growth of the firm, which as previously mentioned, will eventually determine whether a cluster succeeds.

It is also noted in the literature that structures and institutions matter in the development of clusters. Different institutions may be needed for clusters specializing in different economic activities. Inappropriate institutions may thwart the opportunities of a resource-rich country to develop an industry based on such a resource. Eskelinen and Kautonen (1997), for example, demonstrate how Finland, with its bounteous supply of high-quality timber resources, high education standards, and a long track record of world-class designers, has been losing out in wooden furniture industry. The explanation has been that Finnish institutions are catered to support the mass production of pulp and paper, which are unfit to wooden furniture industry characterized by flexible and small-batch production. The hostile institutions in Finland drove the furniture industry away to neighboring Denmark where the industry blossomed. Idiosyncrasies in economic activities require variations in institutions and give rise to distinctive industry clusters.

The institution that is discussed most often in the literature is the institutions for innovation. Regional or national innovation system is therefore the focus of recent studies on cluster – based industrial policy (Lawson 1997; Lundvall 1998). The key element of regional innovation system is a group of networked institutions for the creation, combination, distribution, and application of knowledge. Again, innovation institutions are part of the group of institutions that underscore a cluster. The variety of clusters gives rise to a variety of national (regional) innovation systems. For example, Silicon Valley operates within the American system of innovation, which include laws, regulations and conventions for securities, taxes, accounting, corporate governance, bankruptcy, immigration, research and development, university – business links, intellectual property protection, etc. This system is most favorable to new business ventures (Rowen and Toyoda 2002). In the case of Hsinchu Science-based Park (HSBP) in Taiwan, the regional system of innovation include two premier universities, a government-sponsored research laboratory, a tax scheme that favors R&D, and an employee bonus scheme that attracts highly skilled labor to growing companies. The system also spawns a community of seasoned engineers with strong connections with Silicon Valley. The system is especially effective in spurring follow-up innovations that take advantage of the research originated in the Silicon Valley.

It is also important to note the role of universities or other research institutions (Santoro and Chaknabarti 2002). Although Bresnahan et al. (2001) have found universities to be non-essential to the start-up of a cluster, universities may just be a critical factor for the growth of the cluster. It is clear that a cluster will not grow without innovations and innovations have to come from research. Although some knowledge can be acquired from outside, but R&D is not a free good – if you do not invest, you cannot absorb knowledge (Cohen and Levinthal 1989). It takes some high-caliber universities and research institutions to build a capacity to acquire and use the knowledge that has been produced. It has also been shown in the literature that firms locate close to research centers benefit disportionately from the knowledge produced in such centers, which is especially true for advanced research in fields such as biotechnology (Cooke 2002; Cooke 2003). Likewise, firms locate close to other innovative firms are more productive in R&D output than those locate afar (Wallsten 2001; Orlando 2000). Universities are also critical in providing high-skilled labor to support the growth of a cluster. It is also increasingly recognized that close linkage between universities and industries are conducive to innovations and to commercialization of new ideas. To what extent that universities matter in the development of clusters needs to be answered by more research.

We may also look into the problems that inhibit the establishment of a cluster. Inability to create a knowledge base may be the most obvious barrier that obstructs the development of an industrial cluster. The inability is caused by weak economic institutions that obstruct learning efficiency and by high vulnerability to volatile global currency and financial markets that constrain patient capital necessary for the development of a broad knowledge base (Ernst 2003). The lack of a knowledge base often deprives the developing countries from upgrading themselves from an offshore assembly platform for multinational firms to self-sustained industrial clusters. With footloose international capital, developing countries attract multinational firms by low wages and lose them when the wages rise. Even if foreign investments cluster in a particular location, they usually failed to generate agglomeration benefits.

The emergence of global production networks (GPN) (Borrus, Ernst and Haggard 2000) may have given developing countries a new hope of transforming an offshore production platform into a knowledge-rooted industrial cluster. This is to come from cross-border knowledge diffusion, refuting the proposition that knowledge spillover attenuates over distance rapidly. Gross production networks expand inter-firm linkages across national boundaries, increasing the need for knowledge diffusion. The rise of GPN is necessitated by the aspiration to compete globally and to synchronize production and service around the globe. Central firms in GPNs need to transfer technical and managerial knowledge to local suppliers to achieve systemic efficiency. Even R&D may be divided by labor among member firms of the network. What we need in a cluster is therefore, not an innovative center, but a "learning network" defined by a given geographical boundary with supportive institutional arrangements (Cooke 2000). We will discuss the issue of learning networks in Chapter 3.

Along with the concept of learning networks, the traditional role of factor endowment in the formation of industrial cluster has also changed. Traditional literature along the line of Marshall (1890) has assumed factors to be immobile across counties. Globalization has allowed many factors to be mobile across national boundaries, particularly capital and skilled labor. It is nowadays common for anyone to be born in one country, educated in another country, and to work in yet another country. Human skills also tend to cluster. Most financial experts work in London and New York, most IC-related engineers work in Silicon Valley. These experts and engineers may be born anywhere in the world. A right environment and institutions can attract the flow of skills. In the past, advanced countries attracted the skills from the developing countries, constituting a brain drain. Today, there is a reversal of brain drain whereby skills flow from advanced to developing countries. If skills can be indeed obtained from outside, then the three ingredients for the formation of a cluster would be reduced to only two: entrepreneurship and market access. We will discuss the issue of "human circulation" in Chapter 5.

Finally, what is the role of government in the formation and development of clusters? Although Bresnahan et al. (2001) disapprove proactive government policies based on protectionist or infant industry arguments, or pick-the-winner target setting strategies, they nevertheless confirm the useful role of the government in providing "accommodative" policies. In fact, we question the distinction between proactive and accommodative policies. Is skill training proactive or accommodative? There are plethoras of failing attempts to jump-start an industrial cluster. We can easily point out the missing ingredient in the formula. But does it not mean that the government has not been "proactive" enough in identifying the missing part of the formula and finding a solution before a cluster-based policy is launched. Given that it takes many ingredients to bind together a winning formula and there is no guarantee that a region will be naturally endowed with such resources, the action that brings together these resources constitute that core policy requirement for a government interested in cluster development. This is not to mention various institutions that facilitate the cluster development may have to be created and nurtured through government investments or regulations.

The experience of Taiwan, India, and China in developing their respective IT clusters at least suggests one policy in common: to concentrate scarce resources, e.g., skilled labor, in a small region which is to be developed into a cluster. For Taiwan, this has been Hsinchu, for India, Bangalore, and for China, Shanghai. Government policy has been useful in pooling skilled labor in the region, accommodated by universities and research institutions. Without the government policy, the skills would have been dispersed around the country and employed by heterogeneous industries. It is obvious that labor pooling is not sufficient to generate agglomeration effect, as both China and Taiwan had had enormous academic institutions that collect the nation's top talents but failed to create any industrial clusters. Policies that facilitate market access and promote entrepreneurship may be equally important and indispensable for the formation of an industrial cluster. We will discuss the policy issue in Chapter 6.

1.3 Research Scope

This project will study four aspects of the industrial clusters, using Taiwan, US, and China as an example:

(1) Factors that contribute to the successful formation of an industrial cluster, and the effect of industrial clusters on productivity;

(2) the organization and networking of an industrial cluster, including division of labor within the cluster, location choice of related firms in the cluster, and inter-cluster linkages;

(3) the flow of human resources between clusters in Taiwan, US, and China, focusing on the drivers of such a "brain circle", and the contribution of "brain circle" to technology innovation;

(4) the interrelationship between industrial clusters and innovations, focusing on within-cluster and outside-cluster technological spillovers.

1.4 Research Strategies

The research team will employ both quantitative and qualitative analyses on this project. In addition to the literature survey, field study, questionnaire survey, and secondary data analysis will be used to explore the issue. In particular, the following studies will be conducted:

(1) Using the census data on Hsinchu Science-Based Industrial Park to analyze the organization and networking of the industrial cluster,

(2) using a questionnaire survey to research the cross-cluster linkages in innovations,

(3) using field studies (interviews) to explore the human resources flows between Hsinchu Science-Based Industrial Park, Silicon Valley (US), and Kunshan (China).

Chapter 2 Case Studies of APEC Member Countries' Industrial Clusters

2.1 Introduction

As noted in the opening chapter, there are a number of distinct advantages for firms involved in the formation of an industrial cluster. To reiterate, these include firstly, that a cluster provides complementary resources such as technology and information exchange, management assistance, and so on, to improve the performance of all firms within the cluster. Secondly, the cluster strengthens competition and thus promotes technical efficiency because, as firms are located nearby, the inherently fierce competition for clients or suppliers becomes unavoidable; nevertheless, competition inevitably pushes up the level of efficiency. Thirdly, firms can quickly respond to the demands of the market, or to changes in technology, since firms within the cluster can reorganize subcontracting work more quickly than those outside of the cluster. This particular ability to leverage resources to adapt to fluctuations in the market and changes in technology has been the major benefit for firms located within the cluster.

There are, however, a number of questions surrounding the existence of such clusters, such as: what is the historical background and what have been the major incentives behind the formation of clusters by firms?; how do clusters interact with other clusters?; have they been able to adapt to the more open, internationalized environment that has emerged in recent years?; and, as time goes by, how will these clusters continue to evolve? All of these questions, and perhaps countless others, are worthy of further exploration. Therefore, the aim of this chapter is to introduce four case studies – Taiwan's Hsinchu Science-based Industrial Park (HSIP), the Silicon Valley in the US, Malaysia's Penang and Kelang Valley clusters, and the Hamamatsu cluster in Japan – in an effort to gain an understanding of, and to draw some lessons from, their developmental experiences.

2.2 HsinChu Science-based Industrial Park (HSIP)

Following the first oil crisis in 1973, the government realized that Taiwan's industrial development was built on a weak, labor-intensive structure, which was liable to disintegrate during any protracted period of recession. It was clear that Taiwan needed to pursue a policy of development of hi-tech, high value-added industries, and in order to attract investment and technology transfers from foreign hi-tech industries, the government had to provide a suitably attractive environment. It therefore decided to create a science-based industrial park similar to the well established example of Silicon Valley in California. When deciding on the location for the new park, the availability of highly skilled manpower and technical support were vital preconditions, and Hsinchu was seen as a prime target, with its two universities – the National Tsing Hua University and the National Chiao Tung University – being particularly strong in sciences and thus ensuring that there would be no shortage of skilled workers. One additional factor, the fact that the Industrial Technology Research Institute (ITRI), an organization created to provide much needed technological support, had already been established in Hsinchu, made Hsinchu the obvious choice.

With the effective provision of manpower supply, and other incentive measures for land purchase and building construction having been created, the government formally established the HSIP in 1980. In the previous year, the Statute for the Science-based Industrial Park Establishment and Administration (1979) had been promulgated, providing, in Article 15, five-year tax holidays for companies establishing themselves within the park, along with exemptions from import duties, commodity taxes and business taxes for imported equipment, raw materials, parts and semi-finished products imported from abroad (Article 17), and a variety of other tax incentive measures.

The whole concept behind the establishment of the HSIP represented the creation by the government of a space where industry could group together, enabling manufacturers to reduce the costs of personnel training, buildings, land and other basic infrastructure, whilst also allowing them to enjoy the benefits of concentration in technology transmission (Mai, 1996; Mai and Peng, 1999). In addition, the tax incentives also clearly had the effect of encouraging manufacturers to invest within the park.

In their observations of the development of the HSIP, Wang, et. al. (2002) divided the process of development into several stages, which included the joint venture stage (1980-1987), the dynamic growth stage (1988-1992), the stable development stage (1993-2000), and the innovative transformation stage (2001-present).

The HSIP was founded in 1980, its joint venture stage, as guided by government policy. Following its establishment, only fourteen companies gained approval for their relocation into the industrial park between 1980 and 1987, with the total amount of investment at that time being NT$1.24 billion. The mainstream development of the park at that time fell into the category of computers and peripherals, with only 4,090 of the employees within the park being technical personnel. During this stage, the main dynamic of the park's emerging technical development came from the government statute and the introduction of foreign technologies by the ITRI.

In the dynamic growth stage, which commenced in 1988, Taiwan Mask Corporation started manufacturing optical masks, whilst in the same year, some companies also started engaging in IC testing. These companies laid the foundation for the semiconductor industry by establishing a prototype for the integration of all of the elements of Taiwan's IC industry. In addition, the companies established strategic alliances with other countries, which led to IC becoming the leading industry in the park. As a result of the stable development stage, which has been taking place since 1993, the IC industry has become the number one industry in the park in terms of the number of companies, employment, capital investment and sales revenue. At that time, the market began to pull money in, and the model of vertical disintegration was completed as this unique clustering effect helped Taiwan's science-based technical industry to enter the global market. The vertical disintegration of the IC industry also became the norm in the development of Taiwan's high-tech industry.

The development of the industrial park is closely related to return of Chinese engineers from overseas. Obtaining technologies from foreign countries has long been Taiwan's major industrial development strategy. Many researchers have pointed out that to a very great extent, technology licensing, venture capital and foreign investment have contributed to the development of local industry. In addition, many studies have asserted that returning engineers from the US (where they had received their higher education) had made significant contributions to the development of Hsinchu (Castells and Hall, 1994; Hobday, 1995; Mathews, 1997); however, these studies have largely assumed the US (Silicon Valley) to be the major export source of core technologies, whilst Hsinchu was seen as merely a peripheral area of industrialization since it was receiving the importation of foreign technologies in a passive way.

Although these studies have explained why Taiwan was no longer a low-wage manufacturing base, they have not articulated the ways in which the new dynamics emerging from the interaction between Hsinchu and Silicon Valley have affected technological development in Taiwan. Indeed, such interaction is moving towards a complementary and mutually beneficial relationship rather than a hierarchical and zero-sum relationship. These studies have therefore ignored the phenomenon of interactions with multinational corporations (MNCs) in the construction of various global economic systems. For this reason, we will explain international interaction from a perspective of technology connection, and from an alternative perspective of the introduction of skilled manpower.

2.1.1 Technology Connections

The most successful example of R&D clustering is indeed the technology cluster in Silicon Valley. The subsequent connections developed between Silicon Valley and the HSIP were built by overseas engineers and specialists returning from Silicon Valley to Taiwan, with these connections being based on personal networks via international strategic alliances wherein joint R&D is conducted between MNCs and Taiwanese subcontractors. For example, Taiwan Windows CE Alliance was an alliance that was targeted at expanding the share of the software market. Such cooperation not only accelerated the development of products with high value-added but also reduced the obstacles to R&D through close ties with the major international firms. Such a scenario indicates that Taiwanese high-tech firms were fairly aggressive in both their R&D and their competition for technology licenses, and it also indicates that Taiwanese firms have developed technological capacity which the international community has clearly recognized.

2.1.2 The Introduction of Skilled Manpower

HSIP is supported by a strong research community in close proximity to the park. Two major universities, Tsing Hua and Chiao Tung, are located just outside the park, with both of these universities having traditionally placed significant emphasis on science and engineering disciplines. By 2003, the two universities had a combined student population of 20,268, along with 1,066 professors. Collaborative research projects are often conducted between universities and companies in the park; furthermore, the government-sponsored research institute, ITRI, is located only five kilometers away from the park. Employment within the park is naturally biased toward skilled workers; by 2003, the park was employing a total of 98,685 workers, of which 46 per cent were junior college graduates or above.

Before Taiwan's own capacity for R&D was fully developed, aggressive recruitment of overseas engineers and specialists helped to bring in the advanced technologies and know-how. The introduction of these talented employees contributed to the development of Taiwan's semiconductor and information industries for a number of reasons. Firstly, overseas Chinese workers have an impressive track record of service. As Tu (1995) noted, Taiwan and the US established a special and close relationship way back in the 1950s, with this relationship incorporating material supply during the early stage, and thereafter, increasing numbers of returning overseas students. This relationship therefore provided Taiwan with easy access to Western culture and language.

Secondly, Taiwan developed itself into a depot for MNCs in the Asia-Pacific region by improving its relationships with Japan and Europe. Yang (1998) affirmed that there was a considerable correlation between the development of Taiwan's electronic and information industry, and talented individuals educated in the US. The Taiwanese government has offered strong incentives to encourage overseas specialists to return to work in Taiwan. On 31 December 2001, there were 4,292 overseas engineers and specialists working in the companies in HSIP, and 123 companies had been founded by

Chinese entrepreneurs returning from abroad.

2.1.3 Access to a major and growing market

Since 1980s, because of solid manufacturing ability, timely delivery, efficient management and reasonable cost, us firms such as IBM, Compaq, HP subcontract their production to Taiwan's computer manufacturing companies. As a result of such a partnership, Taiwan's information technology start to take off, which certainly serves a big boost for the further development in HSIP. In the IC industry, Taiwan's foundry firms serve as the manufacturing base for us fabless IC design houses; the growing OEM demand for us IC design houses help build Taiwan's world class foundry company-Taiwan Semiconductor Manufacturing Company (TSMC) and United Microelectronics Company (UMC). In the HSIP, the production value for IC industry has accounted for 57% of Taiwan's overall IC industry.

2.1.4. Entrepreneurship encouragement

Owing to international technology transfer and the nurturing of manufacturing ability, HSIP's favorable environment creates a warmed for entrepreneurship in the mid-1990s. In this period, technology personnel from IC, computer and its peripheral industry began to set up their own business. As of the end of year 2001, the start up companies owned by overseas Chinese has reached 723. The key for the entrepreneurship has been threefolds. First, Industrial Technology Research Institute (ITRI) transfers their research results, which results in the rising of the spin-off companies. As of year 2000, ITRI officially spin-off 31 companies (Wang and Hsu et. al., 2002). Second, demonstration effect instigates entrepreneurship. Since the mid-1990s, Taiwan's IC manufacturing companies (TSMC, UMC), IC design houses (VIA, SIS) performed beyond expectation; consequently, it encourages more people to start up their own venture, and entrepreneurship spreader out. Third, the booming of venture capital also contributes greatly for start up business to raise fund in the early stage.

Overall Performance

As can be seen from the level of employee productivity, measured by sales divided by the number of employees, per capita sales generated by employees within the park in 1992 were lower than in some other industrial areas, such as Taipei and Taoyuan Counties. However, the average per capita sales within the park grew from NT$2.5 million in 1992, to NT$ 5 million in 1995. The calculations shown in Table 2.1 provide a comparison between productivity in the HSIP and other major industrial areas based upon a national productivity perspective. From this comparison, per capita sales in the park's information and electronic industries in 1999 were 30 per cent above the national average. The result suggests that the information and electronic industries achieved more agglomeration benefits than the industries in Taipei and Taoyuan Counties.

Table 2.1 Sales generated by employees (employee productivity)

Unit: NT$ millions

	Employee Productivity		
	1992	1995	1999
National average	2.43	3.82	5.07
HSIP	2.55	5.06	6.60

Source: Wang, et. al. (2002).

HSIP's Contribution to Economic Development

There can be no doubt as to the important contribution made by HSIP to Taiwan's economic development; indeed, the park has had a major impact, both in terms of stimulating development of the hi-tech industry and in earning foreign exchange from the growing level of exports. In the twenty-year period after the establishment of the HSIP, the government had invested NT$18 billion in 'software' and 'hardware' construction at the park, turning it into the main centre for Taiwanese industrial development. Companies located within the HSIP spent, on average, 5.94 per cent of their sales revenue on R&D in 2000, whilst the number of people employed at the park had increased from 8,275 in 1986, to 102,775 in 2000. Furthermore, total sales of companies located within the park increased from US$450 million in 1986, to US$29.80 billion in 2000 (see Table 2.2). Whether investing in the establishment of a new company themselves, or engaging in production or R&D work on behalf of others, the large number of ethnic Chinese technical experts who have returned to Taiwan to work within the HSIP have made a significant contribution towards raising the level of technology in the related industries.

Table 2.2 The development of the Hsinchu science-based industrial park

Indicators	1986	2000
No. of companies established within the park	59	289
No. of persons employed within the park	8,275	102,775
Total paid-in capital of all companies located within the park	US$151 million	US$226 billion
Expenditure on R&D as percentage of business volume	5.4 per cent [a]	5.94 per cent [b]
Total business volume of all companies located within the park	US$450 million	US$29.80 billion
Total export value of all companies located within the park	US$4.51 billion [c]	US$15.98 billion [d]

Notes:

[a] *The data provided here are from 1990, when the park began reporting this data.*
[b] *The data provided here are 1999 data.*
[c] *The data provided here are from 1993, when the park began reporting this data.*
[d] *Accounting for approximately 9.14 per cent of Taiwan's total export value.*

Source: *Science-based Industrial Park Quarterly Statistical Report* (*consecutive issues*).

Thus, one of the major contributions that the HSIP has made to Taiwan's industrial development is the role that it has played in transferring overseas technology and encouraging technical specialists living overseas to return home (San and Wang, 1996). According to estimates by San (1999), over the period from 1980 to 1989, a total of 14,880 people who had been studying overseas returned to work in Taiwan; this figure more than doubled, to around

30,238, over the period from 1990 to 1995, and these figures were equivalent to 44.4 per cent and 56.5 per cent of the respective number of all people obtaining Masters or Ph.D. degrees in Taiwan during the same periods.

In a questionnaire survey of companies located within the HSIP, San (1999) discovered that amongst the main sources of technology for companies in the park, 'technology brought back by people who had studied abroad' was second in importance only to 'own research and development (R&D) work.' Clearly, the HSIP has been very effective in encouraging technical specialists working overseas to return home, and a considerable amount of technology has been acquired as a result. So important has the park been to the development of Taiwan's hi-tech industries, it has become known as 'Taiwan's Silicon Valley'.

The Future Development of the HSIP

The statute covering the development of the high-tech industry has been in place for many years, and given the rapid pace of development of the high-tech industry, this statute may well now be out of date. Consequently, the statute may now represent a hindrance to the continuing development of the new high-tech industries. At the same time, the ignorance of market principles allows businesses of lower performance (or those with no real competitive advantage) to remain within the HSIP, thus wasting these scarce land resources. Hence, both the legislative and administrative obstructions need to be removed so that those truly qualified high-tech businesses can continue to develop in the park. In addition, the HSIP has begun to compete with similar parks in other developing countries, including the Multimedia Super Corridor in Malaysia, and the manufacturing-based technical cluster in Shanghai.

Taiwan is currently facing a crossroads in its R&D and manufacturing. The decision on which pole to stand at, between R&D and manufacturing, depends on how entrepreneurs in Taiwan perceive their future. Since Taiwan's high-tech clusters are under pressure to transform themselves, there will be a risk of them being substituted by the competing clusters in Shanghai if the wrong decisions are made. Thus the leading enterprises in the industry must take this problem seriously and consider how to turn this challenge into an opportunity to achieve another period of growth in technology in Taiwan. These enterprises should also follow the role model set by Silicon Valley and aim to improve their own level of competitiveness in technological development.

As regards the outlook for the industry's comparative advantage, rather than expanding its manufacturing capacity, Taiwan should work harder to develop R&D centres. It will also be necessary for Taiwan to maintain its R&D in high value-added areas so as to create a complementary relationship with Shanghai for the sustainable development of the high-tech industry in Taiwan. Secondly, Taiwan should cooperate with Silicon Valley to make up for the lack of necessary technology required for use in the innovative R&D centres. This cooperation should also cover technology transfer and the establishment of cross-border R&D centres so as to make use of foreign technological resources in order to improve local technologies.

Taiwan's high-tech companies have already transformed themselves from 'original equipment manufacturer' (OEM) subcontractors to 'original design manufacturers' (ODMs), and are now moving towards becoming 'original brand manufacturers' (OBMs). The high-tech businesses on the island should endeavor to enhance the vertical disintegration of R&D and manufacturing, whilst also seeking to develop core industrial competitiveness through complementary and cooperative disintegration between Silicon Valley and Shanghai.

2.3 The Establishment of Silicon Valley

Geographically, Silicon Valley is contained within a thirty-mile by ten-mile strip of land between the cities of San Francisco and San Jose in Santa Clara County in Northern California. This economic region begins in the Northwest of the Valley in Palo Alto, where the bulk of theoretical and practical technological research in this field is carried out at Stanford University and the Stanford University Research Park.

A combination of regional advantages and historical accidents conspired to produce the greatest 'science park' in the world, with observers having identified a number of regional advantages for the valley, including world-class academic institutions (Stanford University and the University of California at Berkeley), brilliant scientists, military procurement of semiconductors, and the pleasant climate of Northern California (Rogers and Larson, 1994).

Several factors have been attributed to the success of the valley, the first of which is the influence of nearby higher education institutions, particularly Stanford University. In the 1920s, Stanford recruited highly respected faculty members from the East Coast of the US, including such important recruits as Fred Terman, David Hewlett and William Packard, who became the pioneers for innovation and commercialization of innovative products. In 1950, Hewlett-Packard (HP) sold 70 different products, achieving sales in excess of US$2 million and rapidly expanding to a 200-employee company, and the formation of HP's distinctive Silicon Valley management style soon encouraged numerous enterprises to follow suit. In 1954, HP rented part of Stanford Research Park for its operations, which then led on to the formation of the cluster of industries in Palo Alto.

Secondly, the government also played a major role in the prosperity of Silicon Valley. The relocation to California of the military contractor, Lockheed, in the mid-1950s brought federal defense dollars to the area, whilst public procurement from defense agencies also hastened the growth of the semiconductor industry.

Thirdly, the flexible environment, informal means of information exchange and the high level of labor mobility also promoted collective learning and flexible adjustment between companies that subsequently encouraged further entrepreneurship and experimentation (Saxenian 1994).

2.3.1 The Contribution of Silicon Valley to the US Economy

The driving force behind the economy in the valley is technology, and more specifically, specialized clusters of technology firms and talented individuals. Almost 40 per cent of Silicon Valley's workforce is employed in technology-related industries, and many more jobs are tied to the support of these industries. These clusters are dynamic; constantly innovating and changing. They draw strength from the valley's business environment, its tangible assets, such as world-class universities, extensive supplier networks and specialized professional services, as well as from intangible qualities such as competitive spirit and the willingness to take risks.

In the 1990s, Silicon Valley's economy has been shifting from a high-tech manufacturing economy to a knowledge-based economy. This economy is now moving towards higher value and greater service-oriented activities. The valley's competitive advantage comes from the productive and creative use of human inputs, from value rather than from volume.

After more than fifty years of continuing progress, Silicon Valley has made a significant contribution to the long-term economic development of the

US, with a number of indices demonstrating its importance. First of all, the value added per employee in the valley (a measure of productivity), increased by 4.6 per cent in 2001 to US$170,000, as compared to the national figure of US$56,000. Secondly, although the valley is home to less than 1 per cent of the US population, its latest annual patent awards came to more than 6,800, eight per cent of all the patents awarded to US residents.

2.4 Penang and the Kelang Valley, Malaysia

2.4.1 Background

The industrial clusters in Penang and the Kelang Valley in Malaysia have enjoyed strong MNC operations in electronics manufacturing since the early 1970s, indeed, foreign-owned corporations accounted for 83 per cent of all fixed assets in the electronics industry in Malaysia in 1998. Comparing these two Malaysian electronics clusters, and drawing on Rasiah (2002), this paper underlines the human capital and network cohesion that exists between the domestic and foreign firms within these clusters, and the coordination between government and businesses as the critical conditions for such industrial clustering.

Both regions enjoy advanced levels of basic infrastructure and educational institutions. Over the period from 1970 to 1990, the high unemployment rates of around 6.0 per cent to 8.1 per cent ensured that MNCs engaged in labor-intensive assembly began relocating to this country. Political stability, financial incentives and controls on unionization ensured that Malaysia was one of the more attractive sites. However the exhaustion of labor reserves in the 1990s resulted in a significant shift in the demand structure for human capital in Malaysia's manufacturing sector. The resultant labor shortages, rising wages and the emergence of other low production cost sites, such as mainland China, Thailand and the Philippines, along with their improvements in basic infrastructure and political stability, began to challenge the ability of Penang and the Kelang Valley to sustain their operations.

The labor shortage problems of the 1990s led to a shift in the government's industrial strategies from a focus on employment generation to industrial deepening, clustering and the upgrading of industry to higher value-added activities. These new policies included the 'Action Plan for Industrial Technology Development' in 1990, and the 'Second Industrial Master Plan,' which set out the guidelines for the proposed transformation in 1995.

Alongside the Federal Ministry of Education, which governs formal education institutions, including general, vocational and technical education, the Human Resource Development Council Fund, which was established in 1993, required manufacturing firms with 20 or more employees to contribute 1 per cent of their payroll to the council, which the firm could then reclaim by submitting bills from approved training establishments. In order to complement the domestic human resource capabilities, the government initiated exemptions for IT firms in the Multimedia Super Corridor (MSC) starting from 1997, to support the importation of technical and professional human capital from abroad.

Despite the intense emphasis on the development of infrastructure, the supply of high-tech human capital has consistently lagged behind the growing demand, and as a result, there has been a severe widening of the gap between the supply and demand of human capital, and a constant structural mismatch caused by coordination problems within the two clusters. Both Penang and the Kelang Valley have therefore failed to establish a sufficient supply of high-tech human capital, largely as a result of the problems of poor coordination of supply and demand. Although allowing immigration by professionals possessing high-tech human capital may be the only answer to overcoming this growing deficit, the main barriers to accessing such high-tech talent are the existing conservative immigration policies.

2.4.2 Penang

Penang's manufacturing sector accounted for 13 per cent of the country's GDP in 1971, a figure which subsequently rose to 46 per cent by 2000. The electronics industry in Penang employed over 90,000 workers in 1995, with the outstanding economic performance of this particular cluster being attributed to the important contribution of the MNCs. The essential intermediary role of the Penang Development Corporation (PDC) was established in 1969 with the aim of placing considerable effort into attracting export-oriented MNCs into the manufacturing sector. Integrated business networks, with the PDC fuelling their cohesion, have helped in the dissemination of knowledge embodied in human capital for the creation of new firms, differentiation and the division of labor. The development of the MNCs has driven strong supplier networks, whilst institutional coordination aimed at supporting their growth has increased the localization of inputs by MNCs.

From a perspective of a global production network, Penang has successfully drawn industry 'species' from other locations. Specific capabilities, in terms of specialization, have helped the region to sustain its level of growth, and have provided the mechanisms for accelerating inter-firm links. Industry 'sub-species' have also evolved domestically in Penang to stimulate further differentiation and diversity. The development of several tiers of firms has enabled workforces to further expand their development of knowledge and its dissemination within the Penang cluster. Within such clusters, there are often a number of MNCs which tend to play the vital role of a training ground for the hiring and nurturing of entrepreneurs; this has thus stepped up the creation of new firms, and has led to a more flexible industrial system within the region. In contrast to the Kelang Valley, Penang was able to develop sufficient network cohesion and institutional coordination to support the need for flexibility and interface between its domestic firms and the MNCs. Strong inter-firm relations and systemic coordination effects have thereby generated and expanded this industrial clustering whilst also appropriating considerable economic synergies.

2.4.3 Kelang Valley

Just barely trailing the accomplishments in Penang, the electronics industry in the Kelang Valley was employing almost 85,000 people in 1995, and in fact, the Kelang Valley was better endowed than Penang when the first major influx of electronics MNCs relocated to Malaysia in the early 1970s. As a result, it was quickly able to set up its high-volume production capacities in consumer electronics, semiconductors and picture tubes. However, the lack of an intermediate agency, such as the PDC in Penang, weakened the network and inter-firm cohesion in this cluster, despite the fact that it already enjoyed a concentration of manufacturing firms. This resulted in the development of comparatively less knowledge spillover, and the lack of real stimulation of inter-firm links and new firm creation.

Generally speaking, many of the parts and components produced by industries within this cluster, particularly those for the electronics industry, have been produced as elements within global production networks coordinated by the parent MNCs. A number of high value-added components, such as TFT LCD display screens, are imported from their subsidiaries or suppliers located in their home bases. Parts of the foreign MNCs act as anchors, offering markets and technological support for both foreign and local firms; however, most local suppliers are still limited to low value-added non-core activities, hence the key technologies and high value-added components are mainly imported from MNCs' other expatriate subsidiaries, or from their home countries, such as the US, Japan and Taiwan.

As a result of their poor network cohesion with domestic firms, MNCs in the Kelang Valley not only source from abroad, but also internalize the production of upstream activities, demonstrating that the more popular form of division of labor is intra-firm rather than inter-firm. The competitiveness of local firms is largely undermined by their costly and poor quality supplies, which results in MNCs building up very few industrial linkages within the domestic economy; indeed, foreign firms will generally tend to source most of their supplies from their home bases. We can thus expect that the weakness of the vertical division of labor between MNCs and local suppliers in the Kelang Valley has also led to limited knowledge spillover.

In addition to infrastructure and national policies, human capital, in particular, abundant skilled labor and entrepreneurship, which are the international linkages that are embodied in MNCs, become even more important in driving the formation of industrial clusters, especially in this era of the globalization of production. Some successful industrial clusters have managed to overcome the problem of local supply capabilities falling behind the existing demand by absorbing those foreigners who have working permits. Under the constraints of restrictive policies on the immigration of foreign professional workers, Penang relies on the network cohesion derived by the PDC, the intermediate agency, to improve systemic coordination, so that the relative ease of firm entry and exit will encourage entrepreneurship. The presence of such systematic coordination also helps to develop the inter-firm dissemination of tacit and experiential knowledge in Penang, much more so than in the Kelang Valley. As noted by Rasiah (2001), the quality of government vis-à-vis business coordination in Penang means that even small machine tool firms in Penang perform much better than those in the Kelang Valley.

2.5 Hamamatsu, Japan

Hamamatsu, which comprises of a cluster of machinery and musical instrument industries, is located to the South of Tokyo, with famous companies within the cluster including Honda, Suzuki, Yamaha and Kawai. The most notable feature of Hamamatsu has been the smooth transition of its traditional industries to modern practices. Once a centre for the production of textile machinery (prior to the Second World War) Hamamatsu successfully transformed itself into the post-war manufacturing centre for motorcycles and musical instruments, and today, it is still one of the most important manufacturing centers in Japan for machine tools and musical instruments.

As a home base for Suzuki Motor, which has evolved from a producer of motorcycles into an automobile manufacturer, Hamamatsu provides virtually all of the parts needed for auto manufacturing. Suzuki's major parts suppliers are located within a 15 kilometer radius of its Hamamatsu plant, thus allowing face-to-face communications at all times. Such proximity and close contact with suppliers reduces transaction costs and facilitates the effective coordination of production. Supporting these parts suppliers are a network of companies specializing in metal molding, precision instruments, computer-aided design, computer software, and so on; this supporting industry underscores the strength of the Hamamatsu cluster.

Hamamatsu also boasts a large number of angel and venture capitalists

(VCs); indeed, there is no shortage of investors for those who can manage to come up with a novel product. Many experienced entrepreneurs turned themselves into VC managers, providing advice to young entrepreneurs seeking to start up their own companies. It is estimated that Hamamatsu is the most concentrated area of VC companies in Japan (Takeuchi, 2002, p.37) and these VCs are well connected to local financial institutions which provide them with the necessary refinancing, whilst local financial institutions are also accustomed to collaborating with such VC operations.

The development of Hamamatsu into an industrial cluster has a long history. Hamamatsu has been an important manufacturing centre since Japan first started out on its path towards industrialization in the 19th century, and since its inception as a manufacturing centre, the area has been characterized by stiff competition within the same industry. Product variety is the key feature of this competition, with the less efficient companies being eliminated and thus allowing the small number of surviving firms to dominate the regional market, the Japanese market, and even the global market. In the heyday of the motorcycle industry, for example, which only emerged after the Second World War, there were at least 30 brands competing with one another. In the end, only Suzuki, Honda and Yamaha survived, and even today, these are still the three major motorcycle producers in Japan, which also dominates the motorcycle market on a global scale. The only major Japanese motorcycle producer outside of Hamamatsu city is Kawasaki, which is located to the north of Hamamatsu.

In the case of musical instruments, the rivalry between Yamaha and Kawai is also notable, with both aspiring to become the world's leading brand. Competition drives innovation and forces competitors to mobilize their upstream suppliers and downstream service providers to engage in closer collaboration. Collaboration takes place not only in the area of production, but also in the area of R&D, with the co-design of products allowing collaborators to exchange information and to share knowledge.

Rivalry exists not only within the market, but it is in fact also noticeable within the community. The employees of the large companies stride along the middle of the street, whilst those of small companies tend to walk along the side of the road. Rivalry between schoolmates and neighbors also extends to the competition between companies, with such rivalry having inspired new innovations and the start up of new enterprises.

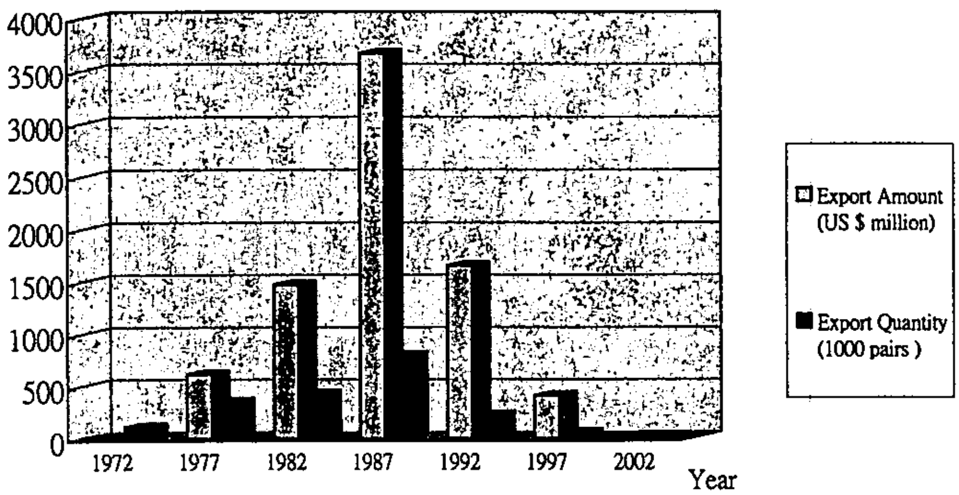
Hamamatsu is renowned for its ability to continuously produce new industries to replace older ones; as already noted, motorcycle manufacturers such as Honda and Suzuki have successfully transformed themselves into auto manufacturers, whilst musical instrument makers, Yamaha and Kawai, have evolved from the production of organs and pianos to manufacturers of electronic musical devices. Furthermore, the more traditional machinery industry has been on the decline in recent years, but the photo electronic industry has emerged as a new industrial force to replace it.

2.6 Taichung and Changhua, Taiwan's Footwear Industrial Cluster

2.6.1 Background

Although the area containing Taichung and Changhua Counties covers approximately 3,100 square kilometers, which is less than one-tenth of the entire area of Taiwan, these two counties were the most important production bases for the Taiwanese footwear industry throughout the 1980s. The Taiwanese footwear industry grew consistently from the early-1960s, and eventually reached its peak in the late-1980s. By 1988, the total amount of exports of footwear products came to US$3.7 billion, taking the leading position in terms of market share and overall export amount as against its competitors in the US shoe market.

The footwear industry in Taiwan once represented one of the most important export-oriented industries for the island; at its peak, Taiwan's footwear industry comprised of more than 1,000 firms, however, rising wage levels and the rapidly appreciating NT dollar after the 1980s, led to a decline in the island's once flourishing sector (See Figure 2.1).



Source: Taiwan Footwear Manufacturer Association

Figure 2.1 Footwear exports from Taiwan, ROC

There are two characteristics which are of interest. First of all, most of the firms within the footwear industry were small in size; the book value of 88.9 per cent of the firms was traditionally lower than US$700,000, whilst more than 90 per cent of them employed less than 300 workers.[1] Secondly, over half of the firms were located in Taichung and Changhua Counties.[2] Based on these observations, it may be worth investigating why so many firms chose to cluster together in such a small area.

1 See: Member List of Taiwanese Footwear Manufacturers (1989); and Wu (1989), pp.10-11.
2 See: Thirty Years of Taiwan's Shoe Industry, pp.2-3.

2.6.2 The Reasons and Advantages for Clustering

The clustering of shoe manufacturers in Taichung and Changhua Counties may have come about as a result of the developing nature of Taiwan's footwear industry. The area had been the production base for straw hats and mats within Taiwan's handicraft industry since the Second World War. Thereafter, in the early 1960s, some firms attempted to use raffia straw, Vietnam straw and viscous to make sandals and slippers. These shoes were welcomed by the markets abroad and their success immediately encouraged other sectors to shift their production bases. Mushrooming like bamboo shoots after a spring rain, many shoe manufacturers became established in Taichung and Changhua Counties, based largely upon the advantages of lower wages and skilled labor.

There was a special phenomenon in Taiwan's footwear industry. Levy (1991) indicated that Taiwan's footwear industry was organized via the subdivision among independent firms of various processes of production. Some specialized in lasting (the assembly of uppers and soles); some in the manufacturing of soles; some in the cutting of materials for footwear uppers; and some in the stitching of uppers. It was rare for a footwear firm in Taiwan to perform in-house more than two of the various subprocesses. The crowded clustering in Taichung and Changhua brought with it some unexpected advantages for Taiwan's footwear industry. Geographical clustering is helpful to connect product networks. It is easy to coordinate these subdivided firms for a trading company. Hsing (1999) found that Taiwan's shoe trading companies functioned not only as marketing agents but also information centers and coordinators of highly decentralized networks, leading small-sized shoe companies to achieve scale and scope economies.[3] For

[3] Wu (1989) also found that trading companies have a similar function, with 16.68 per cent of their acquired production technology coming from their cooperative trading companies.

example, a shoe order might require both women's and children's shoes of the same style but different sizes. The differences in size require different sets of lasts and cutting dies. The trading company would place the order for women's shoes in one factory and children's in another, so that each factory could concentrate on a segment of the order, thus saving the costs of extra sets of lasts and cutting dies.[4] Clustering reduces the transaction costs between manufacturers and their trading partners. Traditionally, most of Taiwan's trading companies have been small, with an average of seven employees (Liu 1991), and a typical shoe trading company has only 12 to 15 partner manufacturers (Hsing 1999); thus, the clustering of manufacturers is of significant help in allowing these trading companies to become part of a close network.

Furthermore, clustering resulted in an easier transmission of information on production and marketing between firms; however, it also put pressure on these firms in that the firms would monitor each other's progress. According to Wu (1989), within the shoe manufacturing industry, 22.5 per cent of acquired production technology came as a result of R&D undertaken by firms themselves, whilst a further 15.5 per cent came from mimicking others within the profession.

As compared with the previous sections, we can find that the clustering of firms does display benefits not only in heavy industries or capital-intensive industries, but also in small and labor-intensive industries.

2.7 Summary

Within this chapter, the sustainability of a cluster has been the most

[4] In addition, Hsing (1999) found that the trading companies also play a role like a supervisor for a shoe firm. Trading companies translated the foreign buyer's requirements from English to Chinese, and from abstract to clear and technical language, and as usual, they would send inspectors to partner factories to control quality at assembly lines and to avoid delayed delivery.

important policy issue to be explored. Such sustainability implies that naturally endowed factors are not the key element for a successful cluster because the region's comparative advantage will shift over time and the price of naturally endowed factors will usually be bid up by the growth of the industry. Indeed, if naturally endowed factors were to be the key to competitiveness, the success of the cluster would become its own enemy. Therefore, comparative advantage must be created through assets such as skilled labor or institutions that are capable of keeping the cluster going. Companies in Hamamatsu are noted for their ability to jump industries; for example, between 1991 and 1994, 1.1 per cent of enterprises in the region switched from one industry to another, the highest proportion amongst all major industrial cities in Japan (Takeuchi 2002, p.34). Many manufacturers of musical instruments diversified into electronic machinery, with such industrial switching being considered as a second time start-up of a new business by existing companies.

The core strength underpinning the evolution of industry in Hamamatsu is its embedded manufacturing capability, a capability which is particularly evident in the vehicle manufacturing industry. From motorcycles to automobiles, Japan's major manufacturers were all born in Hamamatsu, with the subcontracting system comprising of parts suppliers, assemblers of semi-finished goods and machine tool providers, forming a strong network jointly responsible for complete vehicle production; indeed, the vehicle industry is underpinned by a strong and comprehensive machinery industry which was, in turn, initially cultivated by the textiles industry. The machinery industry is itself also underpinned by a strong casting and precision measurement industry.

The experience of Hamamatsu points conclusively to the key roles played by specialized suppliers, whilst the presence of an effective venture capital community, which was conducive to business start-ups, also helped with the transformation of industry. It is also very noticeable that the companies in the Hamamatsu cluster are globally connected, with their products being strongly oriented towards the international market.

Finally, we summarize the features of the above four industrial clusters to compare their similarity and differences (see Figure 2.2). Their features may provide some policy intuition for government as well as firms.

Figure 2.2 The features of the industrial clusters in the APEC member countries

Clusters / Feature	**Taiwan: Hsin-Chu Science - based Industrial Park (HSIP)**	**USA: Silicon Valley**	**Malaysia: Penang and Kelang Valley**	**Japan: Hamamatsu**
The role of government	The government planned the park, and provided tax incentives, industrial land in the early stage. However, in the later stage, HSIP interacts with silicon valley and other clusters, fits in the internationalized environment and achieves self-sustained growth.	Private sector plays major role push the growth and development of the cluster. However, the relocation of military contractor –Lockheed to California in mid-1980s, and defense agencies also fastened the booming of IC industry.	Government provides infrastructure and financial incentives.	Most efforts from private sector , government plays a very limited role.
Source of Innovation	several sources: 1. Silicon Valley 2. Industrial Technology Research Institute (ITRI) 3. Suppliers 4. Interacts with firms inside the cluster	Private sector and nearby institutions, particularly, Stanford university	Multinational firms play a major role in turning grounds for the hiring and nurturing of entrepreneurs.	Continuous innovation is the key for the sustainability of the cluster, which continuously produce new industries to replace old ones. Innovation comes from the in-house innovation of big enterprises such as Suzuki Motor, Yamaha, Honda and Kawai.
Selection of Geographical Location	Planned by the government (based on the location of universities and research institutes)	The economic regions began in the northwest of the valley in Palo Alto, where Stanford university provides abundant research staff and technical personnel.	Government policy to attract export-oriented multinational firms and gradually formed the cluster	Since 19th century, Hamamatsu has been an important manufacturing sector in Japan.

Clusters / Feature	**Taiwan: Hsin-Chu Science - based Industrial Park (HSIP)**	**USA: Silicon Valley**	**Malaysia: Penang and Kelang Valley**	**Japan: Hamamatsu**
Relationship between firms in the clusters and downstream suppliers	very intensive interaction and obtain huge amount of knowledge and know-how from suppliers	very intensive	**Penang:** develop network cohesion and institutional coordination to support flexibility and interface between domestic firms and MNC. **Kelang Valley:** lack of intermediate agency weaken cohesion and interface in the cluster	complete division of labor system between firms and suppliers
Relationship between firms in the clusters and universities, research institutes, and local businesses	Intensive interaction with universities and research institutes.	Intensive interaction between firms, university and research institutes.	**Penang:** vertical division of labor between MNC and local suppliers. **Kelang Valley:** inter-firm division of labor is less popular; linkage between MNC and local company is limited	very intensive interaction
Source of Talents	worldwide	worldwide	Nationwide	Nationwide

As noted in Chapter 1, there are several advantages for firms in the formation of an industrial cluster. First of all, it can provide complementary resources such as technology and information exchange, management assistance, and so on, to enhance the performance of firms within the cluster. Secondly, it strengthens competition and thus promotes the technical efficiency of firms; since these firms are located in very close proximity, fierce competition for both clients and suppliers is unavoidable. However, competition also pushes up efficiency. Thirdly, firms can quickly respond to the demands of the market or to changes in technology; firms within the cluster can reorganize their OEM contractors much more quickly than those outside of the cluster, thus, the ability to leverage resources to adapt to the market and to fluctuations in technology has been a major benefit for firms locating within the cluster.

Rapid cross-border dispersion is also a feature of industrial clusters, with the cluster-based economy and the future path of cluster development continuing to be of significant importance. Such dispersion will also be applicable in the traditional industries such as the textiles industry, but only if dispersion is not restricted to lower-end products.

The need for systems integration also emerges, particularly the ability to combine local connections with geographical differences. A significant example of this kind of evolution is the global production network (GPN), an important inspiration for the future development of industrial clusters. International connections are thus essential with regard to the sustained growth of industrial clusters. Furthermore, not only can these connections revitalize the local connections, but they can also provide the local clusters with opportunities to obtain international knowledge. Silicon Valley is a classic example of this kind of development of infinite upgrading capacity and power.

In terms of the dispersion of international knowledge, the GPN also represents a virtuous circle, for a number of reasons. Firstly, it extends the value chain of a company and fosters greater business opportunities for professional suppliers of small and medium size. Secondly, as suppliers continue to upgrade their capacity, this places additional pressure upon the clusters, in terms of the need for the continuous introduction of knowledge intensive and high value-added supporting activities. Thirdly, the participation of small and medium enterprises (SMEs) in the GPN helps them to obtain knowledge and to overcome the obstacles traditionally involved in this process. A well-known example is Taiwan's computer manufacturers.

The advantages of the GPN cannot rely solely upon market power because there is still a need for government support and policies. The Scandinavian countries, the Netherlands, Taiwan, Singapore and South Korea all provide notable examples of governments providing strong support to their domestic industries as a means of achieving rapid economic development.

From an examination of the experiences of cluster development in Malaysia, there was clearly an imbalance in the demand and supply of research students, scientific researchers and engineers; however, it was also unlikely that industry would be able to increase the inflow of scientific talent from overseas, largely because of the country's very restrictive immigration policies. The inadequate scientific manpower makes it impossible for Malaysia to attract large numbers of high-tech companies to move into Penang and the Kelang Valley; however, the tacit and experiential knowledge attached to human resources in Penang still differs from that in the Kelang Valley.

The Penang Development Corporation (PDC) created the Penang Skills Development Centre (PSDC) as a means of helping vendors to solve their personnel and training problems. The open networks between the companies also reinforced the available interface for adjusting demand and supply in the production lines. These networks then turned some companies' technological limits into other companies' business opportunities, which in turn, strengthened the differentiation and professional labor disintegration in the production system, bringing in human resources with experience and knowledge. This also succeeded in improving the dynamics and diversification of industries in Penang.

In contrast to the industrial development in Penang, there was a lack of connections and networks between the cross-national electronic companies in the Kelang Valley, although these companies were characterized by world-class production and operation methods. The other disadvantage was that the supporting authorities in the local government did not fulfill the role of communicator between the companies. Clearly the industrial operation in the Kelang Valley lacks differentiation and well-defined labor distribution.

Taichung and Changhua used to be Taiwan's footwear industrial cluster provide an interesting case of a labor-intensive industrial clustering. Despite of lower wage and skilled labor, spatial proximity of manufacturing and trading firms can set up the competitive advantage of Taichung and Changhua's footwear industries. Their experience points out that industrial clustering is helpful to save the transaction costs and to transmit production and market information. Taiwan's footwear industry was organized via the subdivision among various independent firms of various stages of value-added chains. In addition to manufacturing firms, trading firms played a critical role in coordinating highly decentralized network, leading small-sized shoe companies to achieve scale and scope economies.

Chapter 3 Industrial Clusters and Learning Networks

3.1 Introduction

The globalization of innovation and learning activities is presenting us with an important question that needs to be investigated: whether roles of nation-state and industrial regions are obsolete or not in the world economy. Some studies in the literature observe a dramatic increase in international trade, cross-border research and development cooperation, and a world-wide human capital flow, and they propose an argument about the end of the nation-state or the end of geographical-specific industrial clusters. Ohmae (1993; 1995) emphasizes that region-states involving either several cross-border economic sites or various adjacent locations have gradually replaced nation-states to become natural economic collective actors in a global economy.[5]

Globalization has failed to recognize that there are wide national differences between countries in the rate and types of internationalization of economic activities. Niosi and Bellon (1996:146-154) systematically analyze the data of internationalization of research and development in technology-advanced countries and prove a significant unevenness in the openness of national innovation systems between small developed countries and large developed countries. The homogenization of economic activities globally has its limit even in those relatively open advanced economic systems. Furthermore, globalization frequently accompanies specialization in which different nations or regions[6] with their leading technology form a global economic network (Porter, 1990). Before being included into the network, they have to demonstrate their more remarkable industrial abilities over others.

[5] Region-states are not traditional local states.
[6] Regions refer to locations and not to region-state in the following discussion.

The approaches of the National Systems of Innovation sharing some similar ideas with regional economic geography emphasize that the particularities of a nation or a region are very important in establishing and maintaining its competitive advantages (Braczyk, 1998; Dosi et al., 1988; Edquist, 1997; Lundvall, 1992; Nelson, 1993; Storper. 1997). Based on a state-centered perspective, these approaches argue that states differ in their strategies and contents of technology policies and institutions, leading to a discrepancy in national innovation and learning capabilities (Lundvall, 1992). In addition, built institutions tend to develop within a path-dependent trajectory that differentiates regions or nations in the global economic hierarchy even further (Edquist and Johnson, 1997; Johnson, 1992).

Spatial proximity itself is a crucial condition in facilitating the formation of social ties and information exchanges among social actors. In some regions, social linkages have a tendency to bring up trust, norms of reciprocity, and shared codes that help to reduce the transaction cost of intangible knowledge diffusion as well as innovation cooperation and to help create a favorable atmosphere for innovation and entrepreneurship (Scott, 1996). Technological skills and the knowledge embedded heavily in these social contexts are very difficult to be either transferred or imitated. Thus, isomorphism of national or regional innovation capacities is very unlikely to be achieved and localized differences still matter in the globalization process.

The approaches of learning regions in a broad sense focus on institutional arrangements for technology innovation and learning within a geographical boundary, and they overlook the fact that a national or regional competitive advantage has to be accomplished at the global and local levels simultaneously. In order to understand the complexity of global-local articulation, this article offers an organization-centered approach that has its emphasis on structures and contents of inter-organizational networks in shaping both local and global technology diffusion and innovation.

The following section discusses the formation of learning regions and negative functions of industrial agglomeration. A detailed discussion about how structural, relational, and cultural characteristics of a network affect technology learning will then be given in the third section. The fourth section elaborates upon dynamic relationships between learning regions and learning networks. The last section is the conclusion and discussion.

3.2 The Formation of Learning Regions

3.2.1 Learning Regions

A learning region is defined by a given geographical boundary with shared normative elements, supportive institutional arrangements, economic specificity, and a governance structure (Cooke, 1998:15). Within this territory, an official political organization makes appropriate economic policies, provides sufficient resources, and offers various tax incentives and laws of intellectual property rights, facilitating the activities of technology innovation and learning. At the same time, collective economic actors who are closely connected to one another possess shared technological narratives, affluent mutual trust, and show a willingness to cooperate (Solvell and Zander, 1998:409). Research and development organizations such as university or government-sponsored research institutes function as a source or an intermediary of new technology (Lundvall, 1992: 13-14). Not only are various actors treated as a system, but they also produce a favorable social atmosphere - the so-called Marshallian atmosphere (Porter and Solvell, 1998:443; Scott, 1998:387). A mature learning region enjoys abundant social capital,[7] intangible knowledge, and human

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7 Social capital is broadly defined as an asset that inheres in social relations and networks (Leana and

resources that are difficult to be transferred into another region.

Depending upon endowed resources and institutional arrangements, a given location might follow different trajectories to evolve into a learning region, an industrial fragmentation, or a regional polarization. (Crevoisier, 1990:29). Those regions have rare institutional supports as well as almost no linkages among collective actors, whereby vertically-integrated corporations compete rigorously with one another instead of seeking cooperation. A fragmented industrial structure instead of a learning region tends to emerge under these circumstances.

3.2.2 Major mechanisms of spatial concentration in economic organizations

There are various perspectives offered to explain the formation of industrial clusters for technological learning and innovation. First, spatial proximity makes continual learning by interaction possible, because two partners in a close distance can exchange information immediately and respond to the other's questions promptly. Major technological learning practices such as demonstration on the scene and real-time instruction can mostly be exercised on the scene. Accordingly, spatial closeness can facilitate deep technological learning.

Second, two partners practicing exchange within a close distance are able to monitor the transaction and to reinforce the agreement with tiny efforts. Moreover, spatial proximity has a great possibility to induce the formation of social solidarity among actors, which is a foundation to facilitate trust-worthy relationships among different organizations (Scott, 1998:387). Mutually

Van Buren III, 1999:538). For other specific definitions see also Bourdieu (1985), Brehm and Rahn (1997), Coleman (1988), and Portes (1998).

trusting relationships will prevent the occurrence of opportunistic behaviors, leading to the reduction of credit-auditing cost and surveillance cost. It is also able to promote information exchange and other cooperative behaviors. Thus, we observe the speedy rate of information exchange that helps to create numerous learning opportunities.

Some studies in the literature have pointed out that intensive cooperative exchange in a location is very likely to forge a Marshallian atmosphere in which social actors are willing to discuss their new inventions with one another and to provide advice for others. These actors not only appreciate assistance from their partners, but they also construct the merit of reciprocal sharing as a principal rule that will be transmitted to new members by socialization (Enright, 1998:319; Porter and Solvell, 1998:443; Scott, 1998:386). In this friendly milieu, technological learning takes place naturally, and at the same time innovation will prosper with great encouragement and suitable help from others.

Storper (1997) proposes another related argument in his geography of convention and relations, which has cognitive, informational, and psychological foundations. In the transformation from the mass production accumulation regime to the flexible post-Fordism, the flexible accumulation regime has replaced traded interdependencies among economic actors with untraded interdependencies in which the exchange of goods has been gradually replaced by the exchange of information, knowledge, and technology. Economic systems of production have become economic systems of technological learning, and accordingly, untraded interdependencies lead to complicated relationships among technology, organization, and territories.

Dominant conventions in a given region may induce the geographical concentration of industrial systems, even though efficient reasons for spatial proximity disappear [8] (Stoper, 1997: 41). The reason is that these region-specific conventions continue to exist for a very long time and they shape the cultural frame of regional actors who usually interact with practical reason. This argument highlights that the formation of spatial concentration in technology learning is not entirely based up instrumental rationality.

Industrial clusters often become repositories for asset-specific skills or knowledge. These skills that are embedded in formal or informal institutions are usually less geographically mobile than those embedded in physical capital (Porter and Solvell, 1998: 447-448). Thus, only those actors inhabiting in these locations obtain accesses to learn the intangible knowledge. Accordingly, a lot of new enterprises will move into industrial districts with both asset-specific and advanced technology in order to benefit from technology diffusion in these regions. The centrifugal movement of economic organizations reinforces the tendency of spatial concentration.

The formation of industrial agglomerations frequently follows a path-dependent trajectory (Ehrnberg and Staffan Jabcobsson, 1997:334). On the one hand, an initial industrial structure in a given location tends to create an imprinting effect that determines patterns of subsequent industrial structures to some extent. For example, production organizations in Taiwan are based upon collaborative manufacturing networks at the very beginning, linking many specialized small- or medium-size enterprises. These production organizations display a pattern of spatial concentration in which collaborative actors exploit advantages of economies of scope. Technology- intensive industries developed at the later stage also naturally adopt the pattern of spatially-concentrated disintegration production networks (Chen, 2000; Mathews, 1998).

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[8] However, an uncertainty of social interactions can be better resolved through conventions other than those of markets and contracts in some cases.

On the other hand, space-bound institutions have very strong inertia to reproduce themselves, because of the expensive cost of changes and relatively high return rate of profits (North, 1990). When those institutional arrangements to facilitate spatial concentration are erected, they are very likely to persist for a long time. Informal institutions such as conventions or helpful atmosphere especially reinforce the tendency of the spatial concentration of economic organizations.

Scott (1998:385) concludes that "the massive globalization of economic activity actually reinforces industrial agglomeration and local economic specialization." This conclusion typically represents a major perspective of the learning regions' approaches.

3.2.3 Negative Functions of Industrial Agglomeration

Negative effects of industrial agglomeration have received limited attention in the literature of technology learning and innovation. Some learning regions might succeed at the beginning stage, but they lose their competitive advantages to other newly emerging regions at the following stage. Two examples from Route 128, Boston and the Ruhr in Germany exemplify the failure of industrial clusters (Grabher, 1993, Saxenian, 1994).

An over-concentration in space might give rise to cutthroat competition, because the demonstration effects of price reduction are accelerated among firms in spatial proximity. Intensive imitation in technologies in a region makes those firms very similar to one another, which might trigger severe competition among homogeneous organizations. Secondly, spatial closeness can create a favorable Marshallian atmosphere or affluent social capital for cooperative relationships between organizations, but an over-embeddedness of strong ties produces an enormous possibility to induce group-thinking, amoral familism, and demanding moral obligations on individual burdens[9] (Chen, 2000; Portes, 1998, Woolcock, 1999). As a result, negative functions of social capital heavily hinder progress of industrial agglomerations that will be selected out by environmental forces eventually.

3.2.4 Facilitating Factors of Learning Regions' Openness

If there are so many forces leading to a spatial agglomeration of production and technological learning, then why will both individual actors and collective actors expand their linkages outside a given geographical boundary? We can explore this question from three dimensions: technology, organizations, and institutions.

3.2.4.1 Technology

The characteristics of technology have a crucial influence on the structures of intra-firm organizations and inter-firm linkage, and these factors also affect the efficiency and modes of technology learning and diffusion. The most fundamental typology of technology is codified (standardized) versus non-codified (non- standardized) technology (Foray, 1997:67-68). It is suggested that non-codified technology can only be attained by means of intensive interaction with geographical proximity; thus, an actor has to locate itself near to those firms with non-codified technology. Accordingly, codified knowledge might contribute to the diffusion of technology outside a given region and consequently results in external inter- organizational linkages.

In addition to the characteristics of technology,[10] Breschi and Malerba (1997:136-142) suggest that the spatial boundary of technology learning and

[9] The mechanism inducing amoral familism, group-thinking, and demanding moral obligations will be elaborated upon later.
[10] Breschi and Malerba (1997:136) further characterize the nature of technology into four dimensions: degree of specificity, degree of tacitness, degree of complexity, and degree of independence.

innovation also relates to opportunities of innovation, appropriability conditions of innovative results, and the degree of serial correlation among innovations (degree of cumulativeness). When economic organizations own rich innovation opportunities, develop highly cumulative technology, and appropriate most results of innovation, they usually generate innovation within their own geographical boundary. The degree of technological cumulativeness and monopoly of innovative knowledge prevent broad technology diffusion as well as spatially-dispersed innovative activities. If the knowledge relevant to innovation is relatively specific, tacit, simple, and interdependent, then the tendency of spatial concentration for these innovative organizations is further reinforced.

Whether related technologies within a region are relatively sufficient will also affect the degree of openness within a learning region. Evidently, when various technologies cannot be transferred from partners inside the region or the nation, then companies have to pursue innovative technologies externally. Moreover, if these technologies are dispersedly distributed across different countries, then these regional companies have to set up their inter-firm networks globally in order to learn advanced technology from various foreign partners. This is especially true in some high-technology industries such as semiconductors, aircraft, computers, and automobiles (Acs, 2000:24).

3.2.4.2 Organizations

The dynamics of interaction on technology innovation and learning with a region are also partially shaped by various organizations in that area, because they are collective actors in innovative and learning activities. Whether these organizations will establish external inter-organizational linkages depend upon absorptive capacities, resources, and organizational cultures.

A given organization must input much more resources in creating as well as maintaining external linkages than those inside the region. Therefore, the amount of resources possessed by the organization influences its motivation and capacity for establishing external connections. Generally speaking, the amount of resources within an organization is usually related to organizational size. Accordingly, large-scale organizations have a higher possibility to globalize their organizational linkages than small- or medium-size organizations.

Cultural distance, it is argued, between different regions or between different nations is a major barrier to establish cross-boundary linkages (Dunning, 1998:298; Lundvall, 1992:64-65). In other words, differences in languages, norms, values, routines, and cognitive frameworks make the outward extension of regional connections quite difficult. However, there is strong empirical evidence that many companies with rich international cooperative experiences tend to initiate much more subsequent across-nation alliances and maintain them successfully versus those without these experiences. Previous experiences of international cooperation make organizations realize the importance of inter-organizational alliances, increase their willingness both to resolve cultural differences and to develop shared codes, and create appropriate procedures for successful international cooperation (Doz, 1996:75-79; Simonin, 1999:474). In the case of those companies with diversified cultural contents and numerous cooperative experiences, one might expect that cultural differences will not obstruct cross-boundary connections.

It is very natural to identify Multi-National Corporations (MNCs) as large-size organizations with sufficient resources and assorted cooperative experiences. Whether or not the emergence of MNCs will diminish regional differences in economic activities and increase technology diffusion, there are two approaches that present different arguments on this issue. On the one hand, international business scholars suggest that global firms can extend cross-national linkages by means of outsourcing manufacturing, international technologies transfer, international research and development alliances, and the establishment of foreign research and development subsidiaries (Bartrlett and Ghoshal, 1990; Dunning, 1993; Hagestoorn, 1990).

On the other hand, different arguments from the global isomorphism are proposed by approaches of the dynamic firm, national innovation systems, and economic geography. The dynamic firm perspective argues that the degree of mobility of knowledge embedded in both human and social capital is too low to generate globally innovative processes. Although some MNCs set up their foreign research and development subsidiaries in different countries with a clear division of labor, these units are usually tightly linked through intra-firm governance mechanisms. Furthermore, MNCs frequently retain their core technologies or leading innovative programs in their home bases to maintain a competitive advantage in their home regions. As a consequence, the emergence of MNCs contributes very limited to the spreading out of advanced knowledge and induces cooperative innovation across nations (Porter and Solvell, 1998:450; Solvell and Zander, 1998). The landscape of global technological innovation and development displays a pattern of a leading local innovative region with hierarchical connections to selective foreign research and development regions.

Scholars from the approach of national innovation systems similarly express their pessimistic view about the impacts of the emergence of MNCs on a national economy. As MNCs organize their production and innovation globally, the new international division of labor usually increases the transaction costs of local collaborators, weakens their ties with the local economy, and decreases opportunities of learning by interaction (Lundvall, 1992:64-65). Hence, national innovation systems, especially those small countries with few MNCs, tend to be demolished by MNCs' expansion. The national economy suffers from losing capabilities of technological innovation and learning within the process of globalization led by MNCs.

As recent research has shown, some diversified MNCs have set up multiple home bases that might offer some contributions to the diffusion of technological innovation (Prahalad and Doz, 1987). The internationalization of research and development measured by the proportion of a country's patenting in the United States has been documented and the results have shown a spillover of innovative activities across nations to some extent (Chesnais, 1992:286-288; Niosi, 1997; Pavitt, 1991). Functioning as technology providers, large MNCs can still have some functions in establishing cross-boundary linkages. For small or developing countries, in order to learn some advanced technology from the outside and to incubate their own innovative capacities, learning and innovative regions in these countries have to pursue external connections aggressively with MNCs and improve their statuses in the hierarchical research and development network structure. Moreover, relatively small- or medium-size corporations with limited innovation capacities in these countries are highly motivated to form external linkages, increasing the speed of global technology diffusion and opening the boundary of the learning regions.

3.2.4.3 Institutions

Recent research has indicated that any activity of technology innovation and learning should rely on corresponding institutional bases[11] (Edquist,

[11] We can summarize four levels of institutional arrangements from the literature: local, national,

1997:24-26; Edquist and Johnson, 1997; Foray, 1997; Johnson, 1992; Lundvall, 1992; Nelson and Rosenberg, 1993). On the other hand, different arguments from the global isomorphism are proposed by approaches of the dynamic firm, national innovation systems, and economic geography. On the other hand, personal networks, conventions, and practical routines are among informal institutional arrangements which can stimulate learning and innovative activities.

Most research studies have their focus on the formation of local or national institutional arrangements and their impacts on regional or national innovation systems. Although there are few exceptions, some cross-national institutional arrangements in supporting international organizational networks have been presented. Based on the experiences of European integration, Caracostas and Soete (1997:397-407) point out that cross-border formal institutions facilitate the formation of different types of transnational organizational learning networks and they might eventually give rise to a European system of innovation.

In those areas lacking transnational formal arrangements, they can still rely on informal institutional arrangements to make cross-boundary connections. Indeed, as a recent study has shown, a large proportion of engineers in American high-technology companies in the Silicon Valley are Taiwanese immigrants who completed their undergraduate degrees in Taiwan and pursued their graduate degrees in the United States. These technology experts have established broad and intensive personal networks in the Silicon Valley with their colleagues and have extended their personal ties to their college classmates in the Hsin-Chu Science Park, Taiwan. As a consequence, the international personal network has placed a crucial basis for the

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regional (transnational), and global.

cross-border technical community that a major mechanism of technology transfer, learning, and innovation in Taiwan's semi-conductor industry (Hsu and Saxenian, 2001).

A tendency for spatial concentration might be counterbalanced by technological factors, organizational initiations, institutional transformation, and environmental impact. At the end, an industrial cluster changes into an inter-organizational network when a region becomes endowed with those facilitating elements. It should be highlighted that an economic agglomeration follows a different trajectory depending upon its various characteristics.

3.3 Characteristics of Learning Networks and Their Impact on Technology Learning

The approaches of learning networks focus on how structures of personal or organizational networks contribute to technology learning and innovation. These approaches choosing networks and firms as their primary analytical units display some different thoughts from the approaches of learning regions. First, the formation of networks primarily relies on societal conditions, which include spatial proximity and many other factors. Therefore, these approaches do not limit their analysis on local or national networks, because they recognize that geographical closeness is only an important necessary condition in facilitating networks' formation. In the process of globalization, many learning networks have been made by cross-national organizations which employ many new telecommunication infrastructures and interaction routines to maintain their efficient partnerships.[12] More often than not, complex

[12] Some studies in the literature have observed that economic globalization powerfully leads to the expansion of economic activities across national territories. For example, Badie suggests that "one observes his process form the global scene, we have to admit that it invents new coherences which might generate solutions since they recognize that economic functions are not reducible anymore to the

patterns of articulation between global networks and local networks (or regions) have occurred. These issues can mainly be explored by network-oriented approaches which systematically clarify interrelationships among actors at different spatial scales and avoid a geography-centered standpoint.

Table3. 1 Three Dimensions of Learning Networks

	Within Group	Between Group
Structural Characteristics	Network density Connectivity Structural holes	
Degree of closure Network size		
Relational Characteristics	Reciprocal ties Degree of strength Degree of power symmetry Multiplexity	
Cultural Characteristics		
1.Normative Dimension	Norm of reciprocity Personal trust	Generalized trust
2. Emotional Dimension	Collective identity Collective memory	
3. Cognitive Dimension	Shared codes Shared narratives Shared cognitive framework	

Source: Revised and Adopted from Paxton (1999) and Nahapiet & Ghoshal (1998).

Second, the approaches of learning regions usually confuse geography-specific assets with network-specific assets, leading them to under-estimate the importance of networks' characteristics in technology learning and innovation. For example, these approaches argue that innovative milieu is an important immobile asset of industrial geographical agglomerations (Storper, 1997; Porter and Sovell, 1998). However, resilient trust, willingness to share information, and entrepreneurships are essential elements of the innovative milieu that are principally derived from social relationships rather from spatial proximity. Therefore, it can be found that an

nation-state territory, that the density and complexity of transnational networks call for an institutionalization which transcends it, that the uneven growth of interdependencies supposes diverse modes of regulation and therefore the differentiation of spatial frameworks." (quoted from Caracostas and Soete, 1997:414).

innovative atmosphere prevails in some global learning networks with long-term successfully cooperative experiences, but not in industrial clusters with completely independent organizations.

Following Nahapiet and Goshal's framework (1998), we suggest that there are three dimensions of learning networks which include structural, relational, and cultural ones. The characteristics in these three dimensions are summarized in Table 3.1 and they affect technology learning and innovation through different mechanisms.

3.3.1 Structural Characteristics of Learning Networks

Based upon a social network literature, structural characteristics that have shown their influence on information exchange and trust formation include structural holes, degree of structural closeness, and centrality.[13] As pointed out by Burt (1992), organizational networks with more structural holes tend to receive more useful information than those with few holes. The number of structural holes increases when non-redundant relationships among networks' connections prevail. It is reasonable to argue that a network with a large network size, out-group linkages, and weak ties will have a large number of structural holes, because members in this type of the network have few opportunities to know each other[14].

Information exchange is very important in technology learning and innovation, because this knowledge can modify a cognitive framework of an organization and enhance its knowledge base. Carlsson and Jacobsson

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[13] Three related measures of network centrality are degree, closeness, and betweenness. The degree measure of centrality is calculated by simply counting the number of adjacent ties to or from an actor. Secondly, the betweenness measure calculates the extent to which actors fall between pairs of other actors on the shortest paths connecting them. Finally, the closeness measure of centrality accounts for both direct and indirect links in indicating how "close" an actor is to all other actors in the network (Brass and Burkhardt, 1992:194-195).

[14] The number of structural holes can only be calculated when we have complete information about a given network. However, this ideal condition is seldom achieved.

(1997:268-273) observe that an organization (network) tends to fix on its own technology, because of path-dependent inertia and a relatively high rate of return in this extant product. The situation becomes even worse when the organization (network) receives little impact from external information.

Although affluent information itself cannot make a large beneficiary technological breakthrough, there are two conditions which organizations (networks) have to possess in order to synthesize crucial external knowledge fruitfully with their own technology. On the one hand, the absorptive capacity of an organization (network) will primarily determine whether the synergy of external advanced knowledge can be achieved or not, because strong absorptive capacity indicates the ability of the organization (network) to discover crucial information and to employ it efficiently (Cohen and Levinthal, 1990). As a matter of fact, the accumulation of organizational absorptive capacity is highly related to the investment in research and development of the organization (network). For those organizations (networks) heavily emphasizing internal research and development, they tend to have stronger absorptive capacities, and they are more likely to take advantage of external knowledge.

On the other hand, an organization (network) usually seeks for the integration of new technology that overlaps with its own technology to some extent (Mowery et. al., 1996). Any organization (network) that wishes to exploit benefits of external knowledge fully has to increase the range of its technological spectrum. However, this organization (network) has to invest tremendous amount of resources to maintain its technological generalism. Generally speaking, a very specialized organization (network) has fewer abilities to make use of external knowledge than a generalized organization (network).

The second structural characteristic is the degree of network closure that is measured by the number of ties between every two members. In a very close network, both mutual trust and norm of reciprocity are easily established while behaviors against groups' norms are efficiently sanctioned (Coleman, 1988; 1990). When members of a network are familiar with one another, they are unlikely to become free riders of collective sanction implementation, because they share a very low cost from participating in collective action and receive instant punishment for disobedience. With the same reason, an organizational network that displays a great degree of closure is likely to obtain positive normative assets.

An organizational network with many structural holes in fact nearly excludes the possibility to own a characteristic of network closure. It is very difficult for an organization to manage an appropriate mixture of these two conditions, because their structural arrangements are contradictory with each other. One possible solution is a network in which each member is connected with its immediate partner by strong ties, but each one does not forge any linkage with other members. Trust can be easily created by direct or indirect strong ties while the openness of the network is still maintained.[15]

The last structural condition of networks related to technology learning and innovation is centrality. In their study of the biotechnology industry, Powell and his colleagues find out that enterprises occupying central positions in a network usually own high visibility as well as a good reputation, and therefore they can easily drive new cooperative alliances. These central enterprises can handily exploit benefits from organizational linkages to facilitate their growth, because of their superior abilities to enlarge the network size and to create a positive feedback circle of inter-organizational alliances

[15] A network composed of strong ties in immediate partners, but not in other partners, has other advantages. Information exchange is very reliable by using channels of strong ties. Moreover, trust transferal from a partner to his indirect partner has a great possibility to be completed successfully (Lin, 1981).

(Powell et. al., 1996: 121-122). In order to obtain resources from a network, an organization needs to pursue central positions of the network by increasing their number of alliances and diversifying their categories of cooperative partners.

An industrial network's members are mainly small- or medium-size enterprises that have a high employee turnover rate and a tendency for employees to start up new companies. The technological diffusion in the network might speed up swiftly in the network with these mechanisms, but it tends to end up with a shallow pattern of technological learning. This is because almost few companies play a role of technological accumulation and development. Therefore, most knowledge distributed in the network is commonly aged. Even worse, most enterprises are reluctant to invest in research and development as well as employee training in order to reduce the loss of the employee turnover. At the end, a vicious circle of personnel mobility in the network begins to take place. Conversely, a network led by some organizations that are centers of information flow and the forerunners of new technology tends to enhance positive results of vast mobility in engineers within a network. These organizations are able to regulate patterns of technological experts' mobility by attracting more prominent engineers into their research and development units who are well organized to raise the technological levels both of the companies and of the network. Subsequent advanced technological diffusion by these companies will benefit most members in the network.

The advantage of network centrality for technology learning will reach its limit when only very few organizations occupy central positions and control flow of tangible and intangible resources. Over-centralization of the network makes stiff entry barriers for peripheral organizations to join, and so it might decrease the mobility of the network's participants and enhance the degree of network closure. As a result, the spillover effect of new technology in the network will be very restrictive, because a small number of central organizations that monopolize useful knowledge is not willing to share it broadly with most members. In addition, the rate of new information exchange will be greatly reduced.

3.3.2 Relational Characteristics of Learning Networks

One of the most frequent mentioned relational characteristics in a network is the strength of personal or organizational linkages. Social interaction that is intensive, frequent, and holistic tends to forge strong ties. Social actors who are connected by strong ties have strong mutual trust and willingness to share information. Moreover, members through intensive interaction will develop shared codes and cognitive framework that facilitate intangible information exchange. Therefore, some studies in the literature about technology learning have pointed out that non-standardized and intangible knowledge can be chiefly obtained by means of strong ties. For explicit and codified knowledge, it can be easily delivered through weak ties or through other formal mechanisms.

3.3.3 Cultural Characteristics of Learning Networks

According to Figure 3.1, the cultural characteristics of learning networks can be further distinguished into three sub-dimensions: normative, cognitive, and emotional. Regarding normative factors, the norm of reciprocity is an important base for mutual trust to appear. If an actor is able to return first the help from an unfamiliar actor promptly, then a subsequent exchange is very likely to occur and trust between each other incrementally builds up. By and large, these reciprocally trusting partners have few opportunistic behaviors, such that they have very low transaction costs for exchange (Powell, 1990). From the positive side, these partners are willing to share information or other resources with each other and to make collective goods, because they consequently will enjoy benefits of the goods (Putnam, 1993). In the case of technology learning, social actors with enormous trust tend to provide crucial information to their partners and will receive something valuable in return. It can be argued that learning by interaction generally occurs among trust-worthy partners.

Research in organizational learning highlights that previous experiences in various research and development cooperation are very significant in affecting the successful probability of new alliances (Simonin, 1999:474). These experiences help an organization to develop an internal consensus on the importance of inter- organization partnership and shared codes on cross-organizational interaction that assist the correct interpretation of complex information exchange between each firm. For those who can appreciate the significance of cooperative alliances and have cognitive abilities to process external information, they can exploit the full advantages of network structures. We are able to observe that shared narratives, shared codes, and a consensus are the main cognitive characteristics of a network.

Doz (1996:75-79) proposes that two organizations should begin with a small collaborative project rather than a complicated long-term assignment. The small project lets these organizations adjust their differences, develop immense commitment to cooperation, and define working objectives together step by step. As a common cognitive framework evolves, subsequent full-range alliances tend to proceed smoothly.

The collective identity of a network is one of emotional factors. It can be easily created from a close network in which group belonging is massive. Since cognitive factors, normative factors, and emotional factors always reinforce one another, members with shared narratives and collective norms are likely to build up a strong group identity as well as loyalty. These arguments are manifestly supported by the cases of ethnic networks (Portes, 1995). A strong collective identity possibly contributes to information exchange among members of a network, but it can also become a principle to exclude outsiders. As a consequence, external information carried out by new partners is difficult in traveling into the network, such that opportunities for technology learning will seriously decrease.

In this section I offer an analytical framework that is very useful in illustrating how structural characteristics, relational characteristics, and cultural characteristics of learning networks affect technological learning and innovation. I have to emphasize that these characteristics are founded upon social interaction or structural arrangements within a network and they are not geographically bound. This framework supplements the approaches of learning regions that ordinarily underestimate the importance of networks' characteristics on innovation.

3.3.4. Interrelationships between Learning Regions and Learning Networks

Interrelationships between learning regions and learning networks need to be put in a dynamic framework in which we can systematically trace different trajectories of complex interaction between these two types of collective actors. Furthermore, it is necessary to investigate how learning regions or learning networks relate to each other at different geographical levels, because an articulation between the two actors shows diversified patterns.

At the very beginning, learning collective actors could emerge at three geographical scales: local, national, and global. Learning regions are mainly meaningful at the first two levels, because space-specific assets can be mostly identified at these two levels. Whereas learning networks do not particularly refer to any specific geographical boundary, they are existent at all three levels.

Much of the literature on transnational or global innovation systems discusses largely on technology learning and diffusion within inter-organizational networks (Doz, 1996; Dunning, 1993; Mowery et. al., 1996; Powell, 1996; Powell and Brantley, 1992; Simonin, 1999). Apparently, transnational geographical boundary or global boundary is too vague to delimit. Without a clear boundary, it is very difficult to discover formal institutions, informal conventions, and personal ties that are spatially attached. Furthermore, formal institutions at the global level, such as the World Trade Organization (WTO) and United Nation (UN), lack strong initiative capabilities, authority, and autonomy to carry out any significant global technology innovation activities.

As mentioned in the above section, transnational formal institutional arrangements facilitate some cross-national technology collaborations in the European Community, but comparable institutions are seldom found in other regions. These institutions are also weaker than state-sponsored ones, which are crucial in activating technology innovation and then in maintaining the national competitive status (Lundvall, 1990; 1992). According to the approach of systems of innovation, boundary-specific formal institutions are the most important element to distinguish a learning region. When few institutions are established at the transnational or global level, the concept of learning regions is not very useful at the two levels.

Interrelationships between learning networks and learning regions display very different patterns at these four spatial levels. First, at the local level, a learning region can possibly overlap with a learning network, depending upon the degree of openness of this region. In a close region, a learning region is the same as a learning network, because both individual actors and collective actors are tightly connected with one another. These actors develop a strong local identity that might result in amoral familism (or groupism). Based on this intense in-group consciousness, external linkages are scarcely pursued by local actors, and organizational networks as well as personal networks are subsequently bounded within the region.

A close local learning region is basically composed of small- or medium-size enterprises that have limited resources to establish outside connections with technology-advanced companies in developed countries. In addition, a close and over-embedded learning region has only a few channels to receive new technological knowledge. Even though these enterprises have obtained new ideas, they might have no capacities to identity the importance of this valuable information and then to synergize new technology with their own existent technology. In other words, they lack absorptive capacities of new knowledge, which seriously decrease their competitive advantage in learning and innovation. Thirdly, a strong normative demand in loyalty within a densely-connected region increases the moral burden of its members to establish social linkages with outsiders. Finally, intensive interaction among one another within a close learning region vastly homogenizes the cognitive frameworks of the members, leading to a prevalence of group-thinking in the region.

Compared to a close learning region, an open learning region definitely owns one or several learning organizational/personal networks beyond the geographical boundary. Thus, learning networks and learning regions do not overlap with each other. An open learning region mostly contains medium- or large-size companies with some leading technological skills. These companies maintain strong organizational or personal strong connections among one another, but they also manage aggressively to build external relationships. The distribution of internal and external linkages is in a balanced condition. Secondly, since these organizations or professional employees have to seek some linkages with outsiders or even strangers, they are inclined to rely on formal attributes such as institutional trust for a network's formation. As a consequence, the underlying bases for these networks within the open learning region cannot be founded largely on particularism, strong ties, and personal trust. The negative impacts of amoral familism, group-thinking, and networks' closure seldom occur within this region.

By means of its multiple external channels, the open learning region receives resourceful information that is crucial for technology learning and innovation. With a diversified cognitive framework, collective actors in the region possess some abilities to recognize the importance and compatibility of exchanged information. Strong absorptive capacities grounded on a highly fluid technical community of professionals, adequate organizations of entrepreneurship, and in-house research and development help to integrate new technology with present technology and expand the benefits of synergy.

Regarding the geographical scales reached by their networks, open learning regions can be classified into nationalized and globalized types. The former one is comparable to national systems of innovation in which inter-organizational networks generally are located within the boundary of nation-states. This is because state-initiated research and development policies successfully promote the leading technology innovation of firms or government-sponsored research institutes in this country. Advanced technological information chiefly exchanges among various organizations within the country, such that the expansion of learning networks reaches their spatial limit on the national boundary. As the approaches of national innovation systems point out, national competitive advantages in research and development are greatly determined by national institutional bases and governmental policies (Lundvall, 1990; 1992). It is also argued that nationalized learning regions are supported as well as limited by public institutional arrangements to some extent.

When research organizations or enterprises in a nationalized learning region establish some cooperative linkages with foreign partners, the region is gradually transformed into a globalized learning region. In order to pursue cross-boundary research and development cooperation, new institutional arrangements for learning and innovation have to be made to substitute for country-specific formal institutions. These new arrangements are mainly invented through accumulated experiences of cooperation and consensus among various actors. Cooke (2000:23) describes that the institutional infrastructure in a globalized region "will be largely internal and highly privatistic rather than public." Large-size companies with sufficient resources and strong research and development capabilities become leaders in constructing transnational innovation alliances and creating different learning trajectories. These actors from the private sector begin to replace the role of governments, but they still maintain strong ties with other local companies who are important collaborative manufacturers or key research and development partners. In a globalized learning region, most members in the network are from the same region or country and they still hold a strong geography-specific identity.

A global learning network can either be transformed from a globalized learning region or be established by technology-advanced organizations, especially MNCs, from different countries. On the one hand, a globalized learning region is identified as a global learning network when the proportion of foreign linkages is more than fifty percent and it has two or more foreign collaborators simultaneously. In addition, these transnational ties are very important in technology innovation and learning for the network, and the dominance of any particular local identities or local linkages does not exist. On the other hand, technology-leading organizations will invite their foreign counterparts to form research consortia, innovation alliances, or joint-venture research institutes in order to share risks of innovation and to develop new technology swiftly. These various models of transnational innovation cooperation are typical cases of global learning networks.

Although a global learning network includes individual or clustered actors from various countries, entry barriers into the network are sometimes very high. One type of global learning network formed by leading MNCs is labeled as Knowledge-based Networked Oligopolies (KBNOs) (Mytekla, 2001:138). Only upper echelon companies in a given industry are able to join the KBNOs in which these members share expensive research and development expenses, innovate new technology through complementary cooperation, and maintain their edge position in the market. This type of global network is very confined in terms of its high technological level rather than in terms of spatial or other social conditions. However, these KBNOs replace incompatible partners immediately, because they face strict competition both from other KBNOs and from very short product life cycles. This type of global network is very close, but quite dynamic.

Some MNCs will establish their research and development subsidiaries overseas or invest in some specialized start-up innovation companies. In this hierarchical network, MNCs occupy the core position in the network structure and own enormous authority to coordinate these small- or medium-size research companies. As recent research has shown, MNCs tend to retain most crucial technology at the research units in their headquarters in order to prevent negative results of technological spillover (Porter and Solvell, 1998:449-451). Small- or medium-size enterprises in developing countries can possibly join a global learning network by means of establishing user-supplier relationships. These enterprises have to develop outstanding abilities in manufacturing and are able to replace the in-house production units of large MNCs.

The first step of technology learning for latecomers is by means of imitation or "reverse engineering" to raise their technological abilities (Hou and San, 1993). When these suppliers have competitive edges on a production process innovation, they begin to establish profound interactive learning relationships with their customers and are able to exploit advanced technology from users to increase their innovation capabilities. At the final step, if these suppliers become leading producers, then they might be incorporated into the KBNOs. Taiwan's leading semi-conductor manufacturer, TSMC, who is included into the twelve-inch fabrication technology consortia, provides a good example.

Whether or not the formation of global learning networks indicates the end of learning regions is a debatable issue. Most studies in the literature have reached a conclusion that the role of a region in the economic globalization processes is still very significant (Cooke, 1998; Dunning, 1998; Enright, 1998; Lundvall, 1992; Malecki, 2000; Porter and Solvell, 1998; Scott. 1998; Storper, 1997). This paper argues that every region has to establish some kind of global linkage with other organizations for technology learning opportunities, but the abilities of the region for global network formation are influenced by several intra-regional factors and environmental conditions.

With regard to intra-regional factors, the structure of a network is one of the important conditions to shape patterns of the articulation of a region and global learning networks. A regional network with many structural holes, a balanced combination of strong and weak ties, and a large scale of network size is more likely to build global connections than one without these characteristics. Moreover, members of the regional network that have not developed an excessive group identity and homogeneous cognitive framework will facilitate their involvement in global networks. Thirdly, if region-specific institutions that support learning and innovation do not become primarily dominant arrangements for the cooperation of technology research and development, then cross-border linkages show a great possibility to emerge. Fourthly, strong absorptive capacities and a wide technology spectrum in a region increase the motivation of regional actors to seek out opportunities for global alliances, because this region will benefit enormously from a synergy of its technology with external knowledge.

The natures of knowledge and industry are two very important factors in affecting the chances of learning regions to be incorporated into global networks. For non-codified and immobile knowledge, an organization confronts many difficulties to learn it from remote partners or to pass it to them. Therefore, global connections might not contribute significantly to technology learning and innovation. The third external condition is the structure of a global network. In an oligarchic global network composed by technology-leading MNCs, relatively small- or medium-size companies in a particular region have little access to be included into the network.

3.3.5 The Case of Taiwan's Integrated-Circuit (IC) Industrial Technology Interaction Network

Chen and Jou (2001) indicate that Taiwan's IC companies have not only established various connections within the Hsin-Chu region on the island, but also have maintained many technology, manufacturing, and financial relationships with American, Japanese, and European companies. The proportion of local connections in the IC industrial network roughly equals that of global connections. Moreover, the industrial network has been established by a balanced combination of strong connections and weak connections. In order to investigate the characteristic of a learning network, we collect events of technology interaction among Taiwan's IC companies with their partners from 1973 to 2002. The events of technology interaction include basically three types: technology transfer, technology diffusion, and technology research and development (R&D). These three types of technology interaction are basic processes of technology learning for Taiwanese companies with their partners.

Technology transfer is defined as a transmission of advanced industrial knowledge from foreign companies to Taiwanese companies. Technology diffusion is defined as a distribution of mature technology among Taiwanese companies or a distribution of technology from Taiwanese companies to other foreign companies by means of a movement of technology experts or formal cooperation. Technology research and development is defined as innovating new technology or products among cooperative partners. The activities of research and development inside an organization are not included.

According to Table 3.2, the total events of technology interaction are seven hundred and sixty-four. More than two-fifth of the events of technology interaction have occurred between Taiwanese companies and American companies. Apparently, the development of Taiwan's IC industry has heavily relied upon American companies. The proportion of technology interaction among Taiwanese companies is about 31%. This highlights that technology exchange among local companies is widespread. Although American companies are major partners in Taiwan's IC technology learning network, Japanese companies have also gradually become important companions for technology learning and collaboration after 1985. The proportion of technology interaction between Taiwanese companies and Japanese companies is about 15%. Moreover, Taiwanese companies have also extended their technology interaction connections to European companies and the proportion of technology interaction there is about 7%. Most Taiwanese IC companies are located in the Hsin-chu Science Park and most events of their technology interaction have occurred inside the park, but this industrial technology learning network has not been .restricted by a spatial boundary. It has included both local partners and foreign partners from the United States, Japan, Europe, and other countries.

Table 3.2 Frequencies of Technology Interaction between Taiwan and Other Countries

Year	U.S.A.	China	Japan	Taiwan	Europe	Asia	Canada
1973	0	0	1	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0
1976	1	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0
1979	2	0	0	1	0	0	0
1980	2	0	0	2	0	0	0
1981	1	0	0	0	0	0	0
1982	0	0	0	1	1	0	0
1983	2	0	0	4	0	0	0
1984	3	0	0	1	0	0	0
1985	5	0	2	6	2	1	0
1986	3	0	3	5	2	2	0
1987	2	0	1	12	2	0	0
1988	5	0	2	10	0	0	0
1989	15	0	2	5	3	0	0
1990	17	0	2	7	1	0	0
1991	32	0	4	18	3	1	1
1992	12	0	1	14	2	0	2
1993	5	0	4	25	1	0	1
1994	17	0	10	18	3	1	0
1995	27	0	16	25	6	3	0
1996	15	0	12	9	2	0	0
1997	11	0	12	8	2	1	0
1998	19	0	11	3	3	0	0
1999	17	0	7	10	1	1	0
2000	38	4	18	16	7	1	0
2001	45	3	3	20	2	1	0
2002	25	4	9	17	14	1	0
Total	321	11	120	237	57	13	4

According Figure 3.1, technology interaction has occurred mostly between American and Taiwanese companies or among Taiwanese companies at the very beginning of the IC industry development. The first peak of technology interaction between Taiwanese and American companies was in 1991, while technology interaction among Taiwanese companies also reached a record height. Except for technology transfer for IC packaging in 1973, technology interaction between Taiwanese companies and Japanese companies slowly started in 1985 and events reached their first peak in 1995. At the same time, both technology interaction between American and Taiwanese companies and that among Taiwanese companies reached another peak. In addition, both technology interaction between Taiwanese companies and European companies and between Taiwanese companies and other Asian countries reached a new peak. By the years 2001 and 2002, another peak for technology interaction between Taiwanese companies and their partners had been reached.

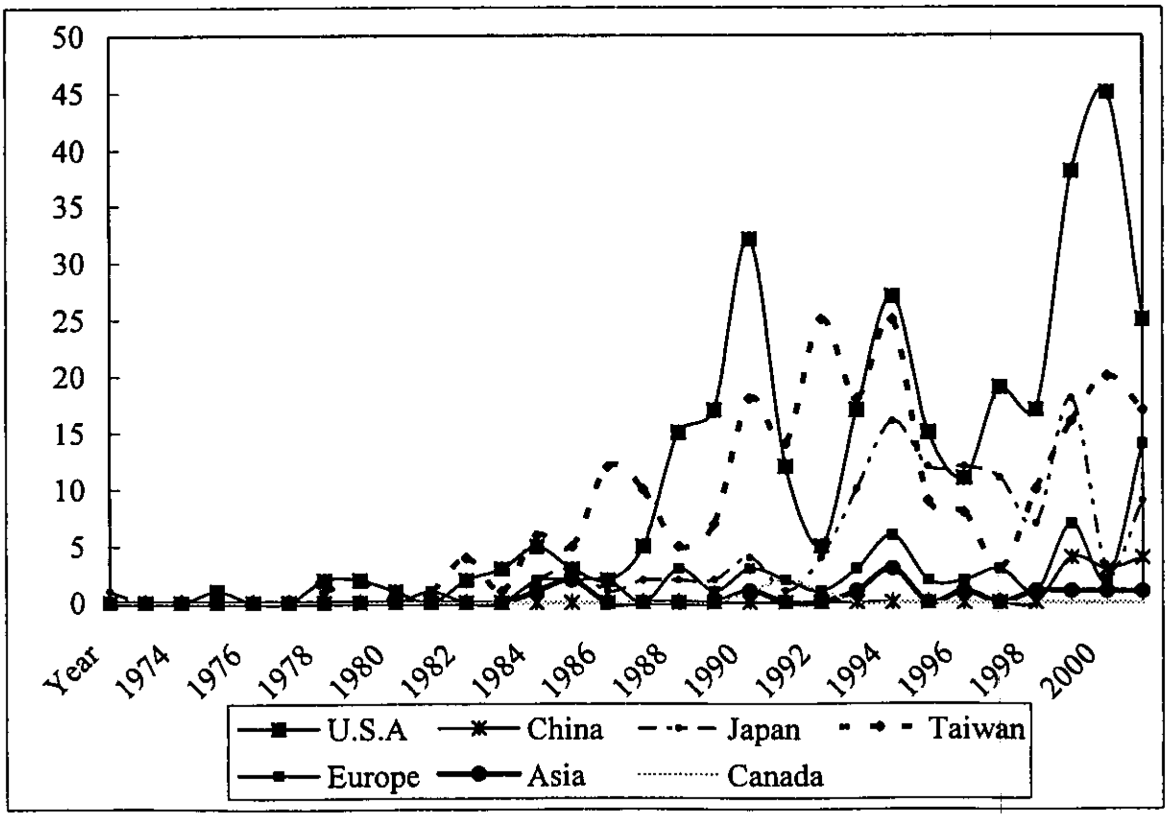


Figure3.1 Frequencies of Technology Interaction between Taiwan and Other Countries

Although American companies have been major partners of technology interaction with Taiwanese companies from the very beginning, new foreign partners joined the technology network at different stages. In other words, the predominant relationships between Taiwanese companies and American companies at the early stage have not limited subsequent technology interaction between Taiwanese companies and new foreign partners. It can be argued that a path-dependent influence on the formation of the IC technology learning network is very minor.

This network has been characterized by a simultaneous increase in the number of technology interaction events between Taiwanese companies and their different partners. When Taiwanese companies enhance their foreign technology collaboration, they also intensify their local technology interaction. External technology interaction does not replace local collaboration, but rather the two types of technology connections reinforce each other. New foreign partners do not substitute for old foreign partners, but rather Taiwanese companies increase their frequency of technology interaction with all the foreign collaborators at the same time. As a result, the expansion of the IC technology learning network has been achieved by both increasing local partners' relationships and involving more technology cooperation with foreign actors from different countries.

According to Table 3.3, the amount of technology interaction in Taiwan's IC learning network has included 60% of technology transfer events, 27% of technology diffusion events, and 13% of technology research and development events. Since this research only counts research and development events involving inter-organizational collaboration, the achievement of Taiwanese companies in products as well as manufacturing innovation has been underestimated. Nevertheless, the research finding still indicates that the development of Taiwan's IC industry has heavily depended on technology transfer from foreign companies. The frequency of technology diffusion among Taiwanese companies has far lagged behind that of technology transfer and the frequency of technology research. At the same time, the frequency of technology of research and development is even farther behind that of technology transfer. This pattern of technology interaction in Taiwan's IC learning network has displayed an essential characteristic of IC technology followers.

Table 3.3 Frequencies of Different Types of Technology Interaction

Year	Technology Transfer	Technology Diffusion	Technology Research and Development
1973	1		
1974			
1975			
1976	1		
1977			
1978			
1979	1		2
1980	3	1	
1981	1		
1982	1	1	
1983	3	2	1
1984	3	1	
1985	5	4	7
1986	8	2	5
1987	8	5	4
1988	7	6	4
1989	17	7	3
1990	21	4	3
1991	34	13	13
1992	15	3	13
1993	10	19	7
1994	25	19	6
1995	46	23	10
1996	23	10	5
1997	25	8	1
1998	28	7	1
1999	23	10	3
2000	58	24	2
2001	48	20	6
2002	43	21	6
Total	**457**	**210**	**102**

In Figure 3.2 we portray the three types of technology events across different stages. It is found that the events of technology transfer, technology diffusion, and technology research and development have achieved three peaks for the years 1991, 1995, and 2000, successively. When activities of technology transfer increase in the IC network, Taiwanese companies also boost their technology diffusion events and research and development collaboration. For an industry late-comer, it is very important for Taiwan to make great efforts to establish a solid industrial base by technology diffusion and to increase technology innovation capabilities at technology transfer proceedings.

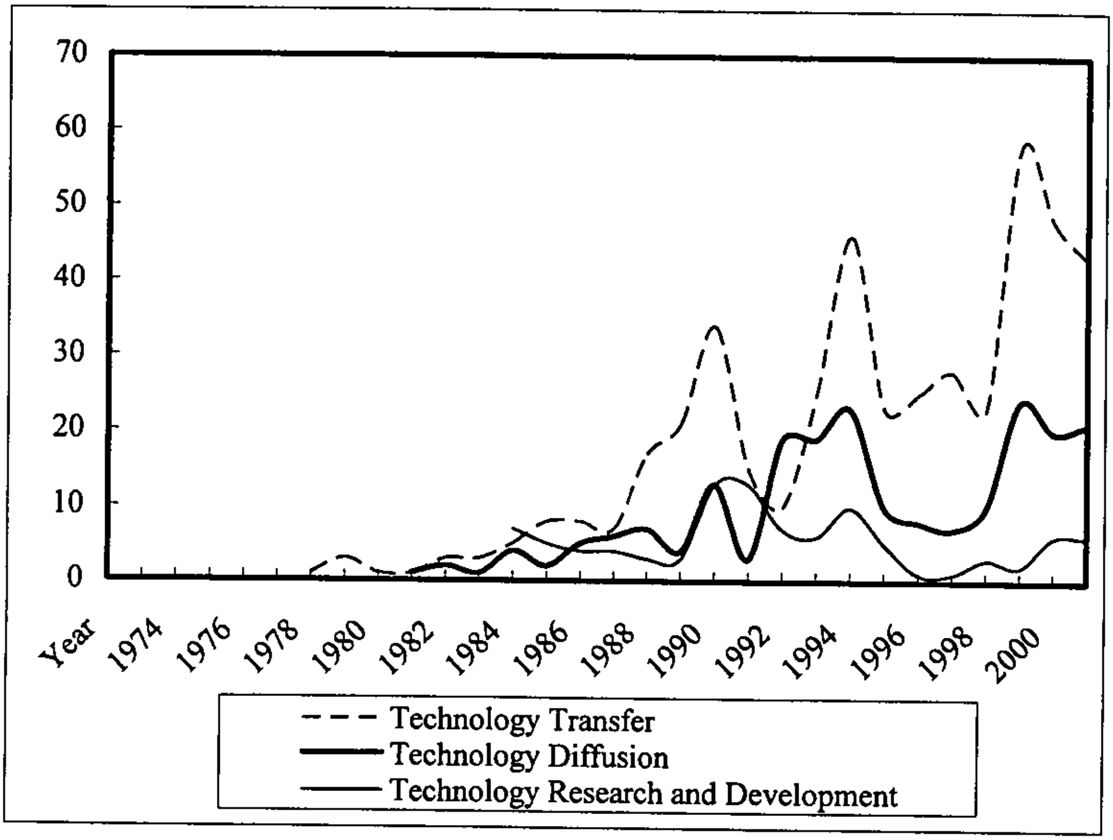


Figure 3.2 Different Types of Technology Interaction Events By Year, 1973-2002

Among the events of technology transfer, 60% of them occurred between Taiwanese companies and American companies, 23% of them took place between Taiwanese companies and Japanese companies, and 10% of them happened between Taiwanese companies and European companies. According to Figure 3.3, technology transfer to Taiwanese companies was mainly from American companies at the early stage, but there were some very significant technology transfer events such as the collaboration between Taiwan

Semiconductor Manufacturing Company (TSMC) and Philips. Technology transfer from Japanese companies to Taiwanese companies then started from 1985 and reached the first peak in 1994 and the second peak in 1999. In the late 1980s, Japanese companies faced severe competition from South Korean companies in the DRAM market, and therefore they pursued a coalition with Taiwanese companies, especially targeting on excellent manufacturing abilities. At the same time, Taiwanese companies enthusiastically looked for opportunities in producing DRAM and manufacturing companies from the two countries formed at least four successful cases of DRAM technology transfer.

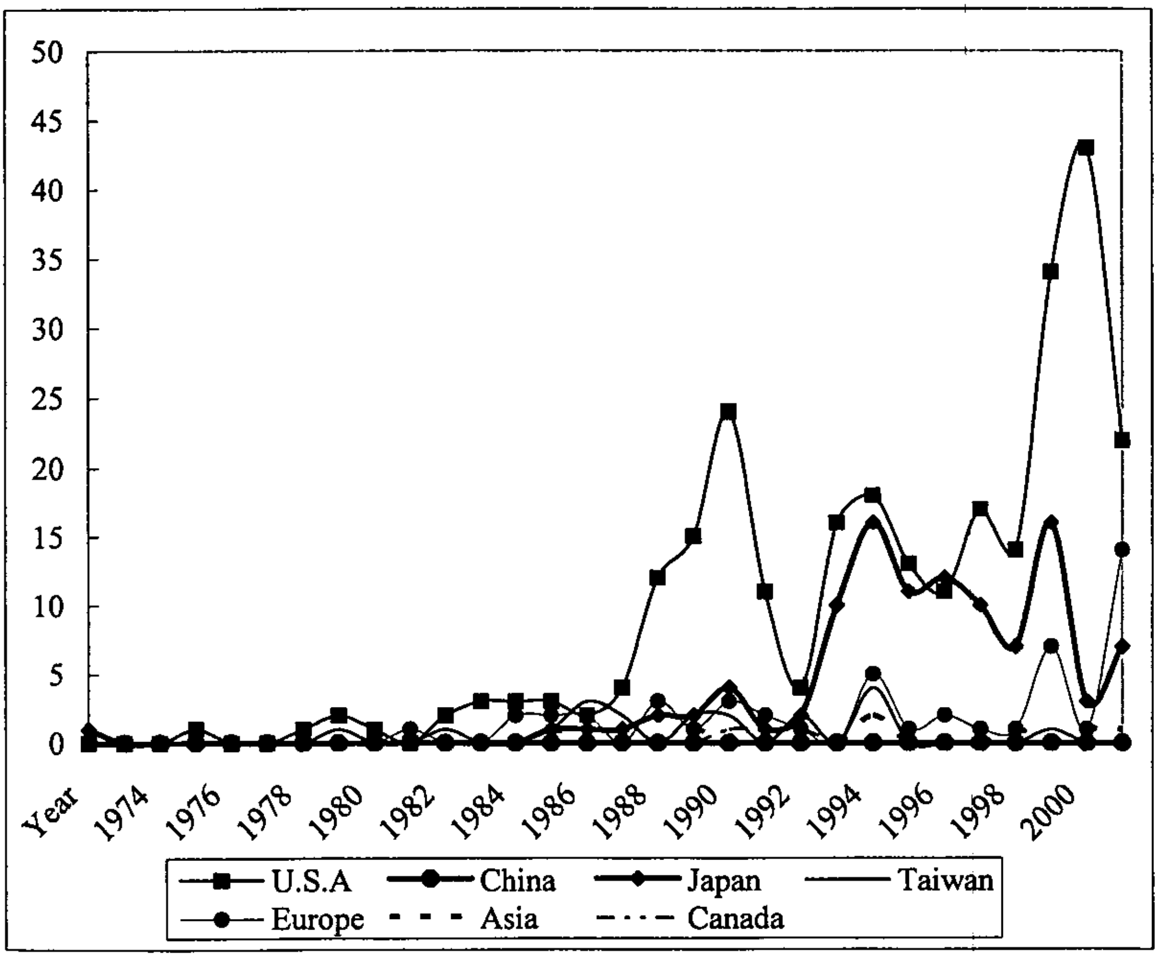


Figure 3.3 Frequencies of Technology Transfer between Taiwan and Other Countries

When Taiwanese companies have established frequent technology interaction relations with Japanese companies, they still have maintained numerous connections in technology transfer with both American companies and European companies. As a consequence, Taiwanese companies have effectively managed their external technology learning channels with great heterogeneity and the Taiwanese technology transfer network is a global one to a certain extent.

In terms of technology diffusion, about three-fourth of the events took place among Taiwanese companies and there was some technology exchange with companies located in the United States, China, Europe, Japan, and other Asian countries. The network of IC technology diffusion is not limited by spatial boundary. Since the IC industry in Taiwan has been characterized by vertical integration in which different companies have specialized only in one procedure of IC design, masking, fabrication, and packaging, these companies have formed an integrated production network. Moreover, technology diffusion among Taiwanese companies has intensified by frequent changes of engineers from one company to another one. Technology diffusion from Taiwanese companies to other countries is relatively rare, because most technology capability of Taiwan's IC industry is not as compatible as other advanced countries. However, it should be noted that Taiwanese companies began to send IC technology to China after 2000 and have maintained a stable trend of technology diffusion since then. In the early stage of IC industrial development, technology diffusion among Taiwanese companies facilitated the expansion of the local industrial base, but it occurred both between local companies and foreign companies later on so as to enlarge the IC network boundary.

Compared to technology transfer and diffusion, the events of technology cooperation in research and development among different actors are relatively few. About 66% of research and development collaboration occurred among local companies while 22% of the events took place between Taiwanese companies and American companies. Collaboration in technology innovation has only occasionally occurred between Taiwanese companies and Japanese or European companies. On the one hand, it is very difficult for Taiwanese companies with less advanced technology to pursue research and development collaboration with other technology leading companies (see Figure 3.4). Therefore, the local companies mainly form research and development coalitions with other companies or publicly-funded research institutes in Taiwan. A few American companies which have either numerous Taiwanese-American engineers or long-term outsourcing collaborations might establish research and development connections with Taiwanese companies. On the other hand, the investment in research and development of the IC industry as a whole has increased significantly after 1996 (see Figure 3.5). It highlights that many activities of research and development were implemented inside the organization in order to protect intellectual property rights. The number of patents filed by local companies in Taiwan's Intellectual Property Right Bureau was two hundred and fifty-two in 1997, and that number increased dramatically to eleven hundred and seventy only four years later.

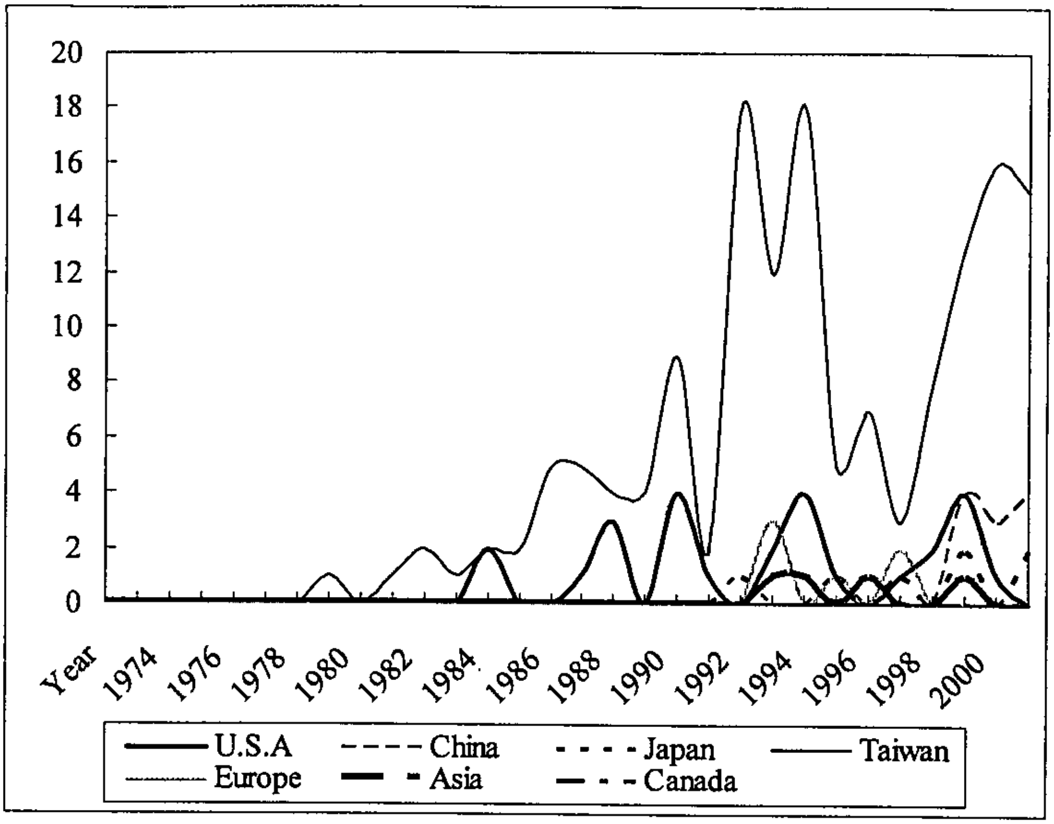


Figure 3.4 Frequencies of Technology Diffusion among Taiwanese Companies and between Taiwanese Companies and Foreign Companies

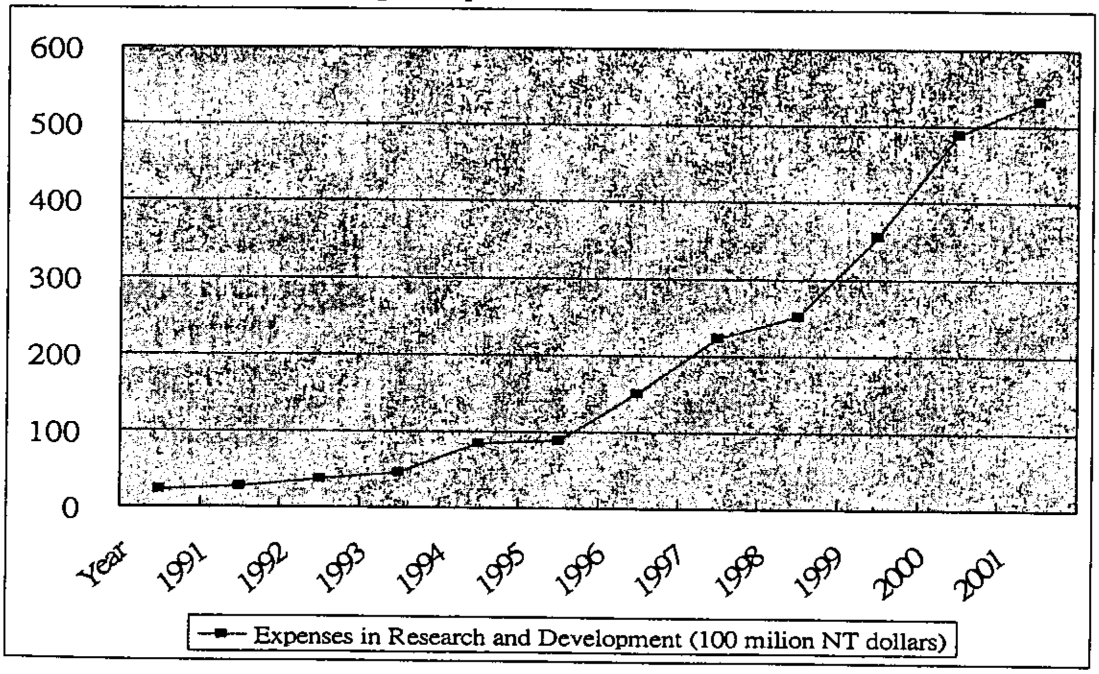


Figure 3.5 The Amount of Expenses in Research and Development for Taiwanese Companies

There are some important characteristics underlying the IC technology learning network in Taiwan. First of the all, this network has been established by both a collaboration among local partners and local-global partners' cooperative relationships. Although most local partners are located in the science park that endows so many space-assets for technology interaction, across-national technology learning still prevails in Taiwan's IC industry. In a clear sense, the pattern of IC technology learning is a globalized learning region in which local learning activities bounded in a specific place accompany numerous external activities of technology learning with major leading countries. Secondly, most technology learning activities belonged to technology transfer from foreign countries, while the events of technology diffusion were only half of the former events, and the events of cooperation in technology research and development were at least among these three types. This displays that Taiwan's IC industry still has to rely on outside advanced technology, but this dependent technology status has improved gradually after 1990 when Taiwanese companies increased their market share and their expenses in research and development.

In the IC learning network, three types of technology activities present a cyclical and simultaneous pattern. First, the increase of the events of technology transfer goes together with the increase of both the events of diffusion and research and development. Second, by great efforts in technology diffusion and research and development, the IC industry could expand its industrial base and upgrade its technology capabilities. Finally, the trajectory of technology learning for Taiwanese companies was not path dependent, and new foreign partners with key technologies were invited into the network at different stages. Moreover, the increase in the frequency of technology interaction between Taiwanese companies and foreign companies from one country reinforced the cooperative relations with foreign companies from other countries. Thus, the diversity of external learning channels has been steadily maintained.

The formation of Taiwan's IC learning network has been embedded in particular societal, economic, and political contexts. From the very beginning, governmental policies for incubating the IC industry were set up to transfer technology from advanced countries and to encourage the division of labor in IC production. Therefore, only major companies specialized in one part of production such as IC design, masking, fabrication, packaging, and testing. Furthermore, policies of spin-offs from a government-sponsored research institute have accelerated a centrifugal tendency of Taiwanese IC organizations. As a result, many new companies have been derived from old companies and there is a noticeable lineage of Taiwanese IC companies from the Electronic Research and Service Organization (ERSO). Finally, the atmosphere of entrepreneurship and the job changes for engineers in the IC industry science park have pushed the structure of the IC industry toward a networking organization even further. This very dynamic IC network has laid a solid foundation for rapid technology diffusion among Taiwanese companies.

With some help from Taiwanese-American engineers, the government's efforts to import IC technology from advanced countries were achieved by establishing learning channels with American companies at an early stage. Later on, many returnees from Silicon Valley founded their own companies in Taiwan and carried leading technology back. However, shared cognitive and normative elements between Taiwanese companies and American companies did not impede the technology interaction between Taiwanese companies and other foreign partners. Since there was different technology knowledge in the IC industry and foreign companies from advanced countries have taken a leading position in different parts of technology research and development, Taiwanese companies had to receive transfer technology from different countries at different stages. In addition, some government agencies and venture capital companies owning numerous weak ties played a significant bridging role in creating technology connections with foreign companies for Taiwanese firms. Hence, the development of the IC learning network is not path dependent and has a great spatial diversity.

Although technology collaboration in research and development shares only a small proportion of the technology interaction events, the increase of technology transfer and technology diffusion did have some positive effects on technology innovation cooperation for Taiwanese companies with their partners. In other words, a very dynamic network tends to reinforce more technology interaction among its actors.

3.4. Conclusion and Discussion

In this paper we are able to draw a very important conclusion in that a learning region cannot possibly succeed without accompanying a local-global learning network. Breschi and Malerba (1997:148-149) correctly point out that the modern microelectronics industry involves many geographically -concentrated innovators with both local and global knowledge boundaries, but they fail to include network perspectives to their space-centered arguments. Therefore, they do not highlight how these locally clustering firms develop capabilities in reaching out to global knowledge domains.

Secondly, any approach of technology learning and innovation should not limit itself both on a static framework of learning activities and on a geographical unit. The two shortcomings lead to overlooking the complicated and dynamic processes of learning regions' transformation in different geographical scales in which local industrial clusters are incorporated into the world economy in various ways. As we have discussed, a local learning region might develop into a nationalized learning region, globalized learning region, or a global learning network depending upon its absorptive capacities in new technology, institutional arrangements, networks' characteristics, and other environmental factors. In different trajectories of development, the patterns of local-global articulation display dissimilar characteristics. For instance, a global learning network frequently is composed of several organizations originating in different locations (nationalities) that have an equally important status in the network and a comparable technology level. Since these organizations interact with one another based on achieved characteristics and geography-free institutions, they tend to leave out their local particularities and forge a new common character.

Thirdly, the approaches of the learning regions over-emphasize their positive functions. However, they are short of providing a systematic discussion on the efficient boundary of the spatial concentration of economic organizations and their possible negative functions. Recent theoretical developments in the literature of organizational networks and social capital are able to fix this lacuna.

Finally, this paper offers a preliminary framework to investigate how structural, relational, and cultural characteristics of learning networks shape learning and cooperative innovation activities. This framework underlies the importance of the distinction between network-specific assets from space-specific assets and the significance in studying the impact of networks on technology learning and innovation. This paper also presents the case of Taiwan's IC industrial learning network so as to show the significance of the proposed analytical framework.

Chapter4 The Cross-Border Technological Linkages of Industrial Clusters

4.1 Introduction

Traditional wisdom dictates that an industrial cluster is generally characterized by the agglomeration of firms in a specific location, collectively gathering developmental momentum, with the support of local 'milieu'. Piőre and Sabel (1984), in particular, pioneered the theory of 'flexible specialization,' championing the concept of 'industrial district,' a concept roughly equivalent to industrial clustering. In short, flexible specialization can be regarded as a stylized production model organized on the basis of small, highly specialized and vertically-disintegrated firms, knitted together by a mix of competitive and collaborative interactions, within a more or less clearly defined region. Although, on an international scale, there may be a hierarchical array of industrial clusters, to some considerable degree, individual clusters are often considered to be self-sustained. However, the increasingly obvious trend towards globalization in production and technology has called into question this location-centric view of industrial clustering.

The purpose of this chapter is threefold. In the first place, industrial clusters do not arise within a historical vacuum, nor are they isolated from the rest of the world; this is not to deny the importance of local milieu in the formation of industrial clusters, but rather, recognition of the role of international linkages in the development of industrial clusters. This is particularly true for economies such as Chinese Taipei, a latecomer in the ladder of economic development, within which industrial clusters have evolved alongside the international industrial structure of the sectors concerned. In addition, whether or not the island's industrial clusters are sustainable is heavily dependent on the extent of 'localization,' which may involve at least two things; first of all, the presence of indigenous firms with substantial innovation capabilities, and secondly, the ability to anchor the 'network flagships'. With regard to the latter, we are referring to more than the local operations or investments of these network flagships, because they can be as footloose as 'branch plants,' as compared to 'performance plants'; rather, we refer to something like international linkages that are so enduring as to enable these indigenous firms to leverage for industrial upgrading.

Moreover, the trend towards globalization involves a process of increasing disintegration of production around the globe, and even disintegration of innovation capabilities (Feenstra, 1998), with the result that some, if not many, of the indigenous firms and/or industrial clusters in the developing world are nowadays able to shoulder important functions that used to be undertaken by their counterparts in the developed world. For one thing, outsourcing has become a widely adopted practice in quite a number of industries as a means of enabling brand marketers to remain cost-competitive. As a result, many network flagships have become 'hollowing-out' corporations, focusing their operations on the two ends of the 'smiling curve' - namely R&D and marketing functions (Chen and Ku, 2000; Kotabe, 1996; Swamidass and Kotabe, 1993; Venkatesan, 1992) - leading to a certain degree of de-linking of both R&D and manufacturing for the sector concerned; typical examples at issue include Ericsson in the handset industry and IBM in the PC industry. Within this process, brand marketers are becoming increasingly linked to other firms that may not even be in the neighborhood.

In addition, in many cases, innovations involve technical systems that are inherently large in scale, comprising of a set of jointly-consumed interdependent products (Windrum, 1999). On the basis of the network effects and product compatibility, successful innovations for technical systems entail intensive interfaces between multiple actors with different knowledge and skills bases, referred to as 'innovation networks'. By implication, not only does such an innovation often result from the collective efforts of inter-related firms, but it also demonstrates that the value chain does not need to be completely internalized within individual firms. In many cases, therefore, industrial competition takes place between rival technological and production networks that contain a multiplicity of differentiated firms, rather than between vertically-integrated oligopolies.

In order to put this into the context of industrial clustering, on balance, we suggest that there may be cross-border technological linkages of industrial clusters. In a sense, the evolutionary approach to technology (Nelson and Winter, 1984) is a constructive building block underlying the concept of international linkages; thus, the essence of this approach is that those things that a firm or an economy can do, or is about to do, are linked strongly to its set routines and previous bases. In technological terms, a firm can be considered as a producer, repository and user of knowledge, producing or acquiring knowledge and putting it to the most efficient use. Each firm's competitive advantage lies in its stock of knowledge, and because firms possess idiosyncratic knowledge, they are therefore likely to be heterogeneous.

4.2 New Geography of Industrial Clusters

There is an interesting question regarding the uneven distribution of innovation in regions, nations and industrial clusters. In the real world, it is often found that some innovative sectors are concentrated on only a few regions and nations. Other sectors are increasingly globally distributed. The reasons for such divergent development could lie as follows: (1) the nature and mechanisms of knowledge transfer and (2) geography of innovation.

All evolution is concerned with the growth of knowledge and information (McKelvey 1997). However, knowledge is different from information. Information relates to data, while knowledge involves a much wider process that involves cognitive structures that can assimilate information and put it into a wider context, allowing actions to be undertaken on the basis of it. Information exists independently of the receiver and transmitter. Knowledge is highly context-dependent information that has been translated so that humans understand it. Knowledge cannot be said to "flow" but can be said to be "shared" or "transferred" (Howells and Roberts 2000). Understanding the distinction between knowledge and information is the first step towards realizing the uneven distribution of innovation.

The evolution of industrial clusters is mainly shaped by the nature of knowledge and the mechanisms of knowledge transfer. Technological knowledge involves various degrees of specificity, tacitness, complexity and interdependence (Winter 1987). Knowledge has one in each of the following pairs of attributes:

1. *Generic vs. specific*: the knowledge base may be of a generic nature with diversified use, but also could be of a specific nature with tailor-made applications.

2. *Codified vs. tacit*: codified knowledge is very transferable and tends to be ubiquitous. However, tacit knowledge has the characteristic that knowledge sharing only takes place in geographical proximity where the actors possess the same language, norm, value, culture and geographical location.

3. *Simple vs. complex*: the knowledge base may show a relatively high or low degree of complexity in terms of the integration of different scientific and engineering disciplines and technologies, or in terms of the variety of competences that are involved in introducing innovation such as R&D, production, marketing and logistics.

4. Finally, *independent vs. interdependent*: the knowledge necessary for introducing innovation may be easily identifiable and independent or on the other hand, it may be embodied within a large system.

Polanyi (1966, 7) stresses that tacit and explicit knowledge are not divided and that explicit or codified knowledge requires tacit knowledge for its interpretation. Therefore, interpreting tacit knowledge itself also generates new tacit knowledge (Faulkner and Senker 1995). The different characteristics of knowledge mentioned above strongly affect firms' effectiveness in accessing the relevant knowledge. General speaking, the more specific, tacit, complex and interdependent the knowledge, the more informal mechanisms of knowledge transfer that are needed, such as personal contacts. On the other hand, the more generic, codified, simple and independent knowledge is, the more formal mechanisms of knowledge transfer tend to be, such as publications and patents.

Knowledge accumulation and utilization occur as the result of search activities, other learning efforts and routines. The firm's R&D contributes not only to the creation of knowledge inside the firm but also to the absorption of knowledge from outside the firm (Cohen and Levinthal 1989,1990). Not all types of knowledge have the same impact on firms. The impacts can depend on the nature of innovation, e.g., whether it is incremental, or radical, and the technological paradigm. Radical technological change can be competence destroying or competence enhancing (Tushman and Anderson 1986). Knowledge needs to be managed well, or otherwise it can form competence rigidity (Leonard-Barton 1995). Knowledge creation and accumulation is not decided only by the firm itself, but is influenced by other firms and knowledge-creating institutions (Lundvall 1992; Coombs and Metcalfe 1998).

The creation, adaptation and use of knowledge have been generally accepted as the center of analysis in forming local and regional clusters (Maskell et al. 1998). Once these systems of innovation have been formed and strengthened by the learning process, firms within them can build their specialization into innovation, which directly delivers them a competitive advantage in the world competition.

The firm-level factors of specialization in innovation highlight the fact that the synergy can occur in industry cluster- or regional-level specialization when these innovative firms establish an innovative network with their users, suppliers, universities and government agencies. In other words, when a development pole (Perroux 1950), or development block (Dahmén 1988, Carlsson 1995) has been formed. These factors convey a message that economies of scale and scope of economics in innovation tend to be easily explored and exploited when development pole exists. A virtuous cycle exists between the formation of new innovative firms and the economic dominance of their development poles. However, the sustainability of firm-level specialization in innovation is decided by whether firms can exploit their technology in each technological trajectory and/or upgrade their current technology into a new technology trajectory.

Why is the distribution of innovation concentrated in specific regions or locations? Howells (1999a) proposes the following five micro-innovation processes that contribute to the proximity of innovation:

Localized patterns of knowledge communication: the importance of geographical distance in affecting the likelihood of knowledge and information links between organizations. To a lesser and greater extent, a typical distance decays function in communication.

Localized knowledge-searching patterns: geographical proximity has a fundamental influence on how a firm searches for a new technology, a new business model or a new collaborative partner. By being located in an innovative milieu, a firm can improve its chance of making effective technological linkages.

Localized learning patterns: the rise of the "learning economy" highlights the fact that learning is the source of innovation and knowledge creation. Spatial proximity facilitates different types of learning, especially learning from spillover and interaction.

Localized knowledge sharing: if technological convergence is dependent on the potential innovators' exposure to solutions related to their own industry or outside the industry, then the innovative milieu definitely provides more multiple possibilities for innovators.

Localized innovation performance: agglomeration can also reduce the risks and uncertainty of innovation and increase its possibility of success (Howells 1999a, 82-85).

By using the concept of technological regime: opportunity, appropriability, cumulativeness and the knowledge base, which underpinning a firm's innovative activities, Breschi and Malerba (1997) argue that the geographical distribution of innovation is shaped by the following conditions of technological regime:

Ceteris paribus, conditions of high opportunity, appropriability and cumulativeness are likely to result in a high geographical concentration of innovators within each country.

In some sectors in which the sources of opportunities are strongly related to R&D activities, universities and R&D institutions, one may expect a noticeable concentration of innovators in a few regions. Moreover, the spatial clustering of innovators may arise because geographical proximity plays a crucial role in facilitating the establishment of stable and durable relationships amongst agents.

The more the relevant knowledge base underpinning innovative activities is tacit, complex and part of a larger system, the more geographically concentrated the population of innovators will be.

If cumulativeness at the firm level is high, then one can expect quite a high level of concentration of innovators and consequently a high level of geographical concentration of innovators. If cumulativeness at the sectoral level is high, this indicates the existence of wider spread knowledge externality (Breschi and Malerba 1997, 137-138).

Despite these factors, studies of micro-innovation processes claim that the effect of distance and proximity on knowledge flow places constraints on cross-border knowledge linkages across industrial clusters and regions. However, Howells (1999c, 52) indicates some factors that can facilitate industrial clusters dispersion in knowledge transfer. These facilitating factors are: (1) increasing codification of knowledge and science; (2) the increasing use of ICTs (information and communication technologies); (3) increasing dispersion of R&D activities by MNEs (Multinational Enterprises); (4) moving towards flatter organisational structure; and (5) decentralizing forms of research, design and technical operation in firms.

In conclusion, the geography of innovation could be influenced by the following factors: (1) the nature of knowledge (tacit or codified, degree of accumulation, appropriability), (2) the means of knowledge transfer (informal or formal), and (3) the importance of co-location in learning and market opportunities.

4.3 Product Innovation in Chinese Taipei's IC Industry

Product innovation involves an assortment of knowledge related to various stages of the value chain. Knowledge applied to manufacturing, marketing and customer services is complementary to the knowledge used in product innovation. Vertical integration of the innovation function in the value chain is only justified, however, if internalization is the best way to acquire the relevant knowledge, and this is not often the case. Since product innovations address the needs of customers, the type of knowledge most valuable to product innovation is that which is obtained from interacting with customers, in a word, marketing. Therefore, product innovation combined with marketing may be the optimal mix of services offered by a firm. In the traditional industries, such as footwear and apparel, Nike, Reebok and Calvin Klein are typical examples of this innovator-marketer combination; nevertheless, this trend towards the emergence of innovation and marketing as the core functions of a firm is even taking place in the high-technology industries. In the IT industry, for example, integrated device makers (IDMs) including Apple, Compaq, Dell and Motorola have partitioned themselves from manufacturing, which is now delegated to contractors.

The driving force behind innovation in the semiconductor industry has come from the so-called 'fabless' designers who rely upon foundry service providers to actually make the chips on their behalf. In some cases, however, where technologies are not characterized by incremental change, leapfrogging development may arise, which may allow the firm or economy concerned to bypass certain stages of the technological trajectory, or to jump straight into a new generation of technology. A typical example at issue is the new industrial standard, TD-SCDMA, for third generation mobile telecommunications, which, despite the low mobile phone penetration rate in the mainland, has been proposed by China and accepted by the International Telecommunications Union. Another example lies in the area of software, because new learners can enter directly and learn the new version (or generation) of software without the need to go through previous versions.

Firms within an industrial cluster may therefore engage in offshore operations in another industrial cluster in order to exploit the 'locational advantage' of the latter (Dunning, 1993). What's more, indigenous firms with substantial innovation capabilities within an industrial cluster may draw on their technological trajectory and/or leapfrogging potential as bargaining power to forge formal or informal partnerships with firms in other clusters. As a result, cross-border technological linkages may arise between industrial clusters.

We run the risk of oversimplifying the issue if we look at such cross-border technological linkages from a static perspective. For one thing, where leapfrogging potential prevails, the cross-border technological linkages may, to a certain extent, break away from the dominant pattern of the international division of labor, as illustrated in the case of the TD-SCDMA industrial standard in China. Regional networks within an industrial cluster may not in fact run only the risk of stagnating technologically, as noted by Piore and Sabel (1984), but they may also find themselves failing to cope with technological discontinuity due to the effects of technological lock-in and institutional inertia (Glasmeier, 1991).

At a more fundamental level, the trend towards increased disintegration of production, and more recently of technology, has arguably resulted in the reshaping of the structure of the global innovation system and the landscape of global technology. Consequently, the most well known industrial cluster, in

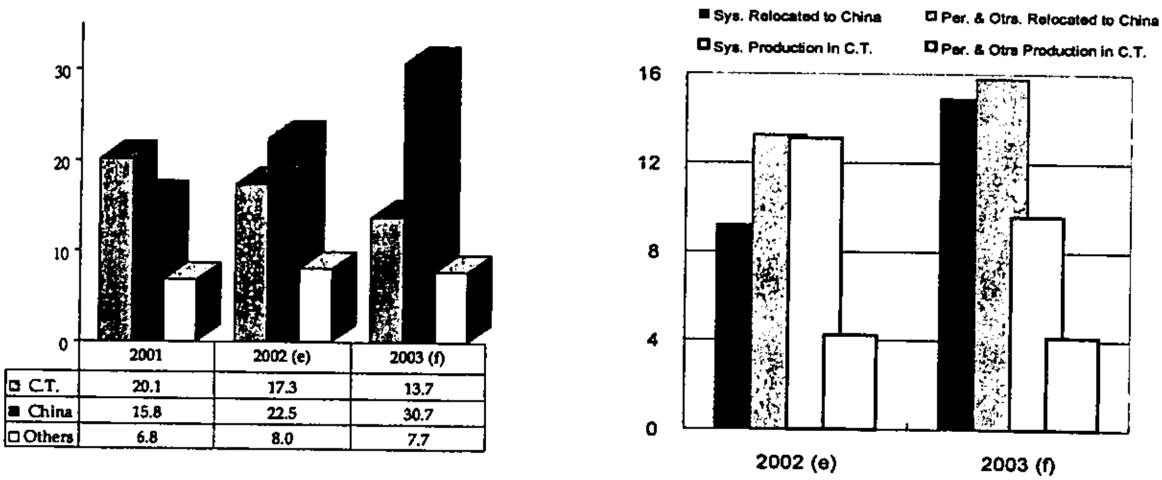
Silicon Valley, has regularly demonstrated to commentators different faces (perhaps part of their original ones) to those described by the exponents of the flexible specialization thesis. For example, where Saxenian (1990) regards the Valley as a small firm-led industrial cluster, Harrison (1994) identifies significant concentrated power and the role of the military as the major factor in its economic development. In addition, Gordon (1993, quoted in Harrison, 1994) has presented evidence revealing that collaborative manufacturing in Silicon Valley does not have any strong association with local inter-firm linkages. In order to illustrate these points, we refer to the PC and IC industries in Chinese Taipei, which are of significance to this part of our analysis because, within the process of their progressive development, local linkages are increasingly giving way to international linkages, and thus, giving rise to the importance of cross-border technological linkages of industrial clusters.

Chinese Taipei's characteristic local industrial clusters and their role in the growth of the PC industry in the economy have been well scrutinized (Hobday, 1995; Kawakami, 1996; Kraemer et al., 1996), but local agglomeration alone can no longer adequately account for the dynamics of Chinese Taipei's PC industry, because whilst global production networks have come to the fore, the way in which the global PC industry is organized has changed. An important milestone in the development of Chinese Taipei's PC industry in this regard was the outreach achieved by local firms starting from the late 1980s. Their outward investment was initially directed towards Southeast Asia, but more recently towards Mainland China and elsewhere in the world.

The offshore production of Chinese Taipei-based PC firms outweighs their domestic production, as China accounted for 46.9 percent of total production in 2002. Along with the PC industry's drive to reduce production costs, lead-time to market and inventory costs, came a profound change in the manufacturing system and inter-firm competition within the industry. It became commonplace for components to be sourced from a global network of suppliers and for final assembly to be done within the end-market (Angel and Engstrom 1995 and Borrus and Borrus 1997). Specifically, major brand marketers moved to adopt outsourcing and order-based production, which greatly rationalized their global supply chain, and hence altered their contractual relationships with the Chinese Taipei's firms.

Such contractual arrangements with the global leaders in the PC industry prompted Chinese Taipei's IT firms to upgrade their position within the global production system, with these firms then beginning to shoulder the essential functions of coordinating the global supply chain for their OEM customers. For example, under its new business model, Compaq outsourced every element of the value chain to Chinese Taipei's subcontractors, with the exception of marketing, imposing upon these subcontractors, a '98-3' operational formula which required them to collect 98 percent of the components and parts needed for the product within 3 days of the order, and to ship the product within 6 days of receipt of the order. By so doing, Compaq handed over its total inventory costs to these subcontractors, who were not only required to produce and deliver subsystem products to very tight schedules, but also to remain in tune with the vagaries of market demand. The Chinese Taipei's firms had to ensure that everything was synchronized up and down the supply chain, and in order to do this, they had to start engaging in cross-border supply-chain management, logistics operations and after-sales services. In order to effectively coordinate all of these activities, they had to form a fast-response global production and logistics network, or what we now refer to as 'global logistics' (Chen and Liu 1999; Schive 2000).

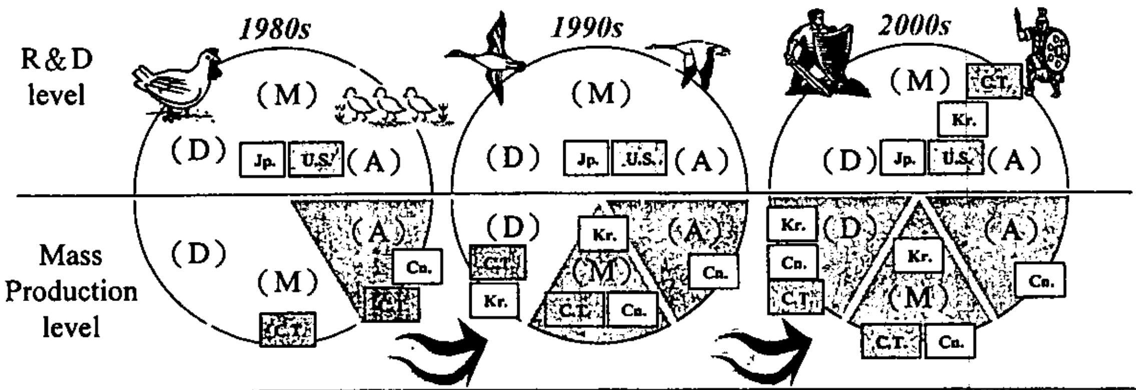
Over recent years, we have witnessed within this process a new phase of cross-strait industrial interaction. The newly emerging geographical concentration of investment in the Long River Delta by Chinese Taipei-based firms, notably in the broadly-defined IT industry, suggests that Chinese Taipei's outward investment into mainland China is becoming more technology- and capital-intensive. Indeed, the electronics and electrical appliances industry has accounted for approximately 40 per cent of Chinese Taipei's annual outward investment in China in recent years. More importantly, China has become an increasingly important offshore production site for Chinese Taipei-based PC firms; having significantly outweighed the latter's domestic production since 2002 (see Figure 4.1).



Source: MIC IT IS Project Nov.2002

Figure 4.1 Domestic and offshore production volume of Chinese Taipei's IT producers

Along with this process comes the evolution of the industrial landscape in the global IT industry, or more specifically the PC and IC sub-sectors, as illustrated in Figure 4.2 In the 1980s when the industry was dominated by vertically-integrated firms in the advanced economies, such as the US and Japan, their outward investment to Chinese Taipei triggered Chinese Taipei's entry into the value chain at mass production level. In particular, the local firms were able to fill the vacuum caused by the withdrawal of foreign firms during the mid-1980s, which then laid the foundation for the formation of the local industrial clusters, stretching from Keelung to Hsinchu.



	R&D level	Mass production level
Design (D)	Design method/CAD/IP	Layout, production of prototype, theoretical testing, etc
Manufacturing (M)	Development of new processes, equipment and materials	Front-end: Fab, motherboards, etc
Assembly (A)	Application of new packaging, modules, materials, etc	Back-end: Packaging, assembly, etc

Source: Nikkei Micro Device, quoted in MIC ITIS Project, August 2002.

Figure 4.2 The evolution of the industrial landscape in the global IT industry

The 1990s witnessed the emergence of economies, such as Chinese Taipei and South Korea, as major players in subcontracting work for brand marketers in the advanced economies, partly because of the rising popularity of outsourcing. Alongside this development, OEM, which used to be the major business of the IT firms in Chinese Taipei and South Korea, has gradually given way to ODM and, to a lesser degree, to production under brand names, thus facilitating their involvement in the design value chain at mass production level. Meanwhile, China's 'open door' policy and the outreach of Chinese Taipei's IT firms have fuelled China's rising significance in the manufacture and assembly of IT products. Since the start of the new millennium, this evolution has gone even further; with IT firms in both Chinese Taipei and South Korea now becoming actively engaged in R&D. In the meantime, China's coverage of the value chain at mass production level has become more comprehensive, and there are even signs that China is adopting a role in R&D which cannot be regarded as negligible, a point to which we shall return later.

On balance, global production networks have come to the fore in the IT industry. Characteristic features of these networks include cross-border modularized production and speedy patchy production, instead of, as before, mass production all under one roof. Therefore, from the viewpoint of Chinese Taipei's IT producers, the triangular linkages, involving Chinese Taipei (Hsinchu), China (the Long River Delta) and the US (Silicon Valley), may mean much more to their prosperity than the local industrial clusters in Chinese Taipei.

The IC industry, although tiny, may be considered as a technical system partly because of the increasing trend towards the vertical disintegration of this industry. This is particularly true if we take into account the fact that the sector is migrating towards the 'system-on-a-chip' (SOC) era, to which Chinese Taipei's firms are contributing in part. Japanese, Korean, Chinese Taipei's firms and US currently dominate the global IC industry, with their worldwide standing being in that order. What is of interest is that, in a number of significant ways, the industry in Chinese Taipei differs from those of the other three. Unlike Korea, which specializes in the production of dynamic random access memory (DRAM), Chinese Taipei produces a much wider variety of IC chips, and dominates in foundry services, capturing around 73 percent of the global market share. In addition, in contrast to the vertically-integrated conglomerates dominating the industry in Korea and Japan, Chinese Taipei's IC industry comprises of many small firms specializing in a narrow range within the value chain, such as IC design, mask production, foundry service, packaging and testing. Indeed, Chinese Taipei's flock of around 180 IC design houses puts it second only to the US in that particular segment. In a sense, Chinese Taipei's IC industry is organized as an industrial network system with a strong connection to Silicon Valley, the center of the global IC market and of global IC technology.

4.4 Organizational Innovation and Innovation Networks

The development of Chinese Taipei's IC industry has been driven by organizational innovation, with foundry services being created as a market niche to specialize in production for external customers. Local entrepreneurs made this choice deliberately as a way of avoiding the risks associated with the market volatility with regard to DRAM. By disintegrating the IC value chain, the emergence of foundry services in Chinese Taipei facilitated the proliferation of small- and medium-sized firms engaged in other market segments, such as IC design, testing and packaging, which gave rise to a balanced and vertically-disintegrated industrial structure.

In essence, the development of Chinese Taipei's IC industry has, to a large extent, come to resemble the scenario of the flexible specialization thesis (Piore and Sable 1984). Fabless IC design houses proliferated in Chinese Taipei partly because access to external fabrication capacity lowered the barriers to entry in the IC design market. In addition, the concentration of IC and computer-related firms in the Hsinchu Science-based Industrial Park (HSIP) generated agglomeration effects that allowed those firms to exploit the benefits of proximity and outsourcing. Therefore, even though they specialize in only one segment or other of the value chain, IC firms in Chinese Taipei are networked by social and business connections. Furthermore, Chinese Taipei's IC industry is also closely connected to the industry center in Silicon Valley, and although, amongst the four largest IC-producing economies, the US ranks first in terms of R&D intensity, it ranks only fourth with regard to capital expenditure intensity, where Chinese Taipei stands in first place (Table 4.1); this points to the emergence of an interesting pattern in the IC industry, with regard to the international division of labor.

Table 4.1 R&D and capital expenditure intensity in the IC industries of the US, Japan, Korea and Chinese Taipei, 1995-99

Unit: %

	1995	1996	1997	1998	1999
R&D intensity					
US	9.7	11.6	12.1	13.9	-
Japan	6.6	6.5	6.6	6.5	-
Korea	-	7.9	11.6	12.9	-
Chinese Taipei	7.0	6.9	8.8	9.1	-
Capital expenditure intensity					
US	20.7	22.8	17.5	18.0	14.0
Japan	16.1	20.8	20.2	18.0	16.0
Korea	25.7	40.1	51.0	26.0	26.0
Chinese Taipei	31.9	63.4	63.4	73.0	68.0

Notes:

a R&D intensity is the ratio of R&D expenditure to sales expressed as a percentage.

b Capital expenditure intensity is the ratio of capital expenditure to sales expressed as a percentage.

c Data refer to fiscal year.

Sources: ITIS (1999) and IC Insight (2000).

Chinese Taipei's strength lies in its foundry services, which depend on substantial investment in fabrication capacity. US IC firms, on the other hand, tend to concentrate on R&D, design, and marketing functions, which are backed up by access to Chinese Taipei's foundry service capacity; indeed, more than half of Chinese Taipei's foundry capacity was used to serve US customers in 2000, and most of the top ten fabless makers in the US have been Chinese Taipei's foundry clients. TSMC, the world's largest foundry service provider, shares its resources and information with its customers, considering them as partners. Each year, TSMC informs its customers of the foundry's plans for the development of process technology over the next five years, thus helping its customers to ensure that the proposed process technologies can support the future development of their products. This sharing of resources and information not only facilitates the development of close long-run relationships with customers, but also helps to reduce the uncertainty of technology development on both sides.

Another aspect of the connection between the IC industries in Chinese Taipei and the US is the intensive interchange between specialists in both economies. Underlying this exchange are Chinese Taipei's and Chinese expatriates, who have played important roles in establishing the trans-Pacific social and business networks that have proved crucial in connecting Chinese Taipei's production system with advanced market knowledge and technology (Saxenian, 1997; Kim and Tunzelmann, 1998). Apart from the ethnic social network, the fact that the IC industrial systems are decentralized and network-based, in both Chinese Taipei and Silicon Valley, has facilitated such interchange. This type of industrial system encourages the pursuit of multiple technical opportunities, heavy reliance on outsourcing and inter-organizational knowledge flows (Saxenian 1997).

The similarity in industrial structure makes networking between Silicon Valley and the HSIP, the center of Chinese Taipei's IC industry, much easier and more intensive, and such industrial networking as exists in Chinese Taipei's IC industry has benefited from recent innovations in IT. First of all, by reducing the uncertainty and transaction costs involved in purchasing from the best outsiders, IT reduces large firms' advantage of centralized purchasing and in-house suppliers. Secondly, technological changes have resulted in smaller production runs, increasing the feasibility of product changes and allowing small, specialized firms to exploit fragmented product markets on the basis of their flexible responsiveness. In addition, the IC industry is following the PC industry in moving rapidly towards order-based production.

Leading IC firms in Chinese Taipei are championing the concept of the 'virtual factory' by deploying the Internet and Extranet to electronically link with their customers and suppliers (Chen, 2002). Indeed, elsewhere we have documented the rising significance of organizational linkages forged by Chinese Taipei's IC industry, by counting the number of inter-organizational events (Jou and Chen, 2001). Our evidence demonstrates the greater likelihood of local organizational relationships being developed, as opposed to global ones, but that the industrial networks for Chinese Taipei's IC industry are not locked into any local/domestic connections (see Table 4.2).

Table 4.2 Organizational connections of the IC industry in Chinese Taipei, by economy and year

Period	Chinese Taipei	US	Japan	Europe	Others	Total
1976-80	1	2	-	-	-	3
1981-85	4	4	6	-	-	8
1986-90	55	32	10	4	3	104
1991-95	128	72	27	7	10	244
1996	36	24	3	2	5	70
Totals (%)	224 (52.2)	134 (31.2)	40 (9.3)	13 (3.1)	18 (4.2)	429 (100)

Source: Adapted from Jou and Chen (2001).

On the one hand, we find a significant increase, from 1976 to 1996, in the number of organizational connections between Chinese Taipei's companies, a phenomenon that occurred alongside the increase in international linkages. The number of organizational connections between Chinese Taipei's IC firms and their US counterparts also increased during the same period. The same phenomenon is also demonstrated between Chinese Taipei's and Japanese firms, particularly after 1991. As Chinese Taipei's companies become large, in terms of both scale and capital, they have much greater resources than before to facilitate the initiation of organizational connections. In addition, their technological excellence, particularly with regard to manufacturing capabilities, has attracted foreign companies to seek out alliance opportunities with them. These are two of the major reasons why the number of organizational links increased significantly after 1990.

On the other hand, as global connections have increased, there has been no corresponding reduction in local organizational relationships, which suggests that within Chinese Taipei's vertically disintegrated industrial system, internal connections remain intense; this is because a large number of local organizational ties are crucial to the maintenance of efficiency and flexibility. Given that with the exception of three IC design houses located in the Taipei area, the study samples (the three-two large-sized IC companies) are all located in the HSIP and surrounding industrial parks, local/internal linkages should benefit greatly from the clustering effects of Chinese Taipei's IC industry.

More importantly, SOC is looming on the horizon, which will arguably bring about fundamental changes to the IC industry. The emergence of SOC has basically induced the modularization of various design technologies, known as silicon intellectual properties (SIPs), which can be used repetitively as the main building block for SOC. Added to this, the technological complexity of SOC may heighten the pressure, in terms of 'time-to-market,' and may also demand a somewhat 'collegial' partnership between a network of technology and business parties. Within this process, there is also an increasing demand for new platforms, in such areas as design tools and design services, in order to achieve cost-effective systems integration, because SOC involves both system complexity and the requirement for outsourcing.

The IC industry will probably witness the proliferation of new industrial players and business functions, with some of these reinforcing the existing ones and, as a result, the industry as a whole may therefore become more physically disintegrated but virtually integrated. Table 4.3 provides a broad outline of the new, albeit simplified, sectoral landscape of the IC industry in terms of four dimensions; design process, production activity, end product and product form (by product form, we mean the form of products produced by each type of players, and because of SIPs, they will take on either a physical or a virtual form). In short, the overall design process involves not only those providing the design, but also those providing design support. In addition, the end products involved can be either components or systems, which can in turn be presented in a physical or virtual form.

Table 4.3 The sectoral landscape of the IC Industry in the new SOC era

	Design Process		Production Activity		End Product		Product Form	
	Design	Design Support	Fab	Fabless	Component	System	Physical	Virtual
IDM	✓	✓	✓		✓	✓	✓	✓
Design house				✓	✓	✓	✓	✓
Design service	✓	✓		✓				✓
Wafer foundry		✓	✓				✓	
EDA Tools		✓		✓	✓	✓		✓

Source: Compiled from Chen and Huang (2002)

In terms of industrial players, apart from the well-recognized IDMs, design houses and foundry firms, design service providers (also known as design foundries) have emerged as a new breed of firms, whilst EDA tool firms are also set to occupy an increasingly important seat within the industry. Design foundries provide mainly design support, although some are also designers, producing virtual components. Such firms tend to have expertise in the design process (particularly downstream) and are able to provide customers with total solutions and/or integrated services for the development of SOC with the emphasis on time-to-market, but without owning a chip. Their business activities therefore come in virtual form.

Equally important, are the other types of firms that are expanding the boundaries of their business activities, and hence stepping into each other's territories, resulting in complex inter-actor relations and perhaps even conflict of interest. It is increasing likely that IDMs will no longer work for own-brand producers only, since it is likely that they will also be engaged in providing design support. Indeed, in order to come to terms with the newly rising trend for outsourcing of handset production, Motorola, for example, is promoting its i250 platform as part of a system solution to assist OEM manufacturers in the design of new handsets. This type of firm is therefore going 'partially virtual'.

Similarly, EDA firms are likely to have a role that goes beyond the former one-shot design tool provider. Indeed, in order to facilitate the design of SOC, they are now focusing on the development of a reusable reference platform that will enable system-level, rather than block-level, design; an example here is Mentor Graphics' 'Platform Express'. Chances are that some of the most widely used standard IP libraries are built on this reference platform, implying that EDA firms may soon become involved in the provision of virtual components. Furthermore, with their knowledge of design methodology, EDA firms may become capable of providing consulting services in order to help customers to come to terms with the new reality.

As for wafer foundries, virtual integration has been considered as an evitable response to the emerging call for SOC; consequently, foundries are increasingly becoming 'integrated service providers' acting as a portal providing comprehensive support for customers' major operational tasks, ranging from prototyping, design and engineering, to logistics. Within this process, they may possibly extend their customer services even further to cover design consultancy services.

The relationships between wafer foundries, design houses and other players have tended to be fairly linear in nature, but a collegial relationship may well be needed for the new era. On balance, the industrial structure of the IC industry is changing, and so too are the relationships between all the parties involved.

Against the backdrop outlined above, the industrial players in Chinese Taipei are now evolving to face the challenges brought about by the emergence of SOC. Chinese Taipei has, for example, already established a world-class capability in wafer foundry and IC design by exploiting a strategy of vertical disintegration and virtual integration. These two sectors in Chinese Taipei may well prove to be mutually reinforcing in the SOC race, and hence cannot be disregarded by the international IDMs and EDA firms. Conversely, some industrial IC players, in the UK for example, tend to be chipless firms providing consultancy services and/or producing virtual components, partly because of the lack of foundry capacity. That said, in order to go through the entire value chain of SOC, the industry is required to bring together a variety of industrial players, including IDMs, chipless firms, design service providers, IC designers, EDA tool providers, foundry and packaging firms, which are very likely to be located in a number of different economies.

The innovation networks in the industry are thus global, or at least international in nature. It will therefore be interesting to see how they will reorganize themselves for industrial upgrading in the new era. For one thing, as the design process becomes more complicated, the design houses will have to find a new way to compete and interact with the other types of industrial players, particularly the IDMs and design foundries, some of which will go 'virtual' and become design foundries.

As SOC goes through the entire value chain, wafer foundries will hold a unique position in verifying, as well as producing, silicon-proven IPs. As discussed already, the technological complexity of SOC may induce these foundries to tighten their networking relationships with the other types of industrial players. For example, in advancing the concept of virtual foundry, TSMC is championing a collegial win-win-win model, instead of the win-win customer/supplier relationship that currently prevails, which in turn, according to TSMC, may entail a business model based upon 'pay-for- performance'. In the same vein, UMC has also proposed a new 'partnership foundry strategy'.

As a result, the industrial network in the IC industry will probably be further 'internationalized,' bringing about the escalation of the level of importance of cross-border technological linkages between the industrial IC clusters around the globe. From the perspective of Chinese Taipei's foundries, SIPs can be classified into soft IP, firm IP and hard IP. Whilst soft IPs and firm IPs are sensitive to the design environment, hard IPs are, to quite a considerable extent, process-dependent. This means that international fabless houses producing hard IPs may have to establish mutual dependency with the foundry providers, such as TSMC and UMC, which may enable the latter to upgrade their capabilities over time.

4.5 An Empirical Study on Mapping Cross-Border Knowledge Links in Chinese Taipei's IC industry

We propose a bottom-up, firm-centered approach to map cross-border knowledge links in Chinese Taipei's IC industry (Figure 4.3). Firms' inter-organisational co-operation can be regarded as knowledge linkages between various kinds of firms and organizations. In Order to map out inter-organisational co-operation, four key issues are considered: who, what, how and where. First, the study considered the actors who are involved in the co-operation. Secondly, it looks at what co-operative mechanisms are used. Thirdly, it measures the strength of the co-operation. Lastly, it examines where the co-operative partners are positioned.

First of all, there are three major types of inter-organisational co-operations, namely: (1) inter-firm co-operation, (2) firm-university co-operation, (3) firm-R&D institution co-operation. Secondly, the issue of mechanisms concerns the way firms establish co-operation. The mechanisms are categorized into three kinds: (1) contract arrangement or licensing, (2) strategic alliance/networking and (3) jointly establishing a new organisation (e.g., equity participation, joint venture, and merger and acquirzation).

Thirdly, if the firm has one specific inter-organisational co-operation, it was asked to indicate the number of co-operative organizations or the number of projects involved. This helps us to measure the strength of each type of co-operation. The number of co-operative organizations is used to measure the strength of inter-firm, firm-university, firm-R&D institution. Finally, the locations of the co-operations are classified into five geographical areas, namely (1) local (within 50kms), (2) national, (3) the US, (4) Japan and (5) other.

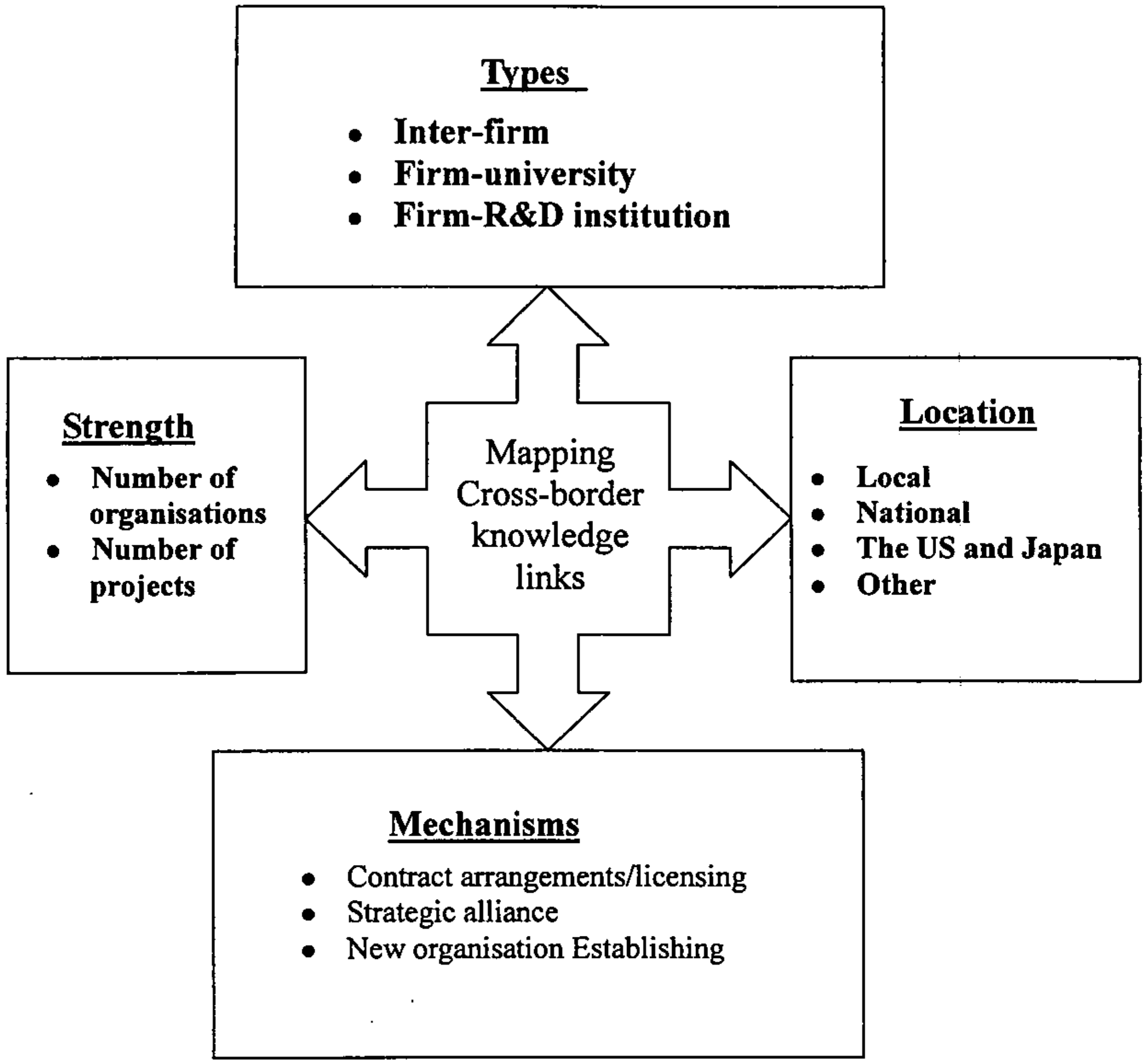


Figure 4.3 Research framework for mapping cross-border knowledge links

4.6 Research Methods

4.6.1 Questionnaire design

There are four sections in total in a four-page questionnaire. The first three sessions investigated the inter-firm co-operation, firm-university co-operation and firm-R&D institution co-operation respectively. The geographical locations and cooperative mechanisms and strength were identified in the first three sessions. The fourth session inquiry the company

2002 profile including sales, intramural and extramural R&D expenditure, number of employees, nationality of company headquarter, innovative performance such as patents, process and product innovation. The author designed almost all of the questions. For the details of the questionnaires, see Appendix.

4.6.2 Pilot study

Before sending all the questionnaires out, a pilot study was conducted to test the quality of the questionnaire. Ten questionnaires were sent for pre-testing. Ten firms from the survey list were randomly selected. A total of four questionnaires were returned within two weeks. After the pilot study, the improvement of wording and structures were made in the questionnaire.

4.6.3 Response rate

In total, 167 IC firms were collected from the Semiconductor Industry Yearbook (2001). After two waves of questionnaire survey and exhaustive telephone follow-ups, 61 responses received, 4 questionnaires invalid. Fifty-seven questionnaires were useful, with an overall response rate, 34%. The proportion of firms by location is forty-five percent (74 firms) in the north of Taiwan, 47% (79 firms) in Hsinchu Science-based Industrial Park, 2% (4 firms) in the middle of Taiwan and 6% (10 firms) in the south of Taiwan. The Taiwanese IC industry has highly clustered in two areas. One is Northern Taiwan along with National Highway No1. Corridor between Hsinchu County and Taoyuan County. The other cluster is located in Hsinchu Science-Based Industrial Park. IC firms clustered in these two areas occupied more than 90% of the whole IC population. The goodness of fit test between population and respondents is statistically significant level at p=0.21 which means that the respondents can represent about 80% confidence of the whole population in term of location (Table 4.4). The goodness of fit test for not reaching the significant level at p< .05 is attributed to the under-representative respondents for Hsinchu Industrial Science Park. It is well documented that Taiwanese IC firms have suffered a lots of questionnaire shooting. Therefore, the respondents of IC firms in HSIP tend to reply reluctantly. It is pertinent to say that the study had a not so bad response rate, 30% from HSIP.

Table 4.4 Proportions of Population and Responses in Taiwan's IC Sector by Location

Location	IC Population		IC returns		Goodness of fit test	
Northern Taiwan (Hsinchu Science Park excluded)	74	45%	27	47%	X^2	p-value
Hsinchu Science Industrial Park	79	47%	24	42%	12.00	.213
Middle of Taiwan	4	2%	1	2%		
Southern Taiwan	10	6%	5	9%		
Total	167	100%	57	100%		

Note: North: Taipei City and Taipei County, Taoyuan, Hsinchu; Middle: Miaoli, Taichung, Changhua and Yuanlin; South: Chiai, Tainan and Kaoshiung.

4.6.4 Number of employees

The number of employees is used to measure the size of respondent firms. There are five categories of firm size: small firms which employ less than 50 employees, large firms which employ more than 500 employees and medium firms which employ between (50-499). According the statistics of Small and Medium Enterprise Administration, Ministry of Economic Affairs, almost 98% of firms in Taiwan are small and medium size enterprises with less than 250 employees. There are 46% of small and medium and 54 % of large firms in Taiwanese IC sector respectively. Relatively speaking, the size of Taiwanese IC firms is bigger than the firms in other industry. This is attributed to the increasing globalization of Taiwanese IC firms ranked the world top 4 IC production and lots of domestic and international mergers and acquisitions undertaken in the Taiwan IC sector (Table 4.5).

Table 4.5 Proportions of Respondent Firms by Number of Employees

Number of employees	Number of firms	Valid Percent	Cumulative Percent
<= 49	11	19.6	19.6
50~249	26	46.4	66.1
250~499	8	14.3	80.4
500~999	9	16.1	96.4
>= 1000	2	3.6	100.0
Total*	56	100.0	

*Note: *Missing case=1*

4.6.5 Turnover

The study analyses the respondent firms in term of turnover. More than 85% of IC firms had more than NT$ 100 million of sales in 2002. About 31 firms, more than 50% of firms, are the majority group with a sales ranged NT$ 101 million ~ 1 billion. The distribution of sales seemed rightly skewed towards the sales more than NT$ 1 billion. The pattern of distribution on sales also indicates that the firm is getting larger in 2002. TSMC and UMC ranked the top two companies in term of sales (Table 4.6).

Table 4.6 Proportions of Respondent Firms by Turnover

Turnover (NT$ million)	Number of firms	Valid Percent	Cumulative Percent
< 50	4	7.7	7.7
51~100	3	5.8	13.5
101~1,000	31	59.6	73.1
1,001~5,000	9	17.3	90.4
5,001~10,000	3	5.8	96.2
>10,000	2	3.8	100.0
Total*	52	100.0	

*Note: * Missing cases= 5*

4.6.6 Ownership

From the ownership perspective, Taiwan's respondent firms are almost all Taiwanese owned in both sectors. One-third of UK respondent firms are foreign-owned, mainly from North America (Table 4.7).

Table 4.7 Proportions of Respondent Firms by Ownership

Ownership	No. of firms	Percent
Domestic	53	93%
Europe	0	0%
Northern America	2	3%
Other	1	2%
Missing cases	1	2%
Total	57	100%

Currently, there are about 160 IC firms involved in IC design, fabrication, testing and packaging in a vertical –disintegrated industrial structure in Taiwan rather than vertical integrated one in Korea. The study collected geographical technological links of Taiwanese IC industry across two periods of time, 1996~1998 and 2000~2002 respectively. The population of Taiwanese IC firms grew.

4.7 Results

Inter-firm knowledge links by location, mechanism and co-operative strength

The study shows that the most frequent knowledge links that Taiwan IC firms established are supplier firms, following by customer firms and the last competitors and other firms (might be in other sectors) (Figures 4.4 and 4.5). In term of co-operative mechanisms, generally speaking, the most frequently used mechanisms are strategic alliance, following by arm-length contract research and licensing, and the last Williamson's hierarch forms such as equity participation, joint venture and M&A. In term of geographical partners, the most frequent knowledge partners are local and domestic firms, following the US firms, firms in the rest of the world and the last, Japanese partners.

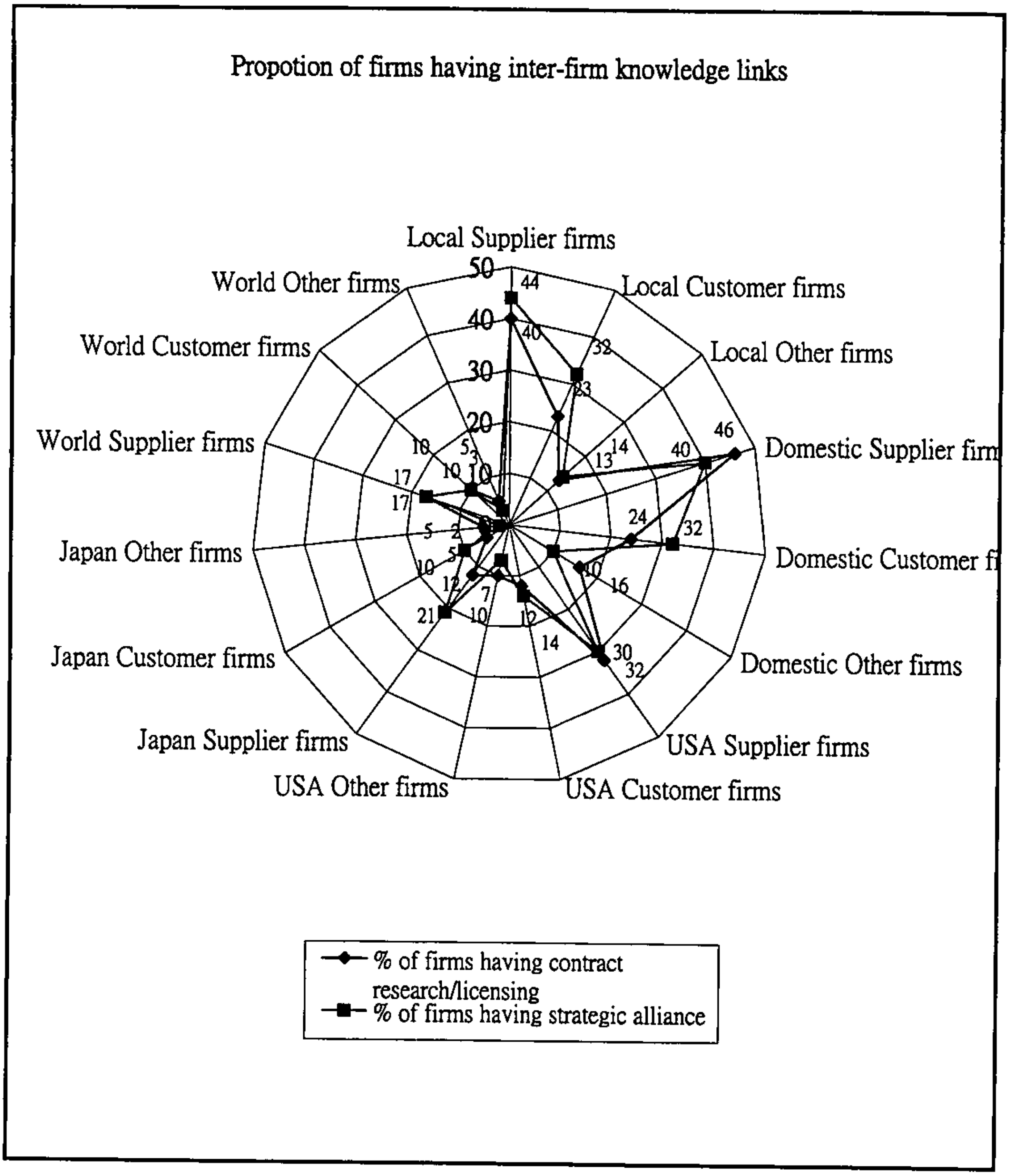


Figure 4.4 Proportion of the firms having inter-firms links by location and cooperative mechanism

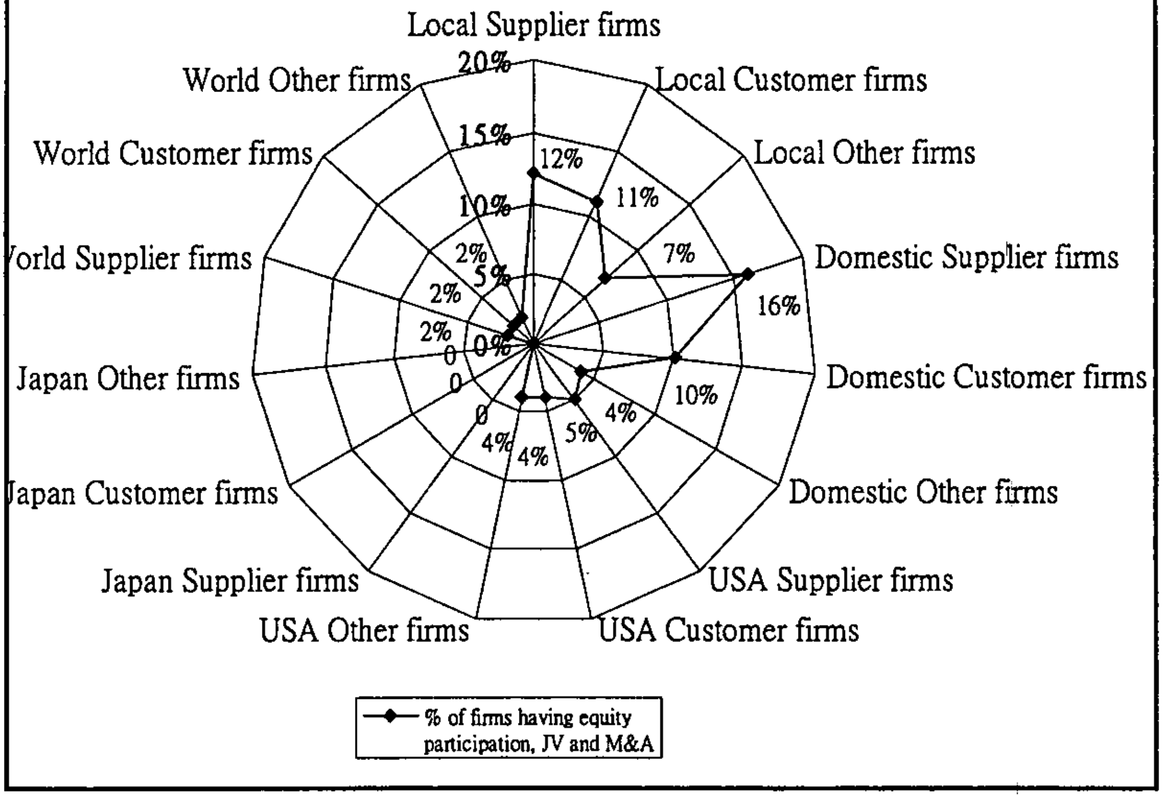


Figure 4.5 Proportion of firms having equity participation, joint venture and M&A by location

The inter-firm knowledge links through contract research and licensing can be broken down by locations and co-operative strength in details (Table 4.8). In the local inter-firm knowledge links, the 40% of Taiwan IC firms reported co-operating 2.2 local supplier firms on average via contract research and licensing. Twenty-three percent of Taiwan IC firms reported co-operating 1.4 local customer firms on average via contract research and licensing. Only 13 % of Taiwan IC firms reported co-operating 0.6 local other firms on average via contract research and licensing.

In the national inter-firm knowledge links, the 46% of Taiwan IC firms reported co-operating 2.65 domestic supplier firms on average via contract research and licensing. Twenty-four percent of Taiwan IC firms reported co-operating 1.4 national customer firms on average via contract research and licensing. Only 16 % of Taiwan IC firms reported co-operating 0.8 national other firms on average via contract research and licensing.

In the inter-firm knowledge links with the US partners, the 32% of Taiwan IC firms reported co-operating 1.65 the US supplier firms on average via contract research and licensing. Twelve percent of Taiwan IC firms reported co-operating 0.6 the US customer firms on average via contract research and licensing. Only 10 % of Taiwan IC firms reported co-operating 0.6 the US other firms on average via contract research and licensing.

In the inter-firm knowledge links with Japanese partners, the 12% of Taiwan IC firms reported co-operating 0.60 Japanese supplier firms on average via contract research and licensing. Twenty-three percent of Taiwan IC firms reported co-operating 1.4 Japanese customer firms on average via contract research and licensing. Only 13 % of Taiwan IC firms reported co-operating 0.6 Japanese supplier firms on average via contract research and licensing.

Table 4.8 Inter-firm contract research and licensing links by locations and co-operative mechanisms (N=57)

Location	Types of firms	Proportion of firms with links	Number of co-operated firms (Mean)	Number of co-operated firms (S. D.)
Local (within 50 km)	Supplier firms	40	2.20	2.80
	Customer firms	23	1.40	2.95
	Other firms	13	0.60	1.65
Domestic	Supplier firms	46	2.65	3.42
	Customer firms	24	1.40	2.80
	Other firms	16	0.80	1.83
USA	Supplier firms	32	1.65	2.56
	Customer firms	12	0.60	1.66
	Other firms	10	0.60	1.91
Japan	Supplier firms	12	0.60	1.66
	Customer firms	5	0.25	1.13
	Other firms	5	0.25	1.13
World	Supplier firms	17	0.90	1.92
	Customer firms	10	0.65	1.55
	Other firms	5	0.25	1.13

The inter-firm knowledge links through contract research and licensing can be broken down by locations and co-operative strength in details (Table 4.9). In the contract research and licensing knowledge links with local firms, the 40% of Taiwan IC firms reported co-operating 2.2 local supplier firms on average. Twenty-three percent of Taiwan IC firms reported co-operating 1.4 local customer firms on average. Only 13 % of Taiwan IC firms reported co-operating 0.6 local other firms on average via contract research and licensing.

Table 4.9 Inter-firm collaborative research and strategic alliance links by locations and types of the firms (N=57)

Location	Types of firms	Proportion of firms with links (%)	Number of co-operated firms (Mean)	Number of co-operated firms (S. D.)
Local (within 50 km)	Supplier firms	44	2.30	2.85
	Customer firms	32	1.65	2.56
	Local Other firms	14	.80	2.07
Domestic	Supplier firms	40	2.35	3.29
	Customer firms	32	1.65	2.56
	Other firms	10	.60	1.91
USA	Supplier firms	30	1.50	2.31
	Customer firms	14	.70	1.75
	Other firms	7	.63	1.71
Japan	Supplier firms	21	1.05	2.21
	Customer firms	10	.55	1.55
	Other firms	2	.10	1.55
World	Supplier firms	17	.90	1.92
	Customer firms	10	.55	1.55
	Other firms	3	.20	.94

In the contract research and licensing knowledge links with national firms, the 46% of Taiwan IC firms reported co-operating 2.65 domestic supplier firms on average. Twenty-four percent of Taiwan IC firms reported co-operating 1.4 national customer firms on average. Only 16 % of Taiwan IC firms reported co-operating 0.8 national other firms on average via contract research and licensing.

In the contract research and licensing knowledge links with the US partners, the 32% of Taiwan IC firms reported co-operating 1.65 the US supplier firms on average. Twelve percent of Taiwan IC firms reported co-operating 0.6 the US customer firms on average. Only 10 % of Taiwan IC firms reported co-operating 0.6 the US other firms on average via contract research and licensing.

In the contract research and licensing links with Japanese partners, the 12% of Taiwan IC firms reported co-operating 0.60 Japanese supplier firms on average. Twenty-three percent of Taiwan IC firms reported co-operating 1.4 Japanese customer firms on average. Only 13 % of Taiwan IC firms reported co-operating 0.6 Japanese supplier firms on average via contract research and licensing.

In the contract research and licensing knowledge links with firms in the rest of the world, the 12% of Taiwan IC firms reported co-operating 0.60 Japanese supplier firms on average. Twenty-three percent of Taiwan IC firms reported co-operating 1.4 Japanese customer firms on average. Only 13 % of Taiwan IC firms reported co-operating 0.6 Japanese supplier firms on average via contract research and licensing.

The inter-firm knowledge links through collaborative research and strategic alliance can be broken down by locations and co-operative strength in details (Table 4.10). In the local strategic alliance links, the 44% of Taiwan IC firms reported co-operating 2.3 local supplier firms on average. Thirty-two percent of Taiwan IC firms reported co-operating 1.65 local customer firms on average. Only 14 % of Taiwan IC firms reported co-operating 0.8 local other firms on average via strategic alliance.

In the national strategic alliance links, the 40% of Taiwan IC firms reported co-operating 2.35 domestic supplier firms on average. Thirty-two percent of Taiwan IC firms reported co-operating 1.65 national customer firms on average. Only 10 % of Taiwan IC firms reported co-operating 0.8 national other firms on average via strategic alliance.

In the strategic alliance links with the US partners, the 30% of Taiwan IC firms reported co-operating 1.5 the US supplier firms on average. Fourteen percent of Taiwan IC firms reported co-operating 0.7 the US customer firms on average. Only 7 % of Taiwan IC firms reported co-operating 0.6 the US other firms on average via strategic alliance.

In the strategic alliance links with Japanese partners, the 21% of Taiwan IC firms reported co-operating 0.9 Japanese supplier firms on average. Ten percent of Taiwan IC firms reported co-operating 1.4 Japanese customer firms on average. Only 3 % of Taiwan IC firms reported co-operating 0.2 Japanese supplier firms on average via strategic alliance.

In the strategic alliance links with partners in the rest of the world, the 17% of Taiwan IC firms reported co-operating 0.9 world supplier firms on average. Ten percent of Taiwan IC firms reported co-operating 0.55 World customer firms on average. Only 3 % of Taiwan IC firms reported co-operating 0.2 world supplier firms on average via strategic alliance.

Table 4.10 Inter-organizational technological links by locations and types of the firms: equity participation, joint venture and M&A (N=57)

Location	Types of firms	Proportion of firms with links	Number of co-operated firms (Mean)	Number of co-operated firms (S. D.)
Local (Within 50 km)	Supplier firms	12%	0.6	1.66
	Customer firms	11%	.55	1.65
	Other firms	7%	.35	1.29
Domestic	Supplier firms	16%	.8	1.84
	Customer firms	10%	.6	1.91
	Other firms	4%	.6	.93
USA	Supplier firms	5%	.25	1.13
	Customer firms	4%	.2	.93
	Other firms	4%	.2	1.86
Japan	Supplier firms	0	0	0
	Customer firms	0	0	0
	Other firms	0	0	0
World	Supplier firms	2%	.1	.66
	Customer firms	2%	.1	.66
	Other firms	2%	.1	.66

The inter-firm knowledge links through Williamson hierarchy forms such as equity participation, joint venture and M&A can be broken down by locations and co-operative strength in details (Table 4.11). In the local hierarchical links, the 12% of Taiwan IC firms reported co-operating 0.6 local supplier firms on average. Eleven percent of Taiwan IC firms reported co-operating 0.55 local customer firms on average. Only 7 % of Taiwan IC firms reported co-operating 0.35 local other firms on average via equity participation, joint venture and M&A.

In the national hierarchical links, the 16% of Taiwan IC firms reported co-operating 0.8 national supplier firms on average. Ten percent of Taiwan IC firms reported co-operating 0.6 national customer firms on average. Only 4 % of Taiwan IC firms reported co-operating 0.6 national other firms on average via equity participation, joint venture and M&A.

In the US hierarchical links, the 5% of Taiwan IC firms reported co-operating 0.25 the US supplier firms on average. Four percent of Taiwan IC firms reported co-operating 0.2 the US customer firms on average. Only 4 % of Taiwan IC firms reported co-operating 0.2 the US other firms on average via equity participation, joint venture and M&A. No firms reported having hierarchical links with any Japanese firms.

In the world hierarchical links, the 2% of Taiwan IC firms reported co-operating 0.1 world supplier firms on average. Two percent of Taiwan IC firms reported co-operating 0.1 world customer firms on average. Finally, 2% of Taiwan IC firms reported co-operating 0.1 world other firms on average via equity participation, joint venture and M&A.

4.7.1 Firm-university and firm-R&D institution knowledge links

The study shows that the most frequent firm-university links that Taiwan IC firms established by locations rank from domestic universities, local universities, the US universities (Figure 4.6). The order of the most frequent firm-R&D institution links of Taiwanese IC firms by location are consistent with that of firm-university links ranking from national, domestic to cross-border links (e.g., the US). It is worth noting that 2% of firms reported having contract research/licensing from world R&D institutions. No knowledge links with Japanese universities, Japanese R&D institutions and other universities in the rest of the world were reported. Contract research and licensing knowledge links are dominant form of link, following co-operative research and/or research consortia, and the least type of link, establishing research centers in the firm-university knowledge links. The research finds that firm- university and firm-R&D institution knowledge links remain confined in local and domestic boundaries rather than cross-border links. Moreover, the Taiwanese IC firms tend to have more national firm-university and firm-R&D institution links than local ones. On contrast to the heavy reliant on university-R&D institutions (e.g., ITRI, Industrial Technology Research Institute) knowledge links in the 1990s, the survey revealed that the changing triple-helix (firm-university-R&D institution) relation was taking place in Taiwanese IC sector during 2000~2002. The IC firms began to establish more formal knowledge links with local and national universities than the links with domestic R&D institutions. However, the firm-science links are still dominant by short-term, arm-length, one-way knowledge transfer such as contract research and licensing rather than long-term and mutual resource commitment such as collaborative research and jointly establishing research centers.

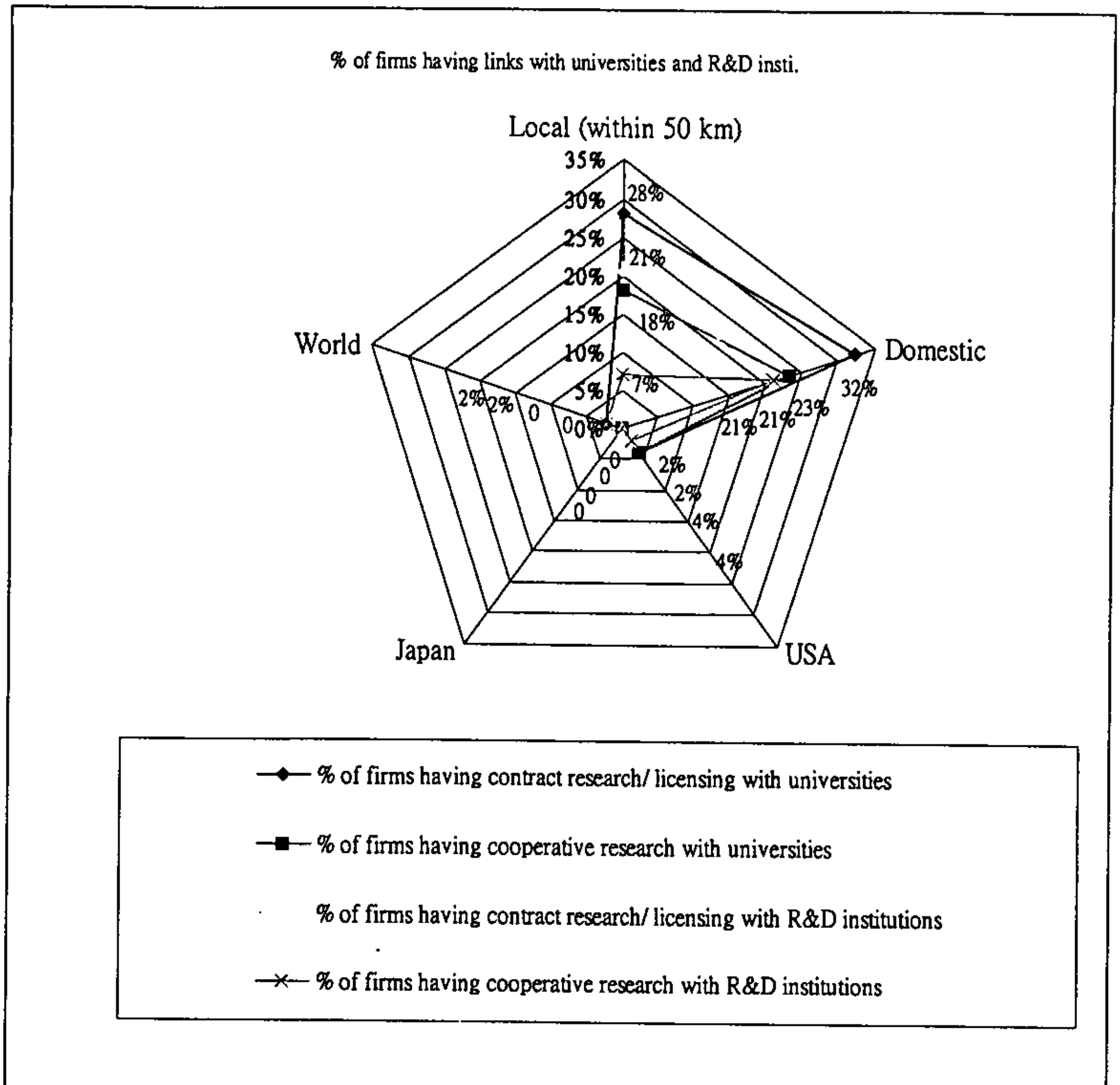


Figure 4.6 Proportion of firms having links with universities and R&D institutions by location and mechanism

The firm-university knowledge links through co-operative mechanisms can be broken down by locations and co-operative strength in details (Table 4.11). In the type of contract research and licensing, the 28% of Taiwan IC firms reported co-operating 0.4 local universities and 0.58 research project on average. Thirty-two percent of the IC firms reported co-operating with .56 national universities and 0.62 research project on average. Only 4 % of the firms reported co-operating with 0.04 the US universities and 0.04 research project on average. Only 2% of the firms reported co-operating with universities in the rest of the world. No firms reported having links with Japanese universities.

Table 4.11 Firm-university links by locations and co-operative mechanism (N=57)

Location	Proportion of firms with links	Number of co-operated universities (Mean)	Number of co-operated projects (Mean)
Contract research/ licensing			
Local (within 50 km)	28%	.4	.58
Domestic	32%	.56	.62
USA	4%	0.04	0.04
Japan	0	0	0
World	2%	0.02	0.02
Cooperative research			
Local (within 50 km)	18%	.21	.25
Domestic	23%	.44	.42
USA	4%	.04	.02
Japan	0	0	0
World	0	0	0
Establishing research center			
Local (within 50 km)	2%	.02	.04
Domestic	0	0	0
USA	0	0	0
Japan	0	0	0
World	0	0	0

In the type of co-operative research, the 18% of Taiwan IC firms reported co-operating 0.21 local universities and 0.25 research project on average. Twenty-three percent of the IC firms reported co-operating with .44 national universities and 0.42 research project on average. Only 4 % of the firms reported co-operating with 0.04 the US universities and 0.02 research project on average. No firms reported having links with Japanese universities and the universities in the west of the world. In the type of establishing research center, only 2% of Taiwan IC firms reported co-operating 0.2 local universities and 0.04 research center on average. No firms reported having links with national, the US, Japanese universities and the universities in the west of the world.

4.7.2 Firm-R&D institution links

The firm-R&D institution knowledge links through co-operative mechanisms can be broken down by locations and co-operative strength in details (Table 4.12). In the type of contract research and licensing, 21% of the firms reported co-operating 0.26 local R&D institutions and 0.35 research project on average. Twenty-one percent of the IC firms reported co-operating with 0.34 national universities and 0.35 research project on average. Only 2 % of the firms reported co-operating with 0.02 the US universities and 0.02 research project on average. No firms reported having links with Japanese R&D institutions and ones in the rest of the world via contract research and licensing.

In the type of co-operative research, the 7% of Taiwan IC firms reported co-operating 0.07 local R&D institutions and 0.07 research project on average. Twenty-one percent of the IC firms reported co-operating with 0.21 national universities and 0.30 research project on average. Only 2 % of the firms reported co-operating with 0.02 the US universities and 0.02 research project on average. No firms reported having links with Japanese R&D institution and the ones in the west of the world. In the type of establishing research center, No firms reported establishing researchers with any geographical R&D institutions.

Table 4.12 Firm-R&D institution links by location and co-operative mechanisms (N=57)

Co-operative mechanism/ location	Proportion of firms with links	Number of co-operated R&D institutions (Mean)	Number of co-operated projects (Mean)
Contract research/ licensing			
Local (within 50 km)	21%	.26	.35
Domestic	21%	.34	.35
USA	2%	.02	.02
Japan	0	0	0
World	0	0	0
Cooperative research			
Local (within 50 km)	7%	.07	.07
Domestic	21%	.21	.30
USA	2%	.02	.02
Japan	0	0	0
World	2%	.02	.02
Establishing research center			
Local (within 50 km)	0	0	0
Domestic	0	0	0
USA	0	0	0
Japan	0	0	0
World	0	0	0

Source: Co-operation for Innovation Survey, CIS (2004)

4.8 Conclusion

The chapter mainly examines the increasing importance of cross-border technological links on the development of Chinese Taipei's PC industry and IC industry. Based on three building blocks of literature review namely: (1) new geography of industrial clusters, (2) the globalization of product innovation and (3) the emerging organizational innovation and innovation networks in the chapter. We proposed a research framework to map cross-border knowledge links in the Chinese Taipei's IC sector. Based a postal questionnaire survey, 57 questionnaires were returned effectively, with an overall response rate, 34%. We synthesize the major results of empirical study as follows:

(1) The most frequent inter-firm knowledge links that Taiwan IC firms established are with supplier firms, following by customer firms and the least links with competitors and other firms (might be in other sectors)

(2) In term of co-operative mechanisms, generally speaking, the most frequently used mechanisms are strategic alliance, following by arm-length contract research and licensing, and the last Williamson's hierarch forms such as equity participation, joint venture and M&A.

(3) In term of geographical partners, the most frequent partners of inter-firm links are local and domestic firms, following the US firms, firms in the rest of the world and the least, Japanese partners.

(4) The most frequent firm-university links that Taiwan IC firms established by locations rank from national universities, local universities, the US universities.

(5) The order of the most frequent firm-R&D institution links of Taiwanese IC firms by location are consistent with that of firm-university links ranking from national, domestic to cross-border links (e.g., the US).

(6) Contract research and licensing knowledge links are dominant form of link, following co-operative research and/or research consortia, and the least type of link, establishing research centers in the firm-university knowledge links.

The research finds that firm- university and firm-R&D institution knowledge links remain confined in local and domestic boundaries rather than cross-border links. Moreover, the Taiwanese IC firms tend to have more national firm-university and firm-R&D institution link than local ones. On contrast to the heavy reliant on university-R&D institutions (e.g., ITRI, Industrial Technology Research Institute) knowledge links in the 1990s, the survey revealed that the changing triple-helix (firm-university-R&D institution) relation was taking place in Taiwanese IC sector during 2000~2002. The IC firms began to establish more formal knowledge links with local and national universities than the links with domestic R&D institutions. However, the firm-science links are still dominant by short-term, arm-length, one-way knowledge transfer such as contract research and licensing rather than long-term and mutual resource commitment such as collaborative research and jointly establishing research centers.

We conclude that the increasing globalization of product innovation will contribute the increase of cross-border knowledge links among industrial clusters such as the US Silicon Valley, Chinese Taipei's Hsinchu and China' Shanghi. However, the informal and tacit nature of knowledge, national systems of innovation will facilitate industrial clusters to establish local/domestic technological links rather than cross-border knowledge links. Only can building appropriate organizational innovation and new partnership among industrial clusters strike a right balance between keeping identify of industrial clusters and active cross-border knowledge links.

Chapter 5 The Movement of High-Tech Manpower between Industrial Clusters in the Silicon Valley, Hsinchu and Shanghai

5.1 Introduction

One of the major characteristics in the formation of industrial clusters is the convergence of the necessary talent, capital, infrastructure and highly complementary factories to form a system of division of labor for industry characterized by mutual dependence between the various factories within the cluster. Since the different factories within the industrial cluster are highly complementary, they can substantially reduce their overall costs, and as they are located in close proximity to one another, their transportation and communication costs are also significantly reduced. The resultant synchronized manufacturing activities that take place between the different factories substantially reduce the need to maintain high inventory levels, which in turn significantly raises their overall level of competitiveness.

Special attention must be paid to fostering close contact between the different factories within the cluster because the closeness of such relationships can ultimately lead to the integration of their particular strengths to develop new technologies, new operational modes, or even new industry-specific niches. Clearly, therefore, industrial clusters also have a vital role to play in technological innovation, whilst their formation is closely related to the gathering of highly educated and talented workers. Experience has shown that universities and large research institutions contribute enormously to the success of industrial clusters, and if we were to liken highly educated and talented workers to the blossoming flowers in the garden, factories could be likened to honey-sipping bees. This form of collaboration in the garden between the flowers and the bees is exemplified in the so-called 'externality' of economics.

When considering the factors contributing to the formation of a cluster, perhaps we should therefore concentrate on how to manage the 'garden' (i.e., the cluster), so that the seeds of the various flowers can germinate, root and blossom. Moreover, we should also consider that the winds will blow the seeds to other places to form new 'gardens' if the soil, air, water and other conditions are good; thus new clusters will form as more bees are attracted there. If the competition between clusters becomes fierce and highly exclusive, the new 'gardens' will flourish even more, and the old 'gardens' will become deserted, as the bees migrate. Certainly, several of these 'gardens' could co-exist if the entire market could continue to grow as the different clusters continued to expand. Under such circumstances, the exclusivity between the clusters would no longer pose a problem. Another possibility is that different flowers will attract different bees because of their diverse characteristics; the result might well be the formation of different types of honey characterized by a variety of tastes and flavors. It is clear, therefore, that the potential formation of industrial clusters with specific regional characteristics should also be taken into consideration.

From the above description, we are provided with a clear indication of the importance of gathering talented individuals, and therefore, also considering the possibility of mobilizing such talent. Given the competitiveness that exists between industrial clusters, it is quite feasible for us to observe one cluster flourishing whilst another withers and dies. The meteoric rise of the Silicon Valley alongside the fall of Boston in Saxenian's (1994) study provides a classic example of such a phenomenon.

In this chapter, we set out to analyze the movement of talent between three industrial clusters, in the Silicon Valley, the Hsinchu Science-Based Industrial

Park in Taiwan, and the major industrial cluster that has taken shape in Shanghai. The significance of our research theme is threefold. First of all, we observe that in the early stages, large numbers of college graduates from Taiwan went to study in the US and stayed there after graduating, thus creating a brain drain. However, since the beginning of the 1980s, as its economy grew rapidly, growing numbers of overseas ethnic Chinese engineers and experts have been returning to Taiwan to help with the setting up and running of the Hsinchu Science-Based Industrial Park; thus, we have witnessed the emergence of a 'reverse brain drain'. Since many of the APEC economies have also faced similar brain drains, we undertake a study which attempts to uncover the factors that brought about the reverse brain drain in Taiwan in the mid-1980s, and the impact that this phenomenon has had on technological innovation. The research results will help us to gain a better understanding of the ways in which industrial clusters such as the Hsinchu Science-Based Industrial Park in Taiwan interact with Silicon Valley and whether the interaction is indeed complementary, as in the abovementioned example of the 'garden'.

Secondly, with the rapid economic expansion of China, a new de facto high-tech industrial cluster has formed in the Yangtze River Delta which has created an influx of high-tech talent from around the world, including Taiwan. As a result, a new wave of the brain drain phenomenon has emerged for Taiwan, which raises the questions of what it is that is attracting these individuals to gather in Shanghai, and what the impacts will be on the management, research and development (R&D), and innovation of Taiwan's enterprises.

Thirdly, this chapter also aims to provide in-depth analyses of the interactions between the three industrial clusters referred to in this introduction. We can provide an illustration of these interactions (see Figure 5.1) which shows that, because Silicon Valley is more technologically advanced than both

Hsinchu and Shanghai, the latter two can play only complementary roles at the present time so as to ensure continued room for growth. Furthermore, in return for Taiwan's supply of capital, technology and talent, Shanghai also provides Taiwan with room for growth and expansion. For this reason, at the moment, the relationship between the two can be considered complementary. Silicon Valley will no doubt continue to retain its complementary role, in relation to both Hsinchu and Shanghai, for the foreseeable future, but whether Hsinchu will remain complementary to Shanghai, or indeed, be replaced by it, remains uncertain.

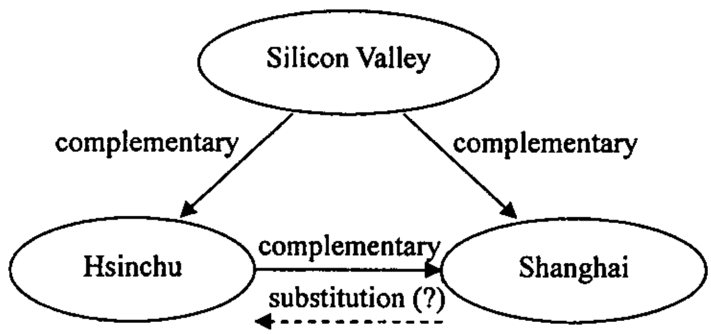


Figure 5.1 Interactions between clusters in the Silicon Valley, Hsinchu and Shanghai

This chapter aims to provide a preliminary analysis of the important questions at hand through an exploration of the mobility of talented individuals, with the results being of potential help to other APEC economies when it comes to developing their own industrial clusters.

5.2 The Reverse Brain Drain in Taiwan

The economic literature on labor migration is quite extensive. Sjaastad (1962) compared human capital investment costs and returns to explain labor migration behavior, arguing that if labor migration is viewed as human capital investment, then the 'investor' would weigh up the return on the 'investment' and the corresponding investment costs when deciding whether or not to emigrate. Investment costs include both pecuniary costs and non-pecuniary costs in Sjaastad's analysis, with pecuniary costs referring to basic living expenses including food, clothing, accommodation, and so on, and non-pecuniary costs referring to the opportunity costs involved in seeking a new job or learning new skills, as well as the psychological costs of having to adjust to a new environment. There is no question that psychological costs are an important factor in determining whether labor migration occurs, and also in the choice of destination. Schwartz (1973) found that the higher the educational level of the migrant, the less the psychological costs increased with an increase in the distance from home; this shows that education level may influence the likelihood of migration.

To move or not to move is certainly a major decision, and it becomes even more complicated when it involves the entire family. Mincer (1978) developed a theoretical model to examine the effects of the situation where one member of a dual-income family is unlikely to be able to find a good job in the target country following the decision to migrate, and even on whether the marriage would be able to survive; he concluded that single people were more likely to migrate than married couples. Where families have to consider their children's education, or have elderly parents to look after, this significantly reduces their probability of migrating. In addition, if the wife has a permanent job, this also significantly reduces the likelihood of the family migrating, whereas the likelihood of migration is higher if the family's income is derived mainly from the husband who has higher educational qualifications than the wife.

Chen and Su (1995) provided a further study on the subject using data on Taiwanese students studying in Japan under scholarships awarded by the Yoneyama Rotary Club during the period 1962-1988. They analyzed why these students were not returning to Taiwan after graduation – and thus adding to the brain drain phenomenon – and found that the main reason was the social stock of capital they had accumulated during on-the-job training in Japan following their graduation, which would have represented a major loss, in terms of opportunity costs, if they had returned to Taiwan. Clearly, however, as the students tended to remain in Japan, the longer they remained there, the greater this capital stock became, and hence the greater the unlikelihood of them wishing to return to Taiwan.

Ministry of Education statistics do, however, show that the number of students returning to Taiwan after overseas study has increased gradually since the 1980s, exceeding 1,000 for the first time in 1981, and rising to over 6,000 a year by the mid-1990s. These statistics are summarized, over five-year periods, in Table 5.1.

Table 5.1 Students returning to Taiwan from overseas study

Year	1975	1980	1985	1990	1995
No. of Returning Students	569	640	1,583	2,863	6,272

Source: Ministry of Education (1998), ROC Educational Statistics, Taiwan.

The Ministry of Education statistics show that of the total of 6,272 students returning to Taiwan in 1995, 5,262 had returned from the US, 645 from Europe, and 244 from Japan. As regards the fields of study, those who majored in the sciences were the largest group, accounting for 2,639, followed by engineering students (1,291), and natural science students (410). Furthermore, 5,247 had obtained Masters degrees, and 1,010 had each obtained a Ph.D. It is thus clear that the quality of the students returning to Taiwan is very high.

In order to gain a better understanding of the motivation behind students' decisions to return to Taiwan and the main factors taken into consideration, as well as to examine what factors hinder the return decision, 1991 and 1994 data on returning students, prepared by the Youth Council at the Executive Yuan, is used as the population for our survey. A random sample of 500 names was taken from the population of each of these two years, giving a total of 1,000, on whom questionnaire surveys were conducted. In order to increase the comparability of the survey, an additional survey was conducted on members of an alumni association of a US Ivy League university in Taiwan, for which 345 questionnaires were dispatched. Thus a total of 1,345 questionnaires were sent out.[16] After deducting those which were undeliverable, there were 1,316 effective questionnaires, of which 462 were returned, giving a response rate of 35.11 per cent. Table 5.2 contains the detailed response statistics.

Table 5.2 Overseas scholars and specialists (OSS) questionnaire return status

Population	Sample Size	Sample size (after exclusion of undelivered questionnaires)	Number of questionnaires returned	Response rate (%)
1991 & 1994 Youth Council samples	1,000	975	317	32.51
Ivy League University Samples	345	341	145	42.25
Total	1,345	1,316	462	35.11

Source: Collated from the survey questionnaires

5.2.1 Factors Motivating or Discouraging Return Home by Overseas Scholars and Specialists

The discussion above has shown that overseas scholars and specialists (OSSs hereafter) have to deal with a considerable number of family-related factors when considering the decision of whether or not to return home, and these family considerations often constitute both encouraging and discouraging factors. The results of our survey in which we explore these dual 'hindering' and 'encouraging' forces are summarized in Tables 5.3 and 5.4.

Table 5.3 presents a summary of the factors which OSSs felt most discouraged them from returning home. In collating the respondents' answers, the most significant, second most significant and third most significant factors

16 Special attention is paid to the two samples in order to ensure that there is no duplication between them.

discouraging them from returning have been given weightings of 3 points, 2 points and 1 point, respectively; these are used to calculate a weighted sum. The table also contains data for a sub-category of 'skilled specialists,' which includes those members of the returning OSS sample who had either (i) obtained a Masters degree and accumulated three years work experience while abroad, or (ii) obtained a Ph.D. degree while abroad; this enables us to contrast this group with the rest of the OSSs holding Masters degrees.

Table 5.3 Level of importance of factors discouraging OSSs from returning home

Discouraging Factors	Youth Council Sample [a] Whole Sample	Youth Council Sample [a] Skilled [c] Specialists	Ivy League Sample [b] Whole Sample	Ivy League Sample [b] Skilled [c] Specialists
The loss that would result from selling off overseas property	18 (8)[d]	6 (7)	11 (8)	8 (8)
The requirement to quit current job overseas	70 (6)	21 (6)	68 (5)	50 (4)
Creation of uncertainty in career planning	229 (3)	48 (3)	72 (4)	49 (5)
Decline in quality of life after returning to Taiwan	600 (1)	134 (1)	212 (1)	154 (1)
Problems with children's education	86 (4)	42 (4)	75 (3)	56 (3)
Concerns over the political and social situation in Taiwan	344 (2)	77 (2)	121 (2)	81 (2)
Opposition from spouse or other family member	71 (5)	27 (5)	60 (6)	46 (6)
Other factors	50 (7)	4 (8)	12 (7)	11 (7)

Notes:

[a] The Youth Council sample includes 317 OSSs, 70 of whom fall into the category of skilled specialists.
[b] The Ivy League university sample includes 145 OSSs, 108 of whom fall into the category of skilled specialists.
[c] The 'skilled specialists' sub-sample includes OSS who either obtained a Masters degree and, either obtained a Ph.D. degree or acquired at least three years' work experience whilst abroad.
[d] Figures in brackets are ranking order.

Source: Compiled for this study.

The weighted statistics in Table 5.3 demonstrate that for both the Youth Council sample and the Ivy League sample, the main factors hindering OSSs from returning to Taiwan were 'the decline in quality of life after return to Taiwan,' and 'concerns over the political and social situation in Taiwan'. The third most significant factor was the 'creation of uncertainty in career planning' for the Youth Council sample, and 'problems with children's education' for the Ivy League sample. In addition to these factors, other factors such as 'having to quit current job overseas,' 'opposition from spouse or other family member' and 'the loss that would result from selling off overseas property' were also mentioned, but were less significant.

As discussed earlier, the factors affecting migration can be put into four categories, namely, environmental, psychological, family ties and pecuniary factors. Amongst the factors noted in Table 5.3, quality of life, political and social stability and children's education all come under the category of environmental factors. Of these, quality of life appears to be the most significant, thus, this is an area in need of greater emphasis in the formation of government policy.

Regarding psychological factors, this study shows that the 'creation of uncertainty in career planning' is a significant factor influencing OSSs' decision on whether or not to return home; this factor was particularly significant in the Youth Council sample, where skilled specialists were excluded. Table 5.3 also shows that factors relating to family ties are not particularly significant. This may be related to fact that the members of both the Youth Council and Ivy League samples are mainly either single, young, or both (the average age being around 32).

As far as pecuniary costs are concerned, the table shows that this is not ranked as particularly significant in either the Youth Council or Ivy League sample; the survey results clearly show that pecuniary costs are only a secondary consideration, in stark contrast to the findings of the Chen and Su (1995) study, where it was suggested that the social stock of capital which students studying overseas accumulated during on-the-job training in their country of residence constituted an important factor discouraging them from returning home. In light of their argument, one would expect that 'having to quit current job overseas' would be ranked as the most significant factor discouraging OSSs from returning home, but in fact this is not the case, particularly amongst the skilled specialists group. There is therefore significant disparity between the results obtained from the Chen and Su (1995) study in

Japan, and the results obtained in this study from the Youth Council and Ivy League samples.

This study also attempts to determine the most important factors motivating the return home, or the 'encouraging' forces. Here again, the most significant, second most significant and third most significant factors are given a weighting of 3 points, 2 points and 1 point, respectively, and the measures are used to calculate a weighted sum. The statistical results are summarized in Table 5.4, which shows that, in terms of the level of importance for returning, the rankings for the entire Youth Council sample were as follows:

Ranking in first place, the most significant factor was 'the ability to spend more time with friends and relatives'; whilst 'identify strongly with and feel more at home in Taiwan' and 'good job opportunities waiting at home' ranked in second and third place, respectively. Within the skilled specialists sub-sample, 'identify strongly with and feel more at home in Taiwan' and 'the ability to spend more time with friends and relatives' ranked first and second, respectively, followed by the 'desire to use newly acquired skills to help the nation' in third place; 'good job opportunities waiting at home' and 'better job opportunities and promotion opportunities than overseas' ranked fourth and fifth place, respectively, whilst 'more used to the customs and culture back home' ranked last.

The rankings for the entire Ivy League sample are as follows: 'the ability to spend more time with friends and relatives,' 'identify strongly with and feel more at home in Taiwan' and the 'desire to use newly acquired skills to help the nation' are ranked in first, second and third place, respectively, with a marginal difference in the weighted sum. Within the skilled specialists sample, the 'desire to use newly acquired skills to help the nation' and 'identify strongly with and feel more at home in Taiwan' were ranked in first and second place, with 'the ability to spend more time with friends and relatives' ranking in third place.

Table 5.4 Level of importance of factors motivating OSSs to return home

Motivating Factors	Youth Council Sample [a] Whole Sample	Youth Council Sample [a] Skilled [c] Specialists	Ivy League Sample [b] Whole Sample	Ivy League Sample [b] Skilled [c] Specialists
Good job opportunities waiting at home	115 (5)	43 (4)	135 (4)	106 (4)
Better job and promotion opportunities than overseas	259 (3)	39 (5)	82 (5)	47 (5)
The ability to spend more time with friends and relatives	507 (1)	99 (2)	164 (1)	112 (3)
More used to the customs and culture back home	87 (7)	15 (7)	46 (7)	35 (7)
Identify strongly with, and feel more at home in Taiwan	398 (2)	101 (1)	162 (2)	129 (2)
Desire to use newly acquired skills to help the nation	243 (4)	74 (3)	160 (3)	130 (1)
Other factors	99 (6)	28 (6)	66 (6)	41 (6)

Notes:

[a] *The Youth Council sample includes 317 OSSs, 70 of whom fall into the category of skilled specialists.*

[b] *The Ivy League university sample includes 145 OSSs, 108 of whom fall into the category of skilled specialists.*

[c] *The 'skilled specialists' sub-sample includes OSS who either obtained a Masters degree and, either obtained a Ph.D. degree or acquired at least three years' work experience whilst abroad.*

[d] *Figures in brackets are ranking order.*

Source: Compiled for this study.

If we classify the various factors motivating OSSs to return home into psychological and economic factors, we can see from the statistics in Table 5.4 that the two motivating factors ranking first and second come under the category of psychological factors, with economic factors ranking lower. This shows that in most cases, the main reasons behind OSSs' willingness to give up their jobs with high salaries and return home are psychological factors, for example, emotional ties to their native land or their relatives and friends. These psychological motivating factors are strong enough to offset the reduction in salary that OSSs suffer on returning home.

5.2.2 The Willingness of OSSs to Return Home and the Resultant Salary Disparity

The survey results of this study show that 25.9 per cent of the Youth Council sample and 44.1 per cent of the Ivy League sample of OSSs had worked abroad before returning to Taiwan. The survey results show that 69.2

per cent of this particular category of OSSs – those with overseas job experience – stated that their salary whilst working overseas was higher than that in their first job on returning to Taiwan, and on average, the overseas salary was 77.8 per cent higher than the domestic salary. Approximately 19.2 per cent of the survey respondents stated that their domestic and overseas salaries were roughly the same. These statistics indicate that overseas salaries are significantly higher than those in Taiwan and that as a result, returning home to Taiwan does mean moving from a higher salary region to a lower salary region, and represents a significant difference of opinion from the literature discussed above.

A possible explanation for this disparity may be found in Table 5.4. Amongst the factors motivating OSSs to return home, 'identify strongly with and feel more at home in Taiwan' and the 'desire to use newly acquired skills to help the nation' are the two most important factors within the Ivy League skilled specialist samples. These two factors represent the respondents' identification with, and their love for, Taiwan. Taking the view that the question of whether the degree of love for Taiwan can explain their willingness to accept a reduction in salary, the following empirical model is utilized to explore this argument:

$$\begin{aligned} WAGE = a0 + a1AGE + a2SEX + a3ED + \\ a4MARRIED + a5TIME + a6BELONG + a7CONTRIB + \varepsilon \end{aligned} \tag{1}$$

In the above model, the dependent variable WAGE represents the disparity in salary, for those within the sample with overseas work experience, between the last overseas full-time job and the first full-time job in Taiwan after returning home. This is given in terms of how much greater or smaller the overseas salary is, in percentage terms, which takes a positive value if the overseas salary was higher, and a negative value if lower. The definitions of the explanatory variables in the model are provided in Table 5.5.

Table 5.5 Definition of explanatory variables

Explanatory Variable	Definition
AGE	Age of the returning OSS at the date of return
SEX	male = 1; female = 0
ED	level of education: = 16 for university and college graduates; = 18 for holders of Masters degrees; = 22 for Ph.D holders
MARRIED	the marital status of the OSS at the date of return: = 1 for married; = 0 for single
TIME	the length of time, in years, spent abroad by the OSS
BELONG	= 3 for those who rate 'identify strongly with and feel more at home in Taiwan' as the major motivating factor for returning home; = 2 for those who rank it as the second most important factor; = 1 for those who rank it as the third most important factor; otherwise = 0
CONTRIB	= 3 for those who rate 'desire to use newly acquired skills to help the nation' as the major motivating factor for returning home; = 2 for those who rank it as the second most important factor; = 1 for those who rank it as the third most important factor; otherwise = 0

Amongst the variables explained above, we consider that the SEX variable might have a positive effect on WAGE. This is because males in the professional field tend to have higher salary levels; hence the wage disparity is likely to be greater. It was also anticipated that a positive relationship would be evident in the level of education and the length of time spent overseas, since the higher a person's level of education, or the longer the period of time spent overseas, the higher their overseas salary would tend to be. In the Chen and Su (1995) study, these salary considerations are regarded as an increase in 'capital stock' in the country of residence. Under these circumstances, the disparity between overseas salary and domestic salary would tend to increase.

As for BELONG and CONTRIB, we consider that the more an OSS was influenced to return to Taiwan by his or her identification with Taiwan, or by a desire to contribute to Taiwan's development, the less concerned they would be about any disparity in the salary level between the country they had been living in and the salary level in their homeland. It is therefore hypothesized that there may be a positive relationship between these two variables and the WAGE variable. Our empirical results are shown in Table 5.6, which shows that the

AGE variable is not at all significant in this model, suggesting that the age factor has no part in explaining the willingness of returning OSSs to give up their high-paying jobs overseas. As far as the SEX variable is concerned, within the Youth Council skilled specialists' sub-sample, the disparity between overseas and domestic salaries was higher amongst skilled male specialists.

As for the level of education of the returning OSSs, the higher the level – i.e., the more likely they were to have obtained a Ph.D. – the smaller the disparity in salary they had to face. The relationship between the variable ED and WAGE in Table 5.6 is both negative and highly significant for both the Youth Council and Ivy League samples, a result which was in line with our expectations. A possible explanation for this is the fact that the improvement in faculty salaries in universities and colleges in Taiwan in recent years has reduced the disparity between Taiwan and the US, which has thus helped to attract OSSs to return. There is, however, no evidence in Table 5.6 to support the argument that the disparity between domestic and overseas salaries is affected by marital status, a result which differs markedly from the findings of Minon (1978). As for the length of time spent overseas (TIME), this is also consistent with our expectations, showing a significant and positive relationship with the disparity between overseas and domestic salaries; the result is also consistent with the Chen and Su (1995) study.

Table 5.6 OLS results (absolute t statistics) on the determination of wage disparity

Explanatory Variable	Youth Council Sample: Whole Sample	Youth Council Sample: Skilled Specialists [a]	Ivy League Sample: Whole Sample	Ivy League Sample: Skilled Specialists [a]
Constant	45.0874	184.2745	48.2213	447.8698
	(1.424)	(3.163)*** [b]	(0.490)	(2.371)**
AGE	0.8270	-0.7577	1.2032	1.8101
	(1.335)	(-0.855)	(1.323)	(1.390)
SEX	-0.7547	20.0343	5.4295	-0.6611
	(-0.167)	(2.199)**	(0.288)	(-0.026)
ED	-3.8406	-8.2109	-5.6880	-24.8032
	(-2.399)**	(-3.372)***	(-1.339)	(-2.863)***
MARRIED	2.4563	5.2377	-3.9324	6.4217
	(0.463)	(0.648)	(-0.229)	(0.277)
TIME	3.4970	3.4111	6.6827	4.6913
	(3.309)***	(2.356)**	(4.023)***	(2.149)**
BELONG	-2.5954	-4.5873	11.5150	10.1096
	(-1.375)	(-1.1318)	(1.677)	(1.153)
CONTRIB	1.1348	1.0034	3.8166	7.7130
	(0.592)	(0.326)	(0.537)	(0.853)
N	82	25	64	47
Adjusted R^2	0.0572	0.2928	0.1395	0.1657

Notes:

[a] *The 'skilled specialists' sub-sample includes OSS who either obtained a Masters degree and, either obtained a Ph.D. degree or acquired at least three years' work experience whilst abroad.*

[b] ** represents significance at the 0.1 per cent level or less; ** represents significance at the 0.05 per cent level or less; *** represents significance at the 0.01 per cent level or less.*

Source: Compiled for this study.

Finally, as regards the subjective sense of belonging and sense of mission, there is no empirical evidence to support any significant relationship between CONTRIB and WAGE. However, within the entire Ivy League sample, it is evident that the BELONG variable may be a factor in encouraging OSSs to give up their well-paid jobs overseas to return home. The existence of a positive relationship between BELONG and WAGE suggests that the stronger the sense of identification, the greater the willingness to give up a high salary overseas and return home. Furthermore, in the Ivy League Sample model, the regression coefficient for the BELONG variable is 11.515, suggesting that, all other things being equal, when an OSSs' level of identification increase by one unit, they will be willing to return home and accept a wage cut of 11.5 per cent. Consequently, for those returning OSSs who consider BELONG to be the most important factor in their decision to return home, our results indicate that they are prepared to accept a wage cut of as much as 34.5 per cent of their overseas salary.

5.3 The Impact of OSSs on Technology Formation in Taiwanese Firms

5.3.1 The Case of Firms in the Hsinchu Science-based Industrial Park

Along with their own level of willingness to return, another important factor influencing OSSs' decisions to return to Taiwan will clearly be the availability of suitable job opportunities at home. A demand side analysis is thus of equal importance. As such, we now examine why firms in Taiwan are interested in employing OSSs, and whether there exists any strong demand for such people. In addition, the question of what kind of contribution these returning OSSs are able to make to firms in Taiwan is also examined. For this purpose, a questionnaire survey was conducted amongst firms in the Hsinchu Science-based Industrial Park.

There were two reasons for choosing the park. Firstly, the number of firms within the park is more or less fixed, making it possible to conduct a survey which represents more a census than a sampling exercise. Secondly, all of the firms located in the park are hi-tech firms, which are more likely to employ the returning OSSs. To put it another way, if OSSs really are important to Taiwanese firms, they should be particularly so for the sort of firms that are located in the park. If the survey results were to show that returning OSSs do not make any significant contribution to improving the technological capability of firms within the park, then it is even less likely that they will be able to make any such contribution to firms in general.

5.3.2 Survey Methodology

A questionnaire survey of 147 firms located within the Hsinchu Science-based Industrial Park was undertaken, and after two reply promptings, a total of 68 questionnaires were returned, representing a response rate of 46.3 per cent. The response rate was highest for integrated circuit manufacturers (65 per cent), followed by communications equipment manufacturers (46.15 per cent), auto-electronics manufacturers (47.37 per cent), biotechnology companies (44.44 per cent) and computer peripherals manufacturers; the lowest response rate was found amongst precision machinery manufacturers (21.43 per cent). The questionnaire return statistics are summarized in Table 5.7.

Table 5.7 Questionnaires returned by manufacturers in the Hsinchu science-based industrial park

Industry	Total Population	No. of Questionnaires Returned	Response Rate (%)	No. of Companies as Proportion of Total Population (%)	Proportion of Questionnaires Returned (%)	Z Value
Computer Peripherals	39	14	35.90	26.53	20.59	-1.11
Integrated Circuits	40	26	65.00	27.21	38.24	2.04*
Communications Equipment	26	12	46.15	17.69	17.65	-0.01
Auto-electronics	19	9	47.37	12.93	13.24	0.07
Precision Machinery	14	3	21.43	9.52	4.41	-1.44
Biotechnology	9	4	44.44	6.12	5.89	-0.08
Totals	147	68	46.23	100.00	100.00	

*Note: * indicates significance at the 0.05 level or less.*
Source: Compiled for this study.

For the appraisal of distribution within the sample and in the overall population for each industry, the population proportion method is used, employing the formula:

$$= \frac{P - P_0}{\sqrt{\frac{P_0(1-P_0)}{n}}}$$

where P is the proportion of the sample, P0 is the proportion of the overall population, and n is the number of the total population. As can be seen from the

Z values in Table 5.7, integrated circuit manufacturers account for a significantly higher proportion of the sample than of the population as a whole; for other industries, there is no significant difference between their proportional share of the sample and their share of the population as a whole.

5.3.3 The Contribution of OSSs to Technology Formation

Another key concern of this study is the question of whether OSSs contribute to the formation of technology for their employers. As part of the study, eight of the most common channels for the introduction of new technology were selected, with the firms being asked to tick the boxes as either 'Very Important,' 'Important,' or 'Secondary Importance'. The resultant selections were then given respective weightings of 3 points, 2 points and 1 point. The results are provided in Table 5.8.

Table 5.8 Main sources of technology for firms, and their level of importance a

Source of Technology	Very Important	Important	Secondary Importance	Weighted Index	Ranking
Developed independently	33	22	4	147	1
Brought back by OSSs	13	7	1	54	2
Collaboration with overseas manufacturers/laboratories	3	8	10	53	3
Provided by overseas parent company	13	2	0	43	4
Provided by domestic R&D institution	3	9	9	36	5
Imitation of similar foreign product	3	4	7	24	6
Collaborative research with overseas university	0	6	5	17	7
Provided by overseas customer (OEM)	1	2	4	11	8
Totals [b]	75	60	40		

Notes:

[a] *The manufacturers' rating of the importance of each source of technology are weighted as follows: 'Very Important' – 3 points; 'Important' – 2 points; and 'Secondary Importance' – 1 point.*

[b] *Effective No. of surveyed firms = 68; however, the totals for each level of importance differ from the total number of surveyed firms because when filling out the form, for any given level of importance, firms could tick more than one box, or no boxes at all. For example, a manufacturer may have felt that they had more than one 'Very Important' channel of access, and therefore will have ticked two or more boxes, or they may have felt that they had no channels of access of 'Secondary Importance,' and will therefore have ticked no boxes for that level.*

Source: Compiled for this study.

It can be clearly seen from Table 5.8 that independent R&D work by firms is their most important means of acquiring new technology, whilst technology brought back by returning OSSs ranks in second place. A related channel is collaboration with overseas manufacturers or laboratories. By contrast, technology provided by foreign customers through original equipment manufacturing (OEM) was rated as the least important source of new technology. The reason that OSSs were rated as the second most important channel for the acquisition of new technology may relate to the type of work that they perform. The survey conducted as part of this study shows that of all OSSs employed in the park, 56 per cent were involved in new product design or in the improvement of production processes, whilst a further 33 per cent held senior managerial positions. It is thus self evident that OSSs are not only assisting in firms' own R&D work, but that they can also help them to acquire technology from abroad; their importance should not therefore be underestimated.

In order to gain a more precise grasp of the mechanisms by which OSSs contribute to technology formation in firms, in this survey, seven possible mechanisms were listed whereby OSSs may provide some contribution to technology formation, with the respondents being asked to tick the mechanisms through which they felt OSSs played an important role. The results are shown in Table 5.9.

Table 5.9 Assessment by firms of the contribution of OSSs to technology formation

Contribution by OSSs to Technology Formation	No. of Firms	No. of Firms as % of Effective Sample	Ranking
1 OSSs have strong R&D capabilities themselves, and are also able to provide guidance for other employees in R&D work	50	86.21	1
2 The leadership and coordination provided by OSSs helps make projects successful	29	50.00	2
3 OSSs are able to use their overseas contacts to establish channels for technology exchange with foreign companies	22	37.93	3
4 OSSs can help solve R&D problems through their contacts with overseas experts	21	36.21	4
5 OSSs can help arrange exchanges between domestic technical personnel and overseas experts	18	31.03	5
6 OSSs know which overseas laboratories are able to help the company with its R&D work	14	24.14	6
7 OSSs can make use of their contacts overseas to help the company arrange overseas financing	1	1.72	7

Note: Effective No. of surveyed firms = 58.
Source: Compiled for this study.

As Table 5.9 shows, the greatest contribution by OSSs was 'OSSs have strong R&D capability themselves, and are also able to provide guidance for other employees in R&D work' (86.21 per cent), followed by 'the leadership and coordination provided by OSSs helps make projects successful' (50.00 per cent). The totals for 'OSSs are able to use their overseas contacts to establish channels for technology exchange with foreign companies,' 'OSSs can help solve R&D problems through their contacts with overseas experts,' 'OSSs can help arrange exchanges between domestic technical personnel and overseas experts' and 'OSSs know which overseas laboratories can help the company with its R&D work' were also all quite high. The lowest rated type of contribution was 'OSSs can make use of their contacts overseas to help the company arrange overseas financing' (1.72 per cent).

It may be helpful to undertake a comparison of the results provided in Tables 5.8 and 5.9. Table 5.8 shows that manufacturers feel that their own independent R&D work is the most important channel for obtaining technology; this fits in with the rankings in Table 5.9, where returning OSSs' abilities to conduct R&D work themselves, and also to direct R&D work, are rated as their two most significant contributions. The third ranking category in Table 5.8 is 'collaboration with overseas manufacturers or laboratories'; this can also be linked to the third, fourth, fifth and sixth ranking types of contribution in Table 5.9, that is, 'OSSs are able to use their overseas contacts to establish channels for technology exchange with foreign companies,' 'OSSs can help solve R&D problems through their contacts with overseas experts,' 'OSSs can help arrange exchanges between domestic technical personnel and overseas experts' and 'OSSs know which overseas laboratories can help the company with its R&D work'. Clearly, as far as the R&D work of firms located in the Hsinchu Science-based Industrial Park is concerned, OSSs do make an extremely valuable contribution to the establishment of overseas technology and information networks.

5.3.4 The Relationship between OSSs and R&D Expenditure

In the analysis undertaken earlier in this study, it was shown that the higher the level of technology intensity, market competition and R&D expenditure, the more likely it was that a company would employ OSSs. In order to explore more closely the relationship between OSSs and companies' R&D work, the following empirical model for R&D was established:

$$RD = a0 + a1SALE + a2AGE + a3FOR + a4CPT1 + a5CPT2 + a6TECR + a7OSSN + \varepsilon \quad (2)$$

The dependent variable RD in Equation (2) is the firm's expenditure on R&D in 1993, given in units of NT$1,000. The related explanatory variables are as follows. SALE: this is the firm's annual sales in 1993, given in units of NT$10,000; AGE: represents the number of years that the firm has been in existence; FOR: represents the percentage of the firm's equity held by foreign shareholders; CPT1: represents the level of competitiveness encountered by the firm in the domestic market, ranging from 1 (very low) to 5 (very high); CPT2: represents the level of competitiveness encountered by the firm in the overseas markets, ranging from 1 (very low) to 5 (very high); TECR: represents the percentage of the firm's total workforce accounted for by engineers and technicians; OSSN: represents the number of OSSs employed at that company.

Of the explanatory variables above, in this study it was assumed that the correlation between SALE and RD would be positive. This assumption is based on the theory put forward by Schumpeter (1950) which argued that the larger a company is, the more it will invest in R&D, and this is primarily a result of the need for economies of scale, although it also reflects the company's desire to maintain its monopolistic market power. As far as the AGE variable is concerned, since the longer a company has been established the more experience it will have accumulated, it should be easier for the company to undertake R&D; the relationship between AGE and RD could therefore be hypothesized as a positive one.

Nevertheless, Siddharthan (1992) held that the longer a company had been established, the more likely it would be that the organization would have become fossilized, which would clearly be an obstacle to the implementation of R&D work. Since the disparity between these two views is so great, in this study, no assumption is made with regard to AGE. As regards the effects of the proportion of a company's equity in R&D held by foreign shareholders, there is also considerable disagreement in the literature. Baranson (1966) and Komoda (1986) both suggested that although foreign investment tends to make it easier for companies to obtain technology from overseas, it also reduces the incentives for manufacturers to carry out their own R&D. In their view, there is a negative correlation between FOR and RD. By contrast, Siddharthan (1992) suggested that technology introduced from abroad might not be completely suited to the local environment, thus making it necessary to carry out appropriate adjustments or modifications, and that this inevitably provides a stimulus for domestic manufacturers to undertake more R&D work themselves. Again, given the lack of uniformity in the literature, no assumptions are made for this variable.

As far as the levels of domestic and overseas market competition (variables CPT1 and CPT2) are concerned, in this study it is assumed that the higher the level of competition a company encounters in the market, the more likely the company is to increase its expenditure on R&D in order to avoid being overtaken by its competitors. It is therefore assumed that the relationship between CPT1, CPT2 and RD will be positive. Furthermore, an increase in a firm's technological intensity, represented by the variable TECR, will induce a firm to undertake greater R&D efforts; we assume, therefore, that the relationship between TECR and RD will be positive. Finally, as regards the number of OSSs employed by the company (OSSN), as shown earlier in this study, OSSs do in fact play an important role in firms' own R&D and in their collaboration with overseas firms and laboratories; it is therefore hypothesized that the relationship between OSSN and RD will be positive.

The empirical results using Equation (2) are presented in Table 5.10, which shows that in both models 1 and 2, the economies of scale represented by annual sales have a positive and significant impact on RD, thus supporting the Schumpeter theory. In addition, the longer a firm has been in existence, the greater the amount it is likely to spend on R&D. The table does not show any significant relationship between the proportions of equity accounted for by foreign shareholders and R&D; however, it does show that when a firm is faced with a high level of competition in the domestic market (i.e. when CPT1 is high), it will tend to spend more on R&D; this result is apparent in all three of the models, and with a high degree of uniformity. By contrast, where firms face a higher degree of competition in the overseas markets (i.e. when CPT2 is high), there is no evidence of this having any impact on RD. This may be due to the high level of correlation between CPT1 and CPT2.

Table 5.10 OLS results (absolute t statistics) of factors involved in firms' R&D expenditure decisions

Explanatory Variable	1	2	3
CONSTANT	-2.4147e8 (3.189)***	-2.5148e8 (3.301)***	-1.4339e8 (2.411)**
SIZE	1.8477e2 (1.732)*	3.1412e2 (4.994)***	1.7112e2 (1.568)
AGE	8.0975e6 (1.811)*	8.3983e6 (1.862)*	5.0295e6 (1.167)
FOR	-2.4369e5 (0.520)	-3.0351e5 (0.643)	-2.9061e5 (0.606)
CPT1	3.4904e7 (2.805)***	3.3676e7 (2.685)**	3.5102e7 (2.752)**
CPT2	1.3546e7 (1.005)	1.6823e7 (1.252)	7.6627e7 (0.568)
TECR	1.4388e6 (2.016)**	1.6307e6 (2.299)**	–
OSSN	1.8557e6 (1.495)	–	2.3059e6 (1.842)*
N	68	68	68
Adjusted R^2	0.4497	0.4386	0.4221

*Note: * indicates significance at the 0.1 per cent level or less; ** indicates significance at the 0.05 per cent level or less; *** indicates significance at the 0.01 per cent level or less.*

This study also shows once again that the higher the level of a firm's technology intensity (the TECR variable), the greater the amount the firm is likely to spend on R&D. This can be seen from the fact that the TECR variable is highly significant in both models 1 and 2 in Table 5.10. Finally, regarding the number of OSSs employed, we show that the OSSN variable is also positive and significant in model 3, which demonstrates that employing OSSs does indeed encourage firms to increase their R&D expenditure.

Whilst the employment of OSSs would seem to encourage firms to increase their R&D efforts, one also has to consider the question of whether it might enable firms to save money on R&D. To put this in more concrete terms, where OSSs already have extensive experience in R&D work, their presence in a firm can help the firm to avoid considerable amounts of unnecessary duplication of effort, and can also help to avoid a lot of unnecessary mistakes caused by inexperience, thereby reducing the amount of time and money spent on R&D. In addition, if OSSs can be used to conduct personnel training so as to speed up the diffusion of technology, they will also be able to help substantially upgrade the company's overall technological capabilities; this would of course be a considerable help to firms, particularly in terms of cost saving.

What is clear from this analysis, therefore, is that the employment of OSSs not only encourages firms to spend more on R&D, but at the same time, if the presence of OSSs within the firm can help to avoid unnecessary waste and errors in R&D work, thereby enabling the firm to save on R&D expenditure, then the employment of OSSs can also make a major contribution towards improving the quality and the efficiency of a firm's R&D efforts. In order to further confirm this hypothesis, the companies surveyed were asked whether employing OSSs as a means of directly obtaining foreign technology could also help a company to significantly reduce its R&D costs. The questionnaire survey results show that 22 per cent of companies felt that employing OSSs was very likely to be helpful in this area, 42 per cent felt that it might be helpful, 34 per cent felt that the likelihood of it being helpful was small, and 2 per cent felt that it would not be helpful at all. This indicates that roughly two-thirds of the manufacturers surveyed agreed that there was a possibility that OSSs could bring back technology directly from abroad, and that this could help a firm to save on its own R&D expenditure. The following empirical model has been established to examine this question:

$$SAVE = a0 + a1AGE + a2FOR + a3SALE + a4RD + a5TECR + a6TRAIN + a7SOURCE + \varepsilon \quad (3)$$

In this model, the dependent variable SAVE is set according to the question which was posed to the surveyed firms 'can OSSs bring back technology which can help a company to save on R&D costs?'. Where it was felt that there was a strong possibility of this, 3 points were assigned; where the answer was that there was a reasonable likelihood of this, 2 points were assigned; where it was felt that the likelihood was small, 1 point was assigned. No points were assigned where it was considered that there was no possibility of this at all. The relevant explanatory variables are defined as in Equation (2) above, with the exception of two new variables, which are (i) the dummy variable TRAIN: if a company stated that they employed OSSs to conduct personnel training, then the variable TRAIN is set at 1; otherwise it is set at 0. If the estimated value for TRAIN in Equation (3) is positive and significant, this indicates that the company is able to reduce its R&D costs through the training provided by OSSs; (ii) the dummy variable SOURCE: if a company stated that OSSs were a 'Very Important' or 'Important' source of technology, this variable is set at 1, otherwise it is set at 0. Where this variable is significant and positive, this indicates that the company views OSSs as an important source of technology, and also that this source of technology could help the company to reduce its expenditure on R&D.

A Tobit model is employed for the empirical estimation of Equation (3) since the dependent variable can only be equal to or higher than zero, and cannot be of a negative value. The results are shown in Table 5.11, which shows that of all the explanatory variables, FOR and TRAIN are the most significant, indicating that both foreign investment and training seminars provided by OSS experts can effectively reduce firms' R&D expenditure levels.

Table 5.11 Tobit Model (absolute t-statistics) of factors leading to reduced R&D expenditure

Explanatory Variable	1
Constant	1.5893 (5.232)***
AGE	-0.0056 (0.208)
FOR	0.0068 (2.545)**
SALE	-0.1012e-6 (0.242)
RD	-0.2554e-5 (0.386)
TECR	-0.0013 (0.320)
TRAIN	0.8115 (4.330)***
SOURCE	0.3065 (1.724)*
N	68

*Note: * indicates significance at the 0.1 per cent level or less; ** indicates significance at the 0.05 per cent level or less; *** indicates significance at the 0.01 per cent level or less.*

5.3.5 Section Summary

This study finds that both psychological and economic factors are involved in the reasons for OSSs returning to Taiwan. Psychological factors include the desire amongst OSSs to use their knowledge in order to help in the development of their home economy, the fact that by returning home they would be able to spend more time with friends and relatives, and the feeling of a strong sense of identification with their homeland. These are the main psychological factors influencing the OSSs' decision to return home.

Economic factors include having good job opportunities waiting for them back home, as well as having better job and promotion opportunities than they do overseas; these are, however, found to be less significant than the above psychological factors. It is also found that the stronger the sense of identification with Taiwan, the more likely an OSS will be willing to give up a high-paying job overseas to return home.

There are, of course, other factors which also discourage OSSs from returning home, the most important of which seems to be that returning to Taiwan will inevitably result in a worsening quality of life, as well as issues of political instability and social problems, and concerns over the education of their children. It would therefore seem advisable that, even if the government is unable to improve the overall quality of life in Taiwan, they should at least attempt to make partial improvements as a means of attracting OSSs to return here. This is a strategy which many developing countries with limited resources could consider employing. Therefore, in addition to maintaining political and social stability within such economies, careful planning of the provision of education for the children of returning OSSs is another area that should not be neglected.

This study has shown that the higher the level of competition in a company's market, the more that company will spend on R&D, and the greater its subsequent need for hiring OSSs after their return. In trying to encourage OSSs to return, one of the leading factors which has brought about the 'reverse brain drain phenomenon' in Taiwan since the 1980s, is the fact that Taiwan has been increasingly able to offer more of the right kind of job opportunities for them, and the establishment of the Hsinchu Science-based Industrial Park in the late 1970s has clearly created a wide array of such opportunities for these OSSs to display their newly-acquired talents.

This study has also shown that OSSs make a very significant contribution to technology formation for their employers after returning to Taiwan; besides assisting directly in a company's R&D work, OSSs can also help firms to identify the experts they need from abroad. All of this can improve the efficiency of a firm's R&D work, and reduce its overall R&D costs. The empirical results in this study confirm that whilst the employment of OSSs can encourage firms to place more emphasis on R&D, they can also help firms to set up the correct, appropriate R&D strategies which will enable them to cut their R&D costs and reduce waste. This may help to explain why Taiwanese firms have been able to achieve impressive results in R&D despite their relatively lower level of spending in this area.

During the interviews conducted for this study, many manufacturers stated that they did not feel that cutting-edge technology was of particular importance for the kind of products that they were currently manufacturing; what they required was mature, practical technology. In this respect, OSSs can often provide manufacturers with exactly what they need. In addition, besides their technical skills, OSSs can also assist in the introduction of new management concepts, and can help firms to implement corporate reorganization in response to changes in technology without being handicapped by the language barrier. These important aspects should not be neglected when assessing the contribution that OSSs can make to indigenous firms.

5.4 Family Decisions on Migration to Shanghai

5.4.1 A New Brain Drain for Taiwan?

The bans on traveling to and visiting relatives in China were lifted in 1987 by the Taiwanese government. Coupled with the appreciation of local currency and the accumulation of foreign exchange in the late 1980s, this policy encouraged investment to move into China from Taiwan; Table 5.12 provides statistics on such investment. The table lists two sets of statistics; those published by the Ministry of Economic Affairs in Taiwan and those provided by the Chinese authorities. The cumulative amount reported by Taiwan is US$19,886.73million, whilst that reported by China is US$29,140million. Irrespective of this difference, it goes without saying that Taiwanese investment in China is growing at a steady pace; indeed, Taiwan is ranked third in the world in terms of overall investment in mainland China.

Table 5.12 Taiwanese investment in mainland China

Unit: US$ millions

Year	MOEA, Taiwan Approved			China Released Statistics				
	No. of Investment Cases	Total Amount	Average Amount	No. of Items	Agreed Amount	Average Amount (A)	Actual Amount (B)	(A)/(B) (%)
1991	237	174.16	0.73	3,446	2,783	0.81[c]	844	30.33
1992	264	246.99	0.94	6,430	5,543	0.86	1,050	18.94
1993[a]	1,262 (8,067)[b]	1,140.37 (2,028.05)	0.90 (0.25)	10,948	9,965	0.91	3,139	31.50
1994	934	962.21	1.03	6,247	5,395	0.86	3,391	62.85
1995	490	1,092.71	2.23	4,778	5,777	1.21	3,162	54.73
1996	383	1,229.24	3.21	3,184	5,141	1.61	3,475	67.59
1997[a]	728 (7,997)	1,614.54 (2,719.77)	2.22 (0.34)	3,014	2,814	0.93	3,289	116.88
1998[a]	941 (643)	1,519.21 (515.41)	2.37 (0.80)	2,970	2,982	1.00	2,915	97.75
1999	488	1,252.78	2.57	2,499	3,374	1.35	2,599	77.01
2000	840	2,607.14	3.10	3,108	4,042	1.30	2,296	56.80
2001	1,186	2,784.15	2.35	4,214	6,914	1.64	2,980	43.10
Up to 2001	24,160	19,886.73	0.82	50,838	54,730	1.08	29,140	53.24
Jan-Apr, 2002	390	816.13	2.09	–	–	–	–	–

Notes:

[a] *These figures are quoted from Issue No.116 of the Cross-Straits Economic Statistics Monthly, published in April 2002 by the Mainland Affairs Council, ROC.*

[b] *Figures in parentheses are registered subsidized cases.*

[c] *Figure refers to average amount up until 1991.*

Sources: Figures for China are the foreign direct investment statistics published by the Ministry of Foreign Trade and Economic Cooperation; Taiwanese figures are obtained from the Investment Commission of the Ministry of Economic Affairs, ROC.

Faced with globalization and the exodus of precious employers to China, Taiwanese workers are also becoming increasingly willing to work in the mainland. As long as employers decide to move out to China, more and more workers will follow them there regardless of remuneration levels. In the early stages, most of those who went to China were senior managers or senior members of the technical staff, and after having lived in China for a number of years, many of them have now become accustomed to the life there and have gained an intention to remain there permanently. They have been forming ever-expanding unique communities for many years now, as increasing numbers have followed in their footsteps. Take, for example, the greater Shanghai region (including Shanghai City, Kunshan, Suzhou and Wuxi); according to the Chinese authorities, around 250,000 Taiwanese businessmen are currently living there.[17]

As more Taiwanese businesses invest in mainland China, more staff members are also being stationed there; however, in addition to the problems associated with mainland investment, there are also a number of social and domestic issues, the most troublesome of which are accompanying family and child education problems. Indeed, many are forced to make the difficult decision between living away from their family, or moving them into China to accompany them.

5.4.2 Survey Data

In order to explore the factors influencing the decision by married migrants working in Shanghai to move their family into China, they were either interviewed in person, or questionnaires were sent to them. Questionnaires were sent to Taiwanese business owners listed in a periodical published by the Chinese National Federation of Industries in July 2001. They were either mailed or faxed, between mid August 2001 and early February 2002. By way of random sampling, 600 Taiwanese businesses were selected, with a low response rate being anticipated due to frequent changes, such as the moving out of these businesses. For this reason, a local Taiwanese business club was also asked to provide assistance. After much effort, 136 copies were returned, giving a response rate of just 22.7 per cent. Nevertheless, despite this low response rate, the questionnaires were still useful.

Examination of the questionnaires indicates that the majority of the respondents were males (88.24 per cent) with an average stay in Shanghai of 4.7 years. Their average age was 37 years, and they had worked for an average

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17 Survey on migration of 300,000 Taiwanese to Shanghai, Huang Huijuan and Zhou Qidong (2001), *Business Week*, Issue No.723. Since the Taiwanese authorities have never held official statistics of this ethnic group, the exact figure has yet to be calculated.

of 13 years when moving to Shanghai. Of the 136 responses, 78.68 per cent of those who were married chose to go there alone. Only 13.97 per cent brought their whole family along with them (spouse and children), whilst just 7.35 per cent of them went with only their spouse.

We examined two types of family migration: (i) non-family migration, i.e. the case where the married individual relocates alone; and (ii) family migration, i.e. where the entire family, or the spouse, accompanies the move. The preliminary statistical results indicate that 78.68 per cent of the married persons who moved to Shanghai adopted the non-family type of migration, whilst the family migration group accounted for the remaining 21.32 per cent. Within the non-family migration group, 79.81 per cent had children in school at the time of the move, whilst in the family migration group the figure was 42.86 per cent. In addition, 70.59 per cent of the non-family migration group had a working spouse in Taiwan, whilst the figure for the family migration group was 85.19 per cent. These descriptive statistics indicate that the spouse clearly plays an important role in deciding whether or not the family will accompany at the time of the initial move of a married migrant into China.

5.4.3 Empirical Analysis

Since this study finds that almost 80 per cent of married migrants go to China without their family, there is sufficient justification to try to identify the factors that determine why their families should be left behind. This should clearly help to provide an understanding of why they decide to go alone, despite the psychological costs that they and their family members must endure as a result of the family separation. The analyzed data are divided into two parts: (i) whether the respondent's family accompanied the respondent at the time of the initial move to China; and (ii) whether the respondent's family was moved to greater Shanghai some time later. By answering these questions, we can correlate family migration decisions with the time the respondent has worked in China, their networking ability, and other relevant social economic factors.

Factors Determining Whether the Family Accompanies the Initial Move to China

In this section, we try to answer the question of whether married migrants moving to China bring along their family (or just their spouse). By determining the answer to this question, we aim to get an understanding of the factors influencing their decision making, to identify the roles that their family members play within the whole process, and then compare our findings with the existing literature on family migration. Such a compilation of family migration literature helps to shed light on the factors influencing family migration decisions (children's education, spouse's employment opportunities, etc). The essential variables constituting family migration decisions are obtained after putting in individual idiosyncrasies gathered during this study. Consequently, the empirical model of this study can be defined as follows:

$$\begin{aligned} p1 &= \Pr(\text{FAMILY1}=1) = b0 + b1\text{WORKER1} \\ &+ b2\text{CHILDREN1} + b3\text{SPOUSEM1} + \varepsilon \end{aligned} \tag{4}$$

In the above formula, p1 stands for the probability of married migrants going to China accompanied by their families. Variable WORKER1 represents the married migrant him/herself; variable CHILDREN1 represents the children of the family; and SPOUSEM1 represents the employment status of the spouse at the time of the initial move to China. We are now going to expand on the definition and evaluation method for all of the variables in Empirical Model 4, and explore their anticipated influence on the decision by married migrants for immediate family migration, beginning with a binary variable. This variable indicates that if FAMILY1 is 1, then the migrant was accompanied by the family (or spouse) to China. If FAMILY1 is 0, this indicates that the family was left behind at the time of the initial move to China. The variables are defined as follows.

■ Married Migrants

Sex

Married female = 1; married male = 0. Generally speaking, having to juggle between work and home, females tend to bring their family along as they move, making it easier to take care of their children. However, the literature also shows that male spouses of migrant workers are less adaptive than their female counterparts, which may discourage female migrant workers from moving with their family (Punnett, et. et., 1992; Westwood and Leung, 1994). Since the literature indicates that both outcomes are possible, we will set the gender variable aside for now.

Education level (EDU)

Evaluation methods for education level in the prior studies vary according to the subjects being researched and the subjective judgments of researchers. This study adopts as its criterion 'number of years of education,' with a higher number equating to a higher level of education. EDU for PhDs = 22, for Masters = 18, for Bachelors = 16, for junior college graduates = 14, for senior high graduates = 12 and for graduates of junior high and below = 9. Agesa and Kim (1999) thought the higher one is educated, the more likely their ability to secure a stable job following migration, and therefore, the more likely it was that the family would accompany the migration. However, the study also discovered that, in general, the higher the respondent's education level, then the higher the spouse's education level. Therefore, the education level of the migrant can also be viewed as a proxy variable for the education level of the spouse. For this reason, the higher the education level of the migrant's spouse, the higher the chances of the spouse having a stable job in Taiwan, and providing an important contribution to family income, which will, in turn, lower the probability of family migration. Based on the above analyses, the role played by education level in family migration decisions is inconclusive.

Work experience (EXP)

This variable represents the number of years working experience that the migrant had at the time of the initial move to China. In general, the greater the level of work experience that had been accumulated, the less likely the family would be to move. In addition, the longer they had worked in Taiwan at the time of the initial move to China, then naturally, the longer they had lived there. The relevance coefficient is 0.7166. Markham, et. al. (1983) discovered that the length of time spent living in a place was negatively correlated to the motivation to move. As a result, it is expected that the longer migrants had worked in Taiwan, the more social resources the family had accumulated. For this reason, they were less likely to move to China. So the EXP variable will have a negative impact on the chances of family migration.

Migration type (TYPE)

TYPE = 1 indicates that the migrant went to China to start up his/her own business. TYPE = 0 indicates others; according to the survey, the majority of 'others' went to China because their employers sent them there.

In general, those who went to start their own business were more likely than 'others' to move with their family (or spouse) because their intention was to stay permanently and they felt that their spouse could help them with their business. So the TYPE variable will have a positive impact on the probability of family migration.

Remuneration disparity pre/post migration (WD)

This variable aims to determine whether the migrant was better remunerated after going to work in China. WD = 1 if the migrant is better remunerated; otherwise = 0.

The literature indicates that the probability of family migration is higher if there are expectations of a dependable, stable job after migration, and thereby, better remuneration. Thus WD has a positive impact on the probability of family migration.

■ Children

Number of school-age children at the time of the initial move to China (CHILD1)

The migrant's number of school-age children at the time of the initial move to China is used as the measurement criterion. Long (1975) and Mincer (1978) considered that non-school-age children had little influence on parents' migration decisions, thus only school-age children should be taken into account as having any influence on parents' migration decisions. Bartel (1979) argued that the presence of school-age children increased migration costs, whilst Maxwell (1988) stated that the presence of school-age children hindered migration. Based on these viewpoints, the greater the number of school-age children at the time of the migrant's initial decision to move to China to work, the less likely family migration is to occur. Thus CHILD1 has a negative impact on the probability of family migration.

■ Employment of Spouse

There are three variables in this category: (i) work status; (ii) job security; and (iii) contribution to family income of the spouse at the time of the migrant's initial move to China. These are used to measure the impact that spouse's employment in Taiwan has on the family migration decision at the time of the migrant's initial move to China. They are detailed as follows:

Employment status of the spouse at the time of the initial move to China (EM1)

This variable is determined by whether the spouse was employed at the time the migrant went to work in China. EM1 = 1 indicates that the spouse was employed at the time; EM1 = 0 indicates that the spouse was not employed.

Job security of the spouse at the time of the initial move to China (STABLE1)

This variable is determined by whether the spouse had a secure job at the time of the migrant's initial move to China. STABLE1 = 1 indicates that the spouse had a secure job; STABLE1 = 0 indicates that the spouse did not have a secure job.

Spouse's contribution to family income at the time of the initial move to China (EARNG1)

This variable is obtained by multiplying STABLE1 by EDU. It is believed that the higher the education level of the migrant, the higher the spouse's education level; as a result, EDU can be used as a proxy variable for the spouse. For this reason, the more secure the spouse's job or the higher their education level, the more they will contribute to family income.

The wife's employment has always been viewed in the literature as a decisive factor in influencing family migration decisions and location selection. Some studies have indicated that the wife's employment and job security may hinder family migration; however, others indicate that when migration is used as a means of transferring or repositioning the individual, the influence of such job security may be weakened. Mincer (1978) discovered that women joining the labor market had an insignificantly negative impact on employee transfer-related family migration. Nevertheless, the wife's contribution to family income and her job security do have a significant impact on family migration. Based on research of the relevant literature, it is expected that all three variables (EM1, STABLE1 and EARNG1) will have a negative impact on family migration, i.e. the spouse's employment may hinder family migration; however, the degree of the impact has yet to be determined empirically.

The definitions of these variables and their impact on family migration are summarized in Table 5.13, whilst the relevant empirical results from a Probit analysis are summarized in Table 5.14.

Table 5.13 Relevant variables in the empirical model of family migration decisions by married Taiwanese migrant workers in China

Variable	Variable Definition	Method of Evaluation	Average (standard deviation)	Expected estimated symbols
1. Causal Variables				
FAMILY1	Family migration decision at the time of the initial move to China	0 = the family will not migrate (going there alone) 1 = family (spouse) migrates	0.2132 (0.4111)	
FAMILY2	'Current' family migration decision	0 = the family will not migrate (going there alone) 1 = family (spouse) migrates	0.3358 (0.4740)	
2. Sample Statistics				
SEX	Gender	Male = 0 Female = 1	0.1176 (0.3234)	?
EDU	Education level	Measured by 'number of years educated': PhD = 22; Masters degree = 18; Bachelors degree = 16; Junior college = 14; Senior high = 12; Junior high and below = 9	14.1556 (2.0979)	?
EXP	Previous work experience in Taiwan	Unit measure: year	13.0476 (7.0539)	–
CHILD1	Number of school-age children at the time of the initial move to China	Unit measure: person	1.3712 (1.0800)	–
CHILD2	Current number of school-age children	Unit measure: person	1.8731 (0.9129)	–
TYPE	Job migration type	Sent by company = 0 Starting own business = 1	0.3015 (0.4606)	+
YEAR	Total working experience in China	Unit measure: year	4.7426 (3.8472)	+
EM1	Spouse's employment status on arrival in China	Unemployed = 0 Employed =1	0.7364 (0.4423)	–
STABLE1	Spouse's Job security at the time of the initial move to China	Insecure = 0 Secure = 1	0.4884 (0.5018)	–
EARNG1	Spouse's contribution to family income at the time of the initial move to China	Obtained by multiplying STABLE1 by EDU	7.0234 (7.3189)	–
STABLE2	Spouse's job security when surveyed	Does not have a secure job = 0 Has a secure job or has trouble finding one in China = 1	0.4961 (0.5020)	–
EARNG2	Spouse's contribution to family income when surveyed	Obtained by multiplying STABLE2 by EDU	7.3136 (7.3852)	–
WD	Better remunerated after going to China?	Worse = 0 Better = 1	0.5952 (0.4928)	+
3. Evaluation of the Economic Environment *				
ECON	China's economy grows so fast it would be unwise not to get a foot in the door	Untrue = 0; not so true = 1; true = 2; very true = 3	0.7794 (1.0659)	+
PUBLIC	China's existing political and social conditions present a considerable hindrance to family migration	Untrue = 0; not so true = 1; true = 2; very true = 3	0.8657 (1.1225)	–
LIVING	China's existing living standards present a considerable hindrance to family migration	Disagree = 0 Agree = 1	0.2059 (0.4058)	–
CEDU	China's different and value educational systems present a considerable hindrance to family migration	Disagree = 0 Agree = 1	0.4265 (0.4964)	–

*Note: * Evaluation of the overall economic environment is assessed by the survey sample*

Table 5.14 Probit model estimates of the determinants of family migration decisions for married Taiwanese workers in mainland China

Variables	Family migration probability at the time of first going to work in China (FAMILY1 = 1)			Current family migration probability (FAMILY2 = 1)			
	1.1	1.2	1.3	2.1	2.2	2.3	2.4
CONST	3.384 (1.959)*	3.660 (2.107)**	3.972 (2.223)**	1.176 (0.931)	1.534 (1.196)	-1.676 (-1.044)	-3.003 (-2.079)**
SEX	1.875 (3.207)***	2.146 (3.408)***	2.189 (3.444)***	1.370 (2.612)***	1.416 (2.672)***	1.662 (2.885)***	1.854 (3.320)***
EDU	-0.154 (-1.664)*	-0.170 (-1.766)*	-0.144 (-1.507)	-0.009 (-0.118)	0.025 (0.330)	0.090 (1.045)	0.118 (1.448)
EXP	-0.031 (-0.962)	-0.048 (-1.374)	-0.048 (-1.375)	-0.054 (-2.312)**	-0.054 (-2.288)**	-0.062 (-2.306)**	
TYPE	0.781 (1.662)*	1.093 (2.124)**	1.094 (2.135)**	0.587 (1.474)	0.566 (1.423)	0.839 (1.850)*	0.591 (1.400)
WD	0.498 (1.321)	0.577 (1.477)	0.556 (1.434)				
YEAR				0.074 (1.875)*	0.073 (1.857)*	0.070 (1.496)	0.089 (2.010)**
CHILD1	-0.825 (-3.903)***	-0.877 (-3.994)***	-0.872 (-3.997)***				
CHILD2				-0.745 (-3.839)***	-0.744 (-3.829)***	-0.769 (-3.486)***	-0.786 (-3.651)***
EM1	-0.124 (-0.302)						
STABLE1		-0.675 (-1.708)*					
EARNG1			-0.049 (-1.801)*				
STABLE2				-0.857 (-2.722)***		-1.382 (-3.349)***	-1.216 (-3.130)***
EARNG2					-0.060 (-2.818)***		
ECON						0.410 (2.512)**	0.412 (2.592)***
PUBLIC						0.024 (0.153)	-0.037 (-0.243)
LIVING						-0.899 (-2.037)**	-0.964 (-2.235)**
CEDU						-0.848 (-2.462)**	-0.741 (-2.242)**
Total No. of valid samples	111	111	111	114	114	112	112
Total No. of family migration samples	26	26	26	37	37	37	37
Normal Log Likelihood	-38.573	-37.065	-36.884	-51.717	-51.431	-42.258	-45.107

Notes:

[a] *Figures in parentheses are t values.*

[b] ** indicates significance at the 0.1 per cent level; ** indicates significance at the 0.05 per cent level; *** indicates significance at the 0.01 per cent level.*

Family Migration Considerations for those Already Working in China

Many Taiwanese migrants have reassessed their intended period of stay in Shanghai from temporary to permanent. According to this survey, almost 80 per cent of married migrants initially went to work in Shanghai by themselves; this was clearly common practice at the time of initial moves to China. However, after having working there for several years (4.7 years on average according to this survey), the situation has changed. Although 66.42 per cent of migrants are still there alone, 24.63 per cent are now accompanied by their family (spouse and children) with the remaining 8.96 per cent having just their spouse with them in China.

Further studies were conducted to determine how family migration decisions relate to the length of stay, networking ability and other relevant social economic factors. Exploration of these issues is particularly meaningful at a time when moving to Shanghai is all the rage in Taiwan. In an extension of Model 4, the migrants' personal evaluations of the overall economic environment in China were taken into account so as to set up an empirical model for family migration decisions. This model is represented by the following formula:

$$p2 = Pr\,(FAMILY2=1) = b0 + b1WORKER2 + b2CHILDREN2 + b3SPOUSEM2 + b4MACRO + \varepsilon \quad (5)$$

In the formula, p2 represents the probability of immediate family migration (at the time of the survey). WORKER2 represents the migrants themselves, CHILDREN2 their children, SPOUSEM2 their spouse's employment status, and MACRO the migrant's personal evaluation of China's overall economic environment. The variable definitions in Empirical Model 5, and their evaluation methods, are further explained in the following subsections, along with their impact on family migration decisions for married Taiwanese migrants working in China, starting with a binary variable which indicates that if FAMILY2 is set at 1, then the surveyed person has 'already' moved the family or spouse to Shanghai. If it is set at 0, this indicates that they have 'so far' not done so.

Since Model 5 was expanded from Model 4, all the corresponding variables have the same influence as their counterparts in Model 4. The definitions and evaluation methods of additional variables appearing in Model 5 are as follows:

■ **Married Migrants**

Number of years working experience in China (YEAR)

This variable is determined by the length of time the married Taiwanese migrant has worked in China, with a unit measure of 'year'. Generally speaking, the longer they have worked there, the more established they are, the more social resources they have accumulated, and the more likely they are to stay permanently and to bring their family to join them. So the YEAR variable has a positive impact on family migration.

■ **Overall Economic Environment (MACRO)**

China's economy grows so fast it would be unwise not to get a foot in the door (ECON)

This variable is determined by whether the surveyed agrees that 'China's economy grows so fast it would be unwise not to get a foot in the door'. ECON is set at 3 if they think the statement is 'very true,' 2 if 'true,' 1 if 'not so true,' and 0 if 'untrue.' The weights of the statement are used to measure the importance of this variable in the minds of the respondents. It is expected that the more they agree with the statement, the more likely that family migration to Shanghai will take place, so ECON is expected to have a positive impact on family migration decisions.

The hindrance presented by China's existing political and social conditions (PUBLIC)

This variable is determined by whether the surveyed agrees that 'China's existing political and social conditions present a considerable hindrance to family migration'. PUBLIC is set at 3 if they think the statement is 'very true,' 2 if 'true,' 1 if 'not so true,' and 0 if 'untrue.' It is expected that the more the respondents agree with the statement, the less likely that family migration to Shanghai will take place, so PUBLIC is expected to have a negative impact on family migration decisions.

The hindrance presented by China's existing living standards (LIVING)

This variable depends on whether the respondents agree that 'China's existing living standards present a considerable hindrance to family migration'. LIVING is set at 1 if they agree; and 0 if they do not. It is expected that the more the respondents agree with the statement, the less likely that family migration to Shanghai will take place, so LIVING is expected to have a negative impact on family migration decisions.

The hindrance presented by China's different educational and value systems (CEDU)

This variable is determined by whether the respondents agree that 'China's different educational and value systems present a considerable hindrance to family migration'. CEDU is set at 1 if they agree, and hence, believe that the hindrance would interfere with their children's educational arrangements; otherwise 0. Bartel (1979) argued that the presence of school-age children increases family migration costs, whilst Maxwell (1988) stated that the presence of school-age children hindered migration. Based on these viewpoints, it is expected that the more the respondents agree with the statement, the less likely that family migration to Shanghai will take place, so CEDU is expected to have a negative impact on family migration decisions.

A summary of the variable definitions and their impacts on family migration, and the relevant Probit empirical results, are provided in Tables 5.13 and 5.14.

5.4.4 Empirical Evidence

As Table 5.14 shows, the gender of married Taiwanese migrating to China to work, and number of children they have in school in Taiwan play major roles in determining whether their move to China will be immediately (or in the near future) accompanied by the family (or spouse). The empirical evidence shows that the SEX variable has an obvious and positive relationship, which means that family migration is much more likely for a married female Taiwanese person moving to China, than it is for her male counterpart. This may be due to the traditional role played by women as caretaker of the household. Nevertheless, studies have also indicated that there have been cases of male spouses having trouble adapting to life in China and going back to Taiwan on their own.

We also discover from Table 5.14 that the number of children in school influences the likelihood of family migration. CHILD1 and CHILD2 variables were used in the empirical model, where the evidence showed that the greater the number of children in school, the less likely that family migration would occur; CHILD1 and CHILD2 variables are negatively correlated in Table 5.14 with a significance level of 0.01. The results match the empirical evidence reported by Maxwell (1988) and are in line with the expectations of this study. This may be due to the fact that the majority of the respondents were males (88.24 per cent).

The empirical evidence shows that the TYPE variable has a positive relationship in Models 1.1 to 1.3 with a significance level of 0.1, thus supporting the proposition that married migrants starting their own business in China are more likely to migrate with their family than those sent by their company, because the spouse can then assist in the starting up of the business, and they are therefore better motivated to stay there permanently. By contrast, even though TYPE displays a positive relationship in Models 2.1 to 2.4, the effect is neither obvious nor stable. This may be due to a higher probability of family migration for those who were sent by their company since they will have worked there longer and accumulated more social resources.

As to EDU in Models 1.1 to 1.3, and 2.1 to 2.4, the effect was neither significant nor stable. This may be due to the offsetting force of the positive and negative effects previously anticipated by this study, i.e. (i) positive force: the higher the education level, the more likely the respondents would be to secure a good job after migration, thus they were more inclined to migrate with their family; (ii) negative force: the higher the education level of the respondent, the higher the spouse's education level, and the greater the likelihood of the spouse having a secure job in Taiwan, and thus, making an important contribution to family income, in which case they would be less inclined to be accompanied by their family.

The employment status of the migrant's spouse (EM1), job security (STABLE1, STABLE2), and contribution to family income (EARNG1, EARNG2) are included in Table 5.14 in order to measure the relevance between family migration and spouse's employment. The empirical evidence shows a negative yet insignificant influence of EM1 in Model 1.1, which indicates a negative yet insignificant influence of the spouse's employment on family migration. STABLE1 is included in Model 1.2, which displays a negative relationship with a significance level of 0.1, whilst in 1.3 the same result was obtained with EARNG1 included. The empirical evidence in Models 1.1 to 1.3 combined indicates that their spouse's employment had no significant impact on family migration decisions at the time when married migrants went to work in China, but that their job security and contribution to family income both had negative impacts.

In Models 2.1 to 2.4 of Table 5.14, the job security of the migrant's spouse (STABLE2) and contribution to family income (EARNG2) were included in order to measure the likelihood of family migration after the respondent had worked in China for several years. The empirical evidence indicates that both variables display significant negative effects in Models 2.1 to 2.4. Even where the respondent worked longer in China, the spouse also worked longer in Taiwan, and as a result, the spouse's job became even more secure, thus further reducing the likelihood of family migration. This is in line with the expectations of the survey. What is worthy of attention is that a large proportion of the cases of family migration (over 60 per cent) belong to the category of 'employee transfer' – similar to the Mincer (1978) study – where spouse's employment status has less impact; nevertheless, even though most Taiwanese expatriates working in China were transferred there by their employer, the more secure the spouse's job, and the higher the contribution to family income, the less likely that family migration would take place. This concurs with the finding of Mincer (1978).

In terms of the number of years the respondent has worked (or lived) in Taiwan, Table 5.14 indicates that EXP displays an insignificant negative effect in Models 1.1 to 1.3, and a significant negative effect of 0.05 in Models 2.1 to 2.3. By comparing the 'then' and 'now' family migration models, we discover that the greater the work experience, or the longer the time spent in Taiwan, as compared to China, the more obvious the negative effect of EXP on family migration; this is because of the greater accumulation of social resources, and thus, the lower likelihood of migration. On the other hand, the lower the level of work experience, or the shorter the time spent in Taiwan, the greater the likelihood of migration. These results are in line with both the Markham, et. al. (1983) study and our expectations.

When taking migration decisions, economic factors are not the only consideration for a migrant, since many non-economic factors are also taken into account. Migration does not take place solely for short-term benefits, such as higher income, but also for long-term benefits such as children's education, political stability, and so on. Therefore, in addition to the variables noted above, this study also included ECON, PUBLIC, LIVING and CEDU in Models 2.3 and 2.4 in order to explore the relationship between family migration and the evaluation of China's overall economic environment as perceived by the respondent.

ECON displays significant positive effects in Models 2.3 and 2.4, which supports the proposition that those who believe 'China's economy grows so fast it would be unwise not to get a foot in the door' are more likely to migrate. In general, the more upbeat one feels about China's economic future, the more likely they will be to migrate to China because it would be beneficial for their career, and for the career of their children, which is consistent with the expectations of this study.

LIVING displays a significantly negative effect of 0.05 in Models 2.3 and 2.4. The more the respondents agree that 'China's existing living standards present a considerable hindrance to family migration,' the less likely that family migration will take place for fear of adaptation problems, which is again in line with this study's expectations. Table 5.14 also shows that the more the respondents agreed that 'China's different educational and value systems present a considerable hindrance to family migration,' the less likely that family migration would take place for fear of problematic educational arrangements for their children.

As anticipated, CEDU displays a significant negative effect of 0.05 in Models 2.3 and 2.4. As to PUBLIC, this has insignificant effects in Models 2.3 and 2.4, so we conclude that China's political and social conditions have no effect on the family migration decisions of the respondents.

Table 5.14 also indicates that family migration is related to the length of time that the respondents have worked in China (YEAR). The empirical evidence shows that YEAR has a significant positive effect of 0.1 in Models 2.1, 2.2 and 2.4, therefore, the likelihood of family migration increases with the length of time that the respondents have worked in Shanghai, which is again in line with this study's expectations. In general, the longer the respondents had worked in China, the more established they had become, the more social resources they had accumulated and the more likely they were to stay permanently and to move their family there.

Finally, another interesting point is worth noting from Table 5.14. We took the Probit model of family migration drawn from the responses at the time that the migrants first went to work in China (then) and then placed it side by side with the same model drawn several years later (now) – the sample average being 4.74 years – to further understand the aging effect of the time factor. By comparing the 'then' and 'now,' we find a distinct aging effect. The longer the respondents had worked in China, the more likely they were to migrate;

however, if, during the same period of time, their spouse also had a secure job in Taiwan, the aging effect would actively work against the family migration probability. By comparing the results obtained from Model 2.1 with those of Models 2.3 and 2.4 in Table 5.14, we discover that the regression coefficient of YEAR (the time Taiwanese businessmen have worked in China) varies between 0.070 and 0.089. The result of Model 2.4 is the most obvious with a regression coefficient of 0.089. On the other hand, the regression coefficient of the job security of the spouse STABLE2 varies between -0.857 and -1.382. With the maximum coefficient (absolute value) of Model 2.3 being -1.382, it has the biggest absolute t statistics.

In terms of the effect on family migration decisions, by multiplying the average value of YEAR of 4.74 by 0.089 and then comparing this value with -1.382, after having worked in China for 15.53 years, the aging effect of the respondent can cancel out that of a spouse who had worked in Taiwan over the same period of time.[18] From then on, family migration becomes increasingly likely, despite the fact that the spouse may have a very a secure job in Taiwan.

Moreover, what is worth noting is that the estimate of 15.53 years was obtained under the assumption that other overall environmental factors remain constant. However, it is highly implausible that these factors will remain unchanged. With the rapid growth of China's economy, there are clear expectations of improvements in basic infrastructure and more flexible educational policies (for example, schools have already been established specifically for the children of Taiwanese businessmen). Such issues will clearly have direct impacts on variables such as ECON, LIVING and CEDU, and they will, in turn, reduce the estimate of 15.53 years still further.

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18 -1.382 = 0.089 * 4.74 * x, therefore x = 3.276, which means it takes 3.276 * YEAR, or 15.53 years to cancel out the spouse's aging effect of having worked in Taiwan for the same period of time.

This study estimates that if variables ECON, LIVING and CEDU[19] were to experience a 10 per cent (1 per cent) change, which means that the average value of ECON of those who believe 'China's economy grows so fast it would be unwise not to get a foot in the door' increases by 10 per cent (1 per cent), whilst the average values of LIVING and CEDU both decreased by 10 per cent (1 per cent), the time it would take for the positive and negative aging effects to reach equilibrium would drop to 4.82 years (5.69 years).[20] This estimate is further compared with the results of this survey. The survey indicates that those married Taiwanese migrants who had worked in China for several years (4 to 5 years on average) have a higher family migration rate (over 10 per cent higher) than when they first went to work there. Almost sixty per cent of those who are still working there alone have indicated their intention to move their family over once they have become more established.

5.4.5 Section Summary

As Taiwanese businessmen are increasingly investing in China, the number of Taiwanese workers stationed in China is also growing. The most problematic issues are their family situation in Taiwan and their children's education; issues which force many families to choose between living separately and having the family accompany them in China. Despite the gravity of the issues, little research has been undertaken on the family migration decisions of such married Taiwanese workers in China.

This study utilizes a Probit Model to deal with these family migration decision issues focusing on Shanghai, with the empirical evidence indicating that the length of stay in China has a positive impact on such family migration

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19 PUBLIC is ignored because of its insignificance in Models (2.3) and (2.4).

20 As indicated by estimates of ECON, LIVING and CEDU in Model (2.3) of Table 2, and the mean value of the variables in Table 1, when the variables 'improve' by 10 per cent, their influence on family migration can be calculated as follows: (1) 0.7794 * (1.1) * 0.410 + 0.2059 * (1.1) * 0.899 + 0.4265 * (1.1) * 0.848 = 0.953; (2) (1.382 – 0.953) / (0.089 * 4.74) = 1.017; (3) 1.017 * 4.74 = 4.82 (year)

decisions, since the longer they stay, the more social resources they accumulate. This may also explain why family migration is more common after the married migrants have worked in Shanghai for some time. Undoubtedly, family migration decisions are determined by the entire family; therefore, they are not only influenced by the individual who has to work in China, but also by other factors such as the education of their children and the employment of their spouse in Taiwan.

This study confirms that school-age children and spouse's job security do tend to hinder family migration, and that the overall environment cannot be ignored. The empirical evidence indicates that the more upbeat on is about China's economic future, the more likely it is that family migration will take place. Moreover, after having evaluated the living conditions in China, those who are more concerned about their family's ability to adapt to life there are less likely to move to China accompanied by their family. In addition, when taking their migration decisions, the respondents will also take into account the educational environment for their children. If they are worried about the different educational and value systems their children may have to face, then family migration will be less likely.

The spouse's employment plays a vital role in deciding whether they will migrate, and if so, to where, with studies having shown that the employment and job security of the spouse may hinder family migration. However, other studies have also indicated that when migration is caused by transfer or a change of job, the spouse's influence may be weakened, and the vast majority of Taiwanese migrants who have gone to work in China were indeed sent there by their employers.

The conclusions of this study support the argument that migration is a decision determined by the entire family and that the job security of the spouse plays a vital role within the process. The study finds that the spouse's job security and their contribution to family income have a significant negative impact on family migration, and that this suppressing force is not weakened simply by the fact most of the Taiwanese migrant workers in China were transferred there by their employers. Furthermore, whether the spouse is employed has little bearing on family migration decisions. In general, the results of this study indicate that the spouse's job security does not play a vital role with regard to family migration decisions.

Time plays a vital role in family migration decisions. As time passes, married Taiwanese migrants working in China will tend to consider more seriously the possibility of family migration as they accumulate more social resources in China. However, if their spouse has a secure job in Taiwan, time may also have a negative impact on family migration decisions. In view of the recent rapid economic growth, aggressive improvements in public infrastructure, and the loosening of the Chinese education system, specifically for the children of Taiwanese businessmen, many are now considering more seriously the idea of bringing their family to join them in China.

The study indicates that even if the Taiwanese businessman's spouse has a secure job in Taiwan, as long as China's overall environment continues to improve, family migration becomes increasingly likely as time progresses. On the other hand, if China's overall economic conditions or public construction fail to improve significantly, then family migration will become less likely.

5.5 The Impacts on Taiwan from the Employment of Taiwanese Engineers and Managers in R&D Efforts in China

5.5.1 The Survey

This section of the survey was specifically designed to research how Taiwanese professionals contribute to the acquisition, transfer and formation of technologies for Taiwanese businesses operating in Shanghai. Questionnaires were either mailed or faxed to the target sample during the period from mid August 2001 to early February 2002, with the research subjects being selected from a periodical published by the Chinese National Federation of Industries in July 2001. By way of random sampling, 600 Taiwanese businesses were selected, with a low response rate being anticipated due to frequent changes, such as moving of these businesses. For this reason, a local Taiwanese business club was asked to provide assistance. After much effort, 102 copies were returned, giving a response rate of just 17 per cent; however, despite the low response rate the questionnaires were still useful. The data contained in the questionnaires returned are compiled and summarized in Table 5.15.

Table 5.15 Taiwanese businesses in the sample, by industry

Industries		Valid Samples Returned	Proportion of Valid Samples (%)
Manufacturing Industries	Computer, telecommunications and electronic parts	13	12.75
	Health care, optical and precision instruments	6	5.88
	Mechanical, electrical industries	45	44.12
	Light industry	15	14.71
	Food industry	4	3.92
	Sub-total	83	81.37
Service Industries	Automotive, transport, recreation, computer system design	19	18.63
Total		102	100.0

Source: Compiled for this study.

5.5.2 Taiwanese Professionals and Technology Transfer

There are plenty of channels for the introduction of new technologies, and for Taiwanese businesses operating in China, employing Taiwanese professionals could well be one of them. Our purpose is therefore, to assess, amongst all the other potential technology transfer channels, the importance of employing Taiwanese professionals, as well as to assess whether the proportion of Taiwanese professionals already employed is too high. This study carries out an in-depth investigation to answer these questions and summarized the results of this investigation in Table 5.16, listing the findings of technology sources amongst the Taiwanese businesses surveyed.

In terms of all the industries combined, the major source of technology is the parent company in Taiwan, with a weight of 327. The second most important source is the R&D staff of the company's mainland China branch, with a weight of 189. The third major source is the Taiwanese professionals stationed in China with a weight of 175. In terms of individual industries, those whose major source of technology is 'Taiwanese professionals stationed in China' fall into the service industry and the electronics industry (part of the manufacturing industry). Second in line are the computer, telecommunications, and electrical and mechanical industries of the manufacturing industry.

If further analyzed by the weights assigned to various industries within the manufacturing industry, Table 5.16 indicates that the three most important technology sources for the computer, telecommunications, and electrical and mechanical industries were: (i) 'provided by the Taiwanese parent company'; (ii) 'the R&D staff of the company's mainland China branch'; and (iii) 'transferred from Taiwanese professionals stationed in (or migrated to) China'. The three most important technology sources for the electronics industry were: (i) 'provided by the Taiwanese parent company'; (ii) 'transferred from

Taiwanese professionals stationed in (or migrated to) China'; and (iii) 'provided by foreign clients (OEM)'.

As indicated above, Taiwanese businesses operating in China consider their Taiwanese parent companies as the major source of technology, with their R&D staff and Taiwanese professionals ranking second and third. What is worth noting is that some parts of the process of R&D were contributed by Taiwanese professionals. Generally speaking, although Taiwanese professionals may not be the most important source of technology, they still play a vital role in providing technology to Taiwanese businesses operating in China.

5.5.3 The Influence of Taiwanese Professionals Operating in China

The influence on manufacturing, management and R&D technology formation

In this study, the respondents were asked to evaluate the influences that Taiwanese professionals have on the technology formation of the respondent's company. The areas of influence included manufacturing, management, R&D technology formation, human resources and education. The results of the survey are listed in Table 5.17.

Table 5.16 Weighted technology sources for Taiwanese businesses operating in China

Source of Technology[a]	All Industry	Manufacturing Industries	Service Industries	Manufacturing industries: Computer and Telecommunications Industries	Manufacturing industries: Electronics Industry	Manufacturing industries: Electrical and Mechanical Industries
Provided by Taiwanese parent companies	327 (1)[b]	283 (1)	35 (1)	20 (1)	32 (1)	147 (1)
R&D staff at the company's China branch	189 (2)	166 (2)	15 (3)	16 (2)	9	110 (2)
Transferred from Taiwanese professionals stationed in (or migrated to) China	175 (3)	152 (3)	19 (2)	13 (3)	20 (2)	98 (3)
Provided by foreign parent companies	110 (4)	83 (4)	14 (4)	4 (4)	3	43
Provided by foreign clients (OEM)	79	75	4	0	14 (3)	47 (4)
Copied from and improved on similar foreign products	65	65	0	3	4	40
Collaborated with foreign manufacturers or labs	61	46	5	0	10 (4)	19
The company does not have a R&D department in place, so local Chinese professionals are commissioned to help	43	29	14 (4)	0	7	9
Provided by local Chinese research institutions	30	27	3	0	3	16
Collaboration with local Chinese educational institutions	23	23	0	0	3	15
Provided by foreign research institutions	21	17	4	0	3	11
Others	0	0	0	0	0	0
Number of valid samples	102	83	19	5	8	45

Notes:
[a] Weights assigned to the level of importance of sources of technology for Taiwanese businesses operating in China are: 'Most important' – 5; 'Important' – 4; and 'Less important' – 3.
[b] Figures in parentheses denote the ranking of that technology source for the industry in question.

Source: Compiled for this study.

Table 5.17 The influence of Taiwanese professionals on technology formation in the Taiwanese firms surveyed

Influence on Technology Formation *	All Industry		Manufacturing Industries		Service Industries		Manufacturing industries: Computer and Telecommunications Industries		Manufacturing industries: Electronics Industry		Manufacturing industries: Electrical and Mechanical Industries	
	No. of Samples*	%	No. of Samples*	%	No. of Samples*	%	No. of Samples*	%	No. of Samples*	%	No. of Samples*	%
1. Training and instructing of local technical staff	68 (1)	67.33	58 (1)	72.50	10 (2)	55.56	4 (1)	80.00	7 (1)	87.50	33 (1)	73.33
2. Helping with the company's operations during the initial setting up	67 (2)	66.34	55 (2)	68.75	11 (1)	61.11	3 (3)	60.00	6 (3)	75.00	33 (1)	73.33
3. Training local management staff and implementing management localization policy	58 (3)	57.43	49 (3)	61.25	7 (3)	38.89	2 (6)	40.00	7 (1)	87.50	33 (1)	73.33
4. Demonstrating, coordinating, and leading in capabilities for the smooth implementation of management tasks	49 (4)	48.51	44 (4)	55.00	4 (4)	22.22	4 (1)	80.00	4 (4)	50.00	28 (4)	62.22
5. Contacting professionals located in Taiwan to solve manufacturing, technical or R&D-related problems	36 (5)	35.64	32 (5)	40.00	2 (7)	11.11	3 (3)	60.00	4 (4)	50.00	15 (7)	33.33
6. Instructing local workers in R&D issues	34 (6)	33.66	30 (6)	37.50	4 (4)	22.22	3 (3)	60.00	0 (7)	0.00	18 (5)	40.00
7. Creating technology exchange channels with existing Taiwanese partners	27 (7)	26.73	23 (7)	28.75	4 (4)	22.22	1 (8)	20.00	0 (7)	0.00	16 (6)	35.56
8. Encouraging technology exchange between Taiwanese and local technical staff	21 (8)	20.79	20 (8)	25.00	1 (8)	5.56	2 (6)	40.00	2 (6)	25.00	9 (8)	20.00
9. Others	1 (9)	0.99	1 (9)	1.25	0 (9)	0.00	0 (9)	0.00	0 (7)	0.00	1 (9)	2.22
Number of valid samples	102		83		19		5		8		45	

Note: * *Figures in parentheses denote the ranking of this particular influence on technology formation for the industry in question.*

Source: *Compiled for this study.*

As Table 5.17 shows, Taiwanese professionals contributed to manufacturing, management and the formation of R&D technology of Taiwanese businesses operating in China mainly through: (i) 'training and instructing of local technical staff' (67.33 per cent); (ii) 'helping with the company's operation during the initial setting up' (66.34 per cent); (iii) 'training local management staff and implementing management localization policy' (57.43 per cent); (iv) 'demonstrating, coordinating, and leading in capabilities for the smooth implementation of management tasks' (48.51 per cent); (v) 'contacting professionals located in Taiwan to solve manufacturing, technical, or R&D-related problems' (35.64 per cent); (vi) 'instructing local workers in R&D issues' (33.66 per cent); (vii) 'creating technology exchange channels with existing Taiwanese partners' (26.73 per cent); and (viii)'Encouraging technology exchange between Taiwanese and local technical staff' (20.79 per cent).

As regards individual industries, the manufacturing industries tend to think highly of Taiwanese professionals for 'training and instructing of local technical staff'; the service industries have high regard for their 'helping with the company's operation during the initial setting up'; the electronics, and electrical and mechanical industries praised their 'training local management staff and implementing management localization policy'; whilst the computer and telecoms industries thought highly of their abilities in 'demonstrating, coordinating, and leading in capabilities for the smooth implementation of management tasks'. What is worth noting is that the computer and telecommunications industries also approved of Taiwanese professionals' contribution in terms of 'instructing local workers in R&D issues' and 'contacting professionals located in Taiwan to solve manufacturing, technical or R&D-related problems'.

As indicated in the above study, the contributions made by Taiwanese professionals are manifold. They provide Taiwanese businesses in China with manufacturing, management, the formation of R&D technology, human resources, the exchange of technical information, and so on. Furthermore, during the process of technology transfer, the cultivation of suitable human resources also plays a vital role; this is especially true in the training of management and technical staff that are lacking in the developing countries. Therefore, in addition to bringing in technical know-how and taking on management and R&D tasks, Taiwanese professionals also bring about technology diffusion effects, including those felt in manufacturing and management technologies, because Chinese employees have little loyalty to their jobs and tend to change jobs frequently, making technology diffusion inevitable.

In summary, the Taiwanese professionals who moved to China took with them advanced manufacturing technology and modern management know-how. Through technology transfer and the movement of labor, what they have brought into China has already spread to other areas and is having a positive impact on advancing technology levels in China and upgrading its industries.

Empirical Analysis of Correlations between Taiwanese Technical Crew and Taiwanese R&D Expenditure in Mainland China

Whilst investment in R&D is often considered to be the major factor affecting the formation of technologies, Taiwanese investment in China involves the investment of both labor and money into R&D activities in order to seek the long-term development of their enterprises. In this subsection, we investigate the economic factors, such as the scale of the enterprise, the degree of market competition and the proportion of technical staff, which either directly or indirectly affect Taiwanese investment in R&D in China. We further investigate the possible relationship existing between the number of Taiwanese employees and the amount of Taiwanese investment in R&D in China using the following empirical model:

$$RD = b0 + b1CCP + b2TYPE + b3SIZE + \\ b4ESTY + b5CPT1 + b6CPT2 + b7HK + \varepsilon \quad (6)$$

In the above model, the dependent variable RD = Taiwanese investment in R&D expenditure in mainland China; HITECH = the industry type; TYPE = the investment style; SIZE = the scale of the enterprise; ESTY = the established year; CPT1 and CPT2 = the level of competition from the major products resulting from Taiwanese investment in China (in the Chinese and international markets, respectively); and HK = the human resources of the enterprise. A description of the definition and measurement of the variables in the model, and their anticipated influences on the RD variable is provided as follows.

■ **Dependent Variable**

R&D expense (RD): measured in US$ millions according to Taiwanese investment in R&D expenditure in China during 2000.

■ **Explanatory Variables**

Industry type (CCP)

CCP is a dummy variable, where CCP = 1 refers to computer/communication (2C) industries; and CCP = 0 refers to non-computer/communication industries.

In general, although constant progress is the only way to maintain survival in the 2C industries, enterprises must continue innovating new technologies through R&D. Hence, Taiwanese investment in China in the 2C industries is expected to involve greater expenditure on R&D; therefore, CCP and RD are positively correlated.

Investment type (TYPE)

TYPE is another dummy variable, where TYPE = 1 represents a joint venture or partnership; and TYPE = 2 refers to wholly-owned. TYPE has been applied to investigate whether or not investment type and R&D expenditure are correlated. As there is no evidence to support the existence of any significant link between these variables, no assumption on the correlations of these variables is made in this study.

Enterprise scale (SIZE)

Capital, turnover, number of employees and added value are the common factors involved in measuring the scale of an enterprise. As the survey results indicated that capital and turnover were highly correlated ($p>0.8226$), the scale of Taiwanese investment in China, expressed in US$ millions, is measured in terms of capital in the model. The correlations between enterprise scale and R&D have long given rise to controversy in the related literature; as Schumpeter (1950) indicated, enterprises of larger scale are more willing to engage in R&D activities, as the uncertainties and risks arising out of these activities can only be handled by large enterprises, which thereby virtually monopolized the market.

This suggests that the larger the scale of an enterprise, the greater the R&D strength it possesses, and the higher its R&D expenditure will be; however, the opposing argument suggests that once a large enterprise has dominated the market, it will not be motivated to innovate further, since it has no competitors in the market, and it will therefore simply enjoy its market supremacy whilst losing its market sensibility. Furthermore, as an enterprise grows larger, its operations and decision processes tend to become more rigid, thus lowering its overall efficiency, so it will tend to spend less on R&D than smaller enterprises. No assumptions are therefore made on the correlation between enterprise scale and R&D expenditure in this study, since such correlations will need to be investigated through further empirical studies.

Established year (ESTY)

ESTY, expressed in years, refers to the amount of time between the establishment and the point of measurement of Taiwanese investment in China. Since most Taiwanese investment focuses on the initial stage of manufacturing operations, investors will tend not to engage in R&D activities until they have accumulated adequate experience and knowledge from these operations. Accordingly, the greater the established year variable for an enterprise, the greater the probability that it will engage in R&D activities. Siddharthan (1992) indicated the opposite, since he believed that enterprises with a longer history would become less flexible and even rigid in their operations, which would hinder the progress of their R&D activities. In this study, however, we believe that the longer the history of Taiwanese investment in China, the greater the R&D expenditure, since they have greater demand and ambition to seek long-term operations for their investment in China. Therefore, we assume that ESTY and RD are positively correlated.

Market competition (CPT1 and CPT2)

This variable refers to the level of competition in Taiwanese investors' major product ranges in China in the domestic and international markets; respondents could choose the degree of competition at five levels, from (1) lowest to (5) highest. We assume that the keener the competition they face, the greater will be the likelihood of them progressing in their level of technology, otherwise, they would soon be eliminated from the market. Therefore, as they must constantly invest in R&D activities in order to maintain their leadership in technology, their R&D expenditure will naturally be higher. Hence, we assume that the keener the competition in the Chinese market CPT1 and international market CPT2, the greater the amount of R&D expenditure, thus CPT1 and CPT2 are positively correlated to RD.

Human resources (HK)

HK refers to the R&D technical crew available to Taiwanese enterprises in China, with the proportion of such technical crew amongst the total employees having been adopted in most of the literature. Whilst most of the Taiwanese technical crew working for Taiwanese enterprises in China possess specialized techniques and competencies, the 'proportion of technical crew,' 'proportion of Taiwanese technical crew' and the 'number of Taiwanese employees' working for Taiwanese enterprises in China are the indicators used for the human resources in these enterprises. These three variants are described below.

Proportion of technical crew (*TECR*). TECR refers to the total number of technical crew expressed as a percentage of the total number of employees, and provides the indicator of technology intensity within Taiwanese enterprises in China, i.e. the higher the TECR percentage, the greater the technology intensity, and the more the concern for R&D activities. Therefore, we assume that with an increase in the proportion of technical crew, enterprises will spend more on R&D activities, thus the TECR and RD variables are positively correlated.

Proportion of Taiwanese technical crew (*TWER*). TWER refers to the total number of Taiwanese technical crew expressed as a percentage of the total number of employees.

Number of Taiwanese employees (*TWEE*). TWEE refers to the total number of Taiwanese staff and technical crew working for Taiwanese enterprises in China.

The survey conducted during this study indicated that R&D work was one of the major functions of Taiwanese technical crew in Taiwanese companies in mainland China. The survey results also indicated that assistance in R&D activities was one of the major contributions of these employees; therefore, the greater the number of Taiwanese technical crew they employ, the greater the willingness to engage in R&D activities, and the greater their level of investment in R&D. However, as these technical employees possess specialized techniques and competencies, they will bring new technologies directly to their employers, and the R&D costs will be lowered; hence, employing Taiwanese technical crew can help to reduce the overall costs of investment in R&D activities. Whilst employing Taiwanese technical crew will be a trade off between new technology and R&D investment, verification of the correlations between the number of Taiwanese technical crew and the nature of the effect on R&D, either positive or negative, as presented in the model, is deemed necessary. Table 5.18 presents the variables, their definitions and anticipated impact in the model.

As the findings indicate, the availability of technical crew for R&D and investment in R&D activities are directly correlated. The explanatory variables TECR, TWER and TWEE were applied to measure the human resources of enterprises in Model 6; the relevant empirical results are presented in Table 5.19. As the table shows, R&D expense and enterprise scale (capital) are correlated. The empirical results also indicate that the greater the SIZE (capital) variable, the higher the RD variable presented in all models.

Table 5.18 Description of variables used in the empirical model of RD costs for Taiwanese investment in China

Variables	Variable Definition	Method of Evaluation	Mean (Standard Deviation)	Anticipated Impact
Dependent variable				
RD	RD expense	RD expense in 2000 (US$ millions)		
Explanatory variables				
CCP	Industry Type	Dummy variable: miscellaneous = 0; Computer/ telecommunications = 1	0.0784 (0.2715)	+
TYPE	Investment Type	Dummy variable: Wholly-owned = 0; Joint Venture = 1	0.2745 (0.4507)	?
SIZE	Enterprise Scale	Capital (US$ millions)	1436.1367 (5134.4584)	?
ESTY	Established Year	Duration between establishment and the time of survey (year)	5.9216 (3.1038)	+
CPT1	Competition in the China market	Lowest-Highest (1-5)	3.6400 (1.2249)	+
CPT2	Competition in the International Market	Lowest-Highest (1-5)	3.0476 (1.3058)	+
TECR	Proportion of Technical Crew	Total number of technical crew/total number of employees (%)	30.7776 (24.9520)	+
TWER	Proportion of Taiwanese Technical Crew	Total number of Taiwanese technical crew/total number of employees (%)	10.3182 (14.7294)	?
TWEE	No. of Taiwanese Employees	Total number of Taiwanese employees	5.6735 (9.2136)	?

Such results concur with the Schumpeterian view. Moreover, positive correlations between TYPE and RD are observed from the empirical results, suggesting that joint ventures would spend relatively more on R&D activities, since the SIZE variable for joint ventures is usually greater, and these organizations will possess greater R&D strength than wholly-owned Taiwanese investor companies in China.

Table 5.19 indicates that CCP and RD are correlated, which suggests that enterprises engaging in computer and telecommunication manufacturing would spend more on R&D activities in order to maintain their leadership in the business. Our empirical results also indicate that ESTY and RD are correlated, i.e. the longer the history of an enterprise, the greater the amount they will invest in R&D activities, since it will be easier for these enterprises to engage in R&D activities once they have accumulated adequate experience and knowledge.

Table 5.19 OLS estimations of the determining factors affecting the RD costs of Taiwanese firms investing in China

Explanatory variables		Model (1)	Model (2)	Model (3)	Model (4)
Constant (CONST)		-256.72080 (-1.95)*	-262.52213 (-2.09)**	-303.71248 (-2.37)**	-188.76495 (-2.11)**
CCP (computers/telecommunications)		160.47842 (1.69)*	177.35961 (1.96)**	174.29571 (1.90)*	157.27751 (2.45)**
TYPE		159.86558 (2.46)**	151.83549 (2.31)**	159.47155 (2.44)**	103.63146 (2.22)**
SIZE (capital)		0.01658 (2.98)***	0.01792 (3.35)***	0.01692 (3.17)***	0.00810 (2.02)**
ESTY		23.19906 (2.48)**	16.07143 (1.81)*	20.60102 (2.17)**	16.69112 (2.49)**
CPT1		-14.93031 (-0.49)	16.07143 (0.65)	4.29575 (0.14)	-31.71374 (-1.53)
CPT2		24.01096 (1.02)	9.43117 (0.43)	17.00642 (0.74)	24.43290 (1.52)
HK	TECR	2.83227 (2.57)**	-	1.78060 (1.49)	2.24782 (2.93)***
	TWER	-	5.71635 (3.07)***	4.34572 (2.13)**	-
	TWEE	-	-	-	14.11128 (6.15)***
N		51	51	51	51
R^2		0.5694	0.5952	0.6284	0.8164
Adjusted R^2		0.4690	0.5008	0.5222	0.7639

Notes:

[a] Although 102 copies of the questionnaire were returned, half of the respondents did not fill out the RD expense item; therefore, only 51 valid observations were available.

[b] Values in parentheses are t value.

[c] * indicates p<0.1; ** indicates p<0.05; *** indicates p<0.01.

Apart from these variables, variables TECR, TWER and TWEE were also applied to measure HK in these enterprises, as presented in Table 5.19, so as to investigate the correlation between HK and RD. Significant correlations were observed between TECR, TWER and RD; although significance was observed only between TWER and RD in the regressions, as TECR and TWER are alternatives to one another (p = 0.3945 as presented in the survey). Whilst TECR and TWEE have little correlation, positive and significant correlations were observed between TECR and RD, and TWEE and RD in the regressions. These results show that the greater the HK, the greater the RD capacity, with

TWER and RD being positively correlated.

The findings further suggest that the major source of technology for Taiwanese enterprises in China comes from Taiwanese technical crew. Within the survey, the respondents were asked: "Will obtaining technology from Taiwanese technical crew be of considerable help in saving R&D funds?" The statistics show that 37.37 percent of respondents answered positively, 41.41 percent believed it was possible, 15.15 percent considered that it was less possible, and 6.06 percent disagreed. Hence, 78.78 percent of respondents believed that employing Taiwanese technical crew could be of considerable help in saving R&D funds. However, empirical analysis of the factors affecting R&D expenditure by Taiwanese investors in China indicate that the greater the number of Taiwanese technical crew, the higher the level of R&D expenditure. This suggests that Taiwanese technical crew have a more positive than negative effect on R&D expenditure. The reason for this contradiction is that, although Taiwanese technical crew can help save R&D funds by bringing technologies to the enterprises, the enterprises would then encourage these employees to engage in R&D with these technologies. Consequently, there would be an increase in R&D expenditure. In sum, Taiwanese enterprises in China obtain their technologies from Taiwanese technical crew and improve this technology through R&D activities guided by these employees, in order to create new technologies.

5.5.4 Section Summary

As Taiwanese enterprises in China usually employ (assign) experienced Taiwanese management staff or technical crew to support the operations and development of their subsidiaries in China, Taiwanese enterprises in Shanghai were surveyed to investigate the role of Taiwanese technical crew in the formation of technology within these enterprises. Our empirical results indicate that the Taiwan parent companies of these enterprises were the major source of technology supply, with Taiwanese technical crew being the second major source. What is noteworthy is that some contributions, in the form of self-development activities, also came from Taiwanese technical crew. In general, although Taiwanese technical crew may not be the major source of technology for Taiwanese enterprises in China, they are an important source that should not be overlooked.

The findings also indicated that the contributions made by Taiwanese technical crew were wide-ranging, including know-how in manufacturing, management and R&D, human resource training and technology exchange. Furthermore, when these employees outflow to China, they take with them advanced production techniques and modern management know-how to the Taiwanese enterprises in China and help them to develop their technical capacity, which will subsequently promote their technological advancement and industrial upgrading in China through technology transfer, circulation of the labor force and the spread of this know-how to other parts of China.

Within the model, investigation of the factors affecting the number of Taiwanese technical crew employed in Taiwanese enterprises in China indicated that enterprise characteristics, such as technology intensity, enterprise scale, established year and local market competition would affect the number (proportion) of Taiwanese technical crew employed by these enterprises. The results showed that the bigger the scale (higher turnover), the longer the history, and the keener the local competition, the less such Taiwanese technical crew would be employed. However, the empirical analysis indicates that the more technology-intensive the enterprise, the greater the proportion of Taiwanese technical crew. These factors are significantly and positively correlated. Amongst all possible reasons for this, technology intensity is the most important and influential variable.

Moreover, the empirical results of the factors affecting R&D expenditure amongst Taiwanese enterprises in China indicate that R&D expenditure and human resources, enterprise scale (capital), investment type, established year and industry type are correlated. Enterprises with greater human resources, larger scale (higher capital) or longer history would also be likely to promote R&D activities more easily, and their R&D expenditure will be higher. Amongst all possible reasons for this, the most important and influential variable is human resources, with Taiwanese technical crew and R&D expenditure being significantly and positively correlated. In sum, Taiwanese enterprises in China obtain their technologies from Taiwanese technical crew and improve such technology through R&D activities guided by these employees, in order to create new technologies.

5.6 Conclusions

The main purpose of this chapter has been to describe the study undertaken to investigate the correlation between clusters in Silicon Valley, Hsinchu and Shanghai, and the interaction between high-level technical crew circulating within these clusters. The findings indicate that the interaction of these clusters is changing constantly over time alongside the movement of industry. Practically speaking, the Hsinchu Science-based Industrial Park, which opened at the end of the 1970s, marked the start of a new industrial cluster which was very different from other existing industrial clusters in other parts of Taiwan, since industrial clusters in Taiwan had been centred on export processing zones (EPZ) prior to the establishment of the park. As the first oil crisis at the beginning of the 1970s awoke Taiwanese awareness of the relatively low output value of EPZs – which were unable to cope with the rapid growth in technology – the park thus came into existence. In order to encourage R&D activities, enterprises within the park are required to reach a certain level of R&D investment. What is also noteworthy is that the National Science Council is the competent authority for the park, as opposed to the Ministry of Economic Affairs (MOEA), which means that the purpose behind establishing the park was more to promote technological upgrading and thereby to enhance the added value of industry.

In order to achieve these goals, the park began headhunting from Silicon Valley; thus, the success of the park is correlated to the development of the Valley. Personal data on the employees working within the park indicates that a high proportion of them are Chinese Americans. Moreover, many of the senior engineers and technical crew working within the park have also studied in the US. All this suggests an intimate relationship between the park and Silicon Valley.

By contrast, the development of Shanghai began much later. It was not until the beginning of the 1990s that the Chinese government began the process of reengineering in Shanghai, including improvements to various areas of infrastructure; this then marked the opening of a new chapter of industrial development in Shanghai. Following the massive movement of Taiwanese enterprises into China and the discovery of the excellent new investment conditions in Shanghai in the mid-1990s, Taiwanese investors began to move their bases from the Zujing Delta to the Yangtze Delta. Such movement also marked a change in industrial clustering in China. Following this increased investment in Shanghai by Taiwanese investors, the city has become the new haven for Taiwanese high-tech industries. The city clearly also attracts investment from other countries, so it is making every effort to transform itself into a new business, financial and manufacturing centre, in order to connect with the world economy. All this indicates that both the park and Shanghai are putting effort into developing a complementary relationship with the economic activities and industrial clusters in the rest of the world. Moreover, many enterprises within the park have initiated investment plans in Shanghai, which suggests that the complementary relationship between the park and the city is growing rapidly.

As indicated in the findings, high-tech crew move rapidly and efficiently, and this movement from Silicon Valley to the park and then into Shanghai will direct the future development trend of the entire industry and rock the competition between the park and Shanghai in the future. Furthermore, alongside industrial development, the movement of people is correlated to the social, family and economic development of a country. Therefore, the government should seek to create an environment with well-established infrastructure for industrial development and human settlement. Within the park for example, the Taiwanese government has opened bilingual schools to provide education for the dependents of overseas technical crew. The findings also show that the Chinese government's attempts to improve public construction and to provide suitable education for the children of Taiwanese investors are key factors affecting decisions on long-term development in China by these investors. Therefore, macroeconomic conditions, particularly the educational facilities for their dependents, are a key factor with regard to attracting high-tech employees.

Overseas high-tech employees make a significant contribution to local industrial development. As indicated in the study, such employees have made significant contributions to the technological upgrading of enterprises within the park. In addition to R&D activities, such employees also help enterprises to recruit other similar high-tech workers, which of course can help to enhance the efficiency of the enterprise's R&D activities. The enterprises themselves also provide education and training for other employees so as to strengthen their overall R&D capacity.

Our investigation has shown that Taiwanese technical crew can help (i) to instruct and train local technical crew; (ii) to operate the enterprise during the initial setting up phase; (iii) to train management staff and localize management policies; (iv) to coordinate and lead local employees in completing management work; (v) to solve production, technical and R&D-related problems through communication with experts in Taiwan; and (vi) to instruct local technical crew in R&D activities. Hence, Taiwanese investors have made significant contributions to the training of local technical crew and to improvement in local R&D capacity. The findings further indicate that the increase in Taiwanese technical crew has led to a significant increase in R&D expenditure by Taiwanese investors in China, thus demonstrating that Taiwanese technical crew and R&D expenditure by Taiwanese enterprises in China are significantly and positively correlated.

In sum, whether employing overseas technical crew in enterprises within the park or Taiwanese technical crew in Taiwanese enterprises in China, these technical employees can help to improve the technical level of the host enterprise, to train their employees, and to subsequently promote the formation of local industrial clusters, which will, in turn, make a significant contribution to improvements in the level of competitiveness for the host country.

Chapter 6 Cluster and Labor Force Dynamics: Human Resources and Structural Change of the Labor Force in the HSIP

6.1 Introduction

The literature related to analysis of the labor market of industrial clustering is relatively sparse, although the effect of labor pooling on agglomeration has been highlighted ever since Marshall's early study (Marshall, 1890). A more recent study by Rosenthal and Strange (2001), using data on the U.S. manufacturing industry, also found that labor market pooling has the most robust effect on influencing agglomeration at all levels of geography in the United States (see p.3 in the mid-term report, 2003/8). However, it specifically refers to the pooling effects of skilled labor on agglomeration. As our introduction chapter indicates as well, skilled labor is one of the most critical ingredients to start a industrial cluster and even maintain its competitive advantage, sources of a skilled labor force, incentives/channels/mechanisms, or even milieus to attract a skilled labor force, and their contribution to innovative activities has become critically important for the initiation and sustainability of a cluster. Therefore, studies on the labor market or labor force of an industrial cluster tend to focus on these aspects.

Among those in the literature, empirical studies on latecomers or new clusters in the world economy tend to emphasize the contribution of the exogenous source of the highly-skilled labor on cluster formation and the effects of this labor force on technology spillover in that particular cluster. For example, the reverse brain drain and overseas Chinese connections have been identified to have a significant contribution on Taiwan's high-tech industrialization and the success of the Hsinchu Science-Based Industrial Park

(HSIP) (Mathews, 1997; Hsu, 1997; San & Su, 2002; Tsai & Tai, 2002; Saxenian & Hsu, 2000; Hsu & Saxenian, 2001; Pack, 2001). Although the upgrading of its domestic labor force quality and their ability to generate new knowledge have been well recognized (Pack, 2001), identifying the contribution of the domestic labor force remains neglected in studying the competitiveness of the late coming high-tech cluster, such as that in the Hsinchu region. In short, the literature that particularly bridges the human resources and industrial cluster enhances too much on the exogenous infuses of the highly-skilled labor force to the formation and even the success of an industrial cluster. It is quite surprising and arguable that the structure of the labor market and its dynamic has drawn little attention for analysis in the current literature.

Some studies in the literature did notice the lack of labor-market analysis and have tried to call attention on this aspect to study the high-tech agglomeration (Malecki, 1989; Angel, 1989; Angel, 1991). This vein of investigation is interested in studying how the labor market has successfully facilitated the flexible production system for a certain industrial district of the post-Fordism regime. For example, Angel's study focused on examining local labor-market dynamics and their relation to the organization of a production system in Silicon Valley (Angel, 1991). There are also research studies examining the effects of a clustered high-skilled labor force and its fluid nature of the labor market to allow the high intensity of internal mobility for the technical community, especially in job-hopping. This generates prominent effects on enhancing the quick diffusion and learning of technology and, in turn, to consolidate the stickiness of a particular cluster. These studies more or less use Silicon Valley as a prototype of an industrial cluster, which is unable to represent the diversities of industrial bases and differential paths of development for different industrial clusters all over the world.

The HSIP, eversince it was established in 1980, has been undergoing different stages of development and has kept up its dramatic growth during the 1990s. In addition to the contribution of overseas returnees, the domestic high-tech labor force has been playing a far more significant role in creating the second Taiwan miracle, namely the high-tech development in the world market, representing the expansion stage for HSIP's development. It is quite critical to understand how the domestic technical community contributes to sustain HSIP's global competitiveness, as it can demonstrate significant policy implications for other industrial clusters to achieve their relative autonomy and self-sustainability in this highly competitive and spatially-linked global market. Nevertheless, this issue has been greatly neglected by the literature of industrial clustering.

The purpose of this chapter is to provide a descriptive analysis and discussion on the changes of labor force structure and quality in the HSIP along with its developmental path. This topic in the project aims at providing a more historically dynamic picture to understand the internal development of a high-tech cluster in this extreme globally-connected market based on the analysis of labor force structure. Hopefully, it will generate more deliberative ideas in sharing development experiences among APEC members either at different stages or on different tracts of high-tech development.

This chapter focuses mainly on HSIP's labor force and its changes through different developmental stages based on aggregated data. It looks at how the sources and composition of human resources have changed through time and among different industries in the HSIP. It indirectly reflects that there are differential roles for the returnees and the domestic high-tech labor force in different industries and at different stages of development.

6.2 Structure of HSIP's Labor Force

Owing that the HSIP in Taiwan has a distinctive nature of high-technology industrialization, highly-skilled and young labor forces are the major compositions for its human resources (Table 6.1). Through the end of 2002, there were 98,616 employees in total in the park, not including foreign labor. Employees with PhDs and master degrees accounted for around one-fifth of the total labor force. Two-thirds of the labor force have higher than a college degrees. The quality of the labor force in general is significantly higher than other regions on the island that provide labor forces with high educational levels (Table 6.2). This high-tech cluster also attracts a concentration of relatively young labor force with an average age of only 32 years old. Eighty-seven percent of employees are in the age category of twenty to forty years old.

Looking at the distribution of labor force by industry, we find that more than half of the total employees are hired in the sector of integrated circuits. In addition to this leading industry, opto-electronics and computers & peripherals are the other two industries using more labor force, followed by telecommunications. Employees for precision machinery and biotechnology are both less than 1,000 ersons. Although the distribution of labor force by industry provides an aspect to examine the industrial structure of the HSIP, it is not necessary to show their relative contribution to the competitiveness and sustainability of the cluster. We will come back to this point in the later part of this chapter.

Table 6.1 Educational levels and age structure of employees in the HSIP, 2002

Education	Items	Total	Ph.D.	Master	Bachelor	Junior college	High school	Others
	Employees	98,616	1,210	17,967	21,690	24,433	27,202	6,114
	Percentage	100.00	1.23	18.22	21.99	24.78	27.58	6.20
Average age: 32.01								
Age	Items	Total	14-19	20-29	30-39	40-49	50-59	Others
	Males	48,750	361	16,103	25,436	5,749	970	131
	Females	49,866	994	27,177	17,076	4,115	480	24
	Total	98,616	1,355	43,280	42,512	9,864	1,450	155
	Percentage	100.00	1.37	43.88	43.10	10.00	1.47	0.18
Industry	Items	Total	Integrated circuits	Computers & peripherals	Telecom-munications	Opto-electronics	Precision machinery	Bio-technology
	Total	98,616	60390	12,813	6,869	16,939	893	712
	Percentage	100.00	61.2	13.0	7.0	17.2	0.9	0.7

Source: The Hsinchu Science-based Industrial Park Quarterly Statistical report, 2002/12 (The Hsinchu Science-based Industrial Park Administration).

Table 6.2 Educational levels in percentage for total labor forces in selective regions of Taiwan, 2002

Regions	PhD & Master	Bachelor	Junior college	High school	Others
The HSIP	**19.45**	**21.99**	**24.78**	**27.58**	**6.20**
Taipei City	4.08	20.11	15.31	28.86	31.64
Hsinchu City	4.80	15.42	13.42	29.62	36.74
Hsinchu County	1.77	9.33	12.56	32.95	43.39
Taichung City	2.55	15.17	16.44	34.11	31.73
Kaoshiung City	2.21	13.28	14.86	34.07	35.58
Whole region	**1.48**	**9.76**	**12.05**	**31.97**	**44.74**

Source: Urban and Regional Development Statistics, 2002 (Urban and Housing Development Department, Council for economic Planning Development, Executive Yuan)

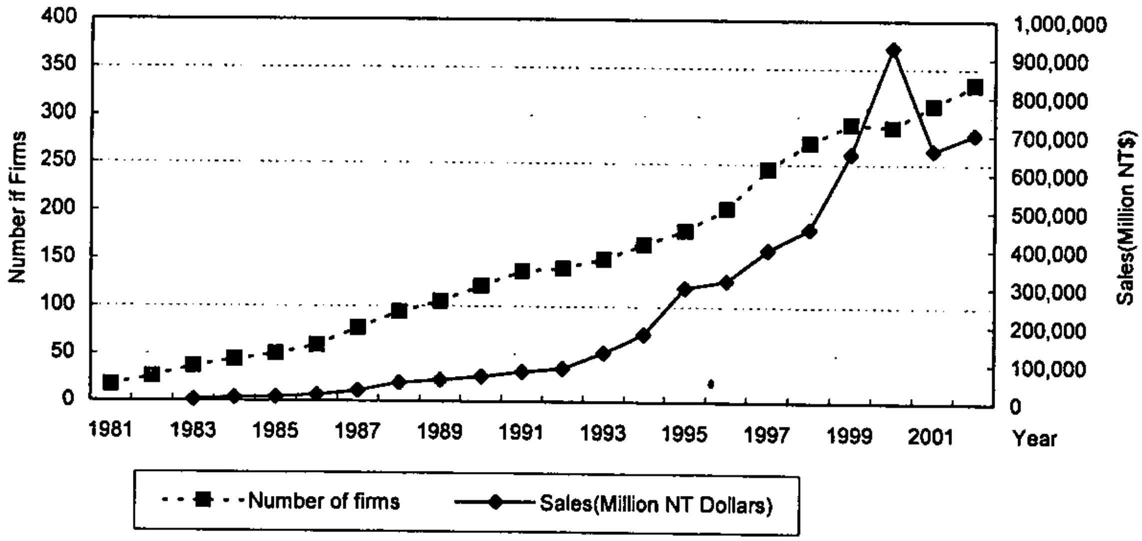
6.3 Dynamic of the HSIP's Development

Although the HSIP has been admired as the "Eastern Silicon Valley" and has contributed much to the "Second Taiwan Industrial Miracle" in terms of overall sales, it is now facing another stage of development. For the past few years, one can see that a significant number of high-tech firms based in the

HSIP have accelerated their investment in China. Along with the rapid growth of China's economy, a new map for the global linkages of high-tech clusters is emerging (see other chapters for a detailed discussion). This new trend of a high-tech division of labor definitely has great influence on HSIP's future development. If we look at the past developmental tract of the HSIP, we can also find that its growth rate has moderated since the year 2000, which is not surprising for most industrial clusters after an expansion stage. The competitiveness of a high-tech cluster is rooted in its capabilities of innovation. Taiwan, in particular, is well known by its capability in technology learning. Although this is not the subject of this chapter, in this part we try to examine how the dynamics of a labor force structure shows a growth path with this high-tech cluster.

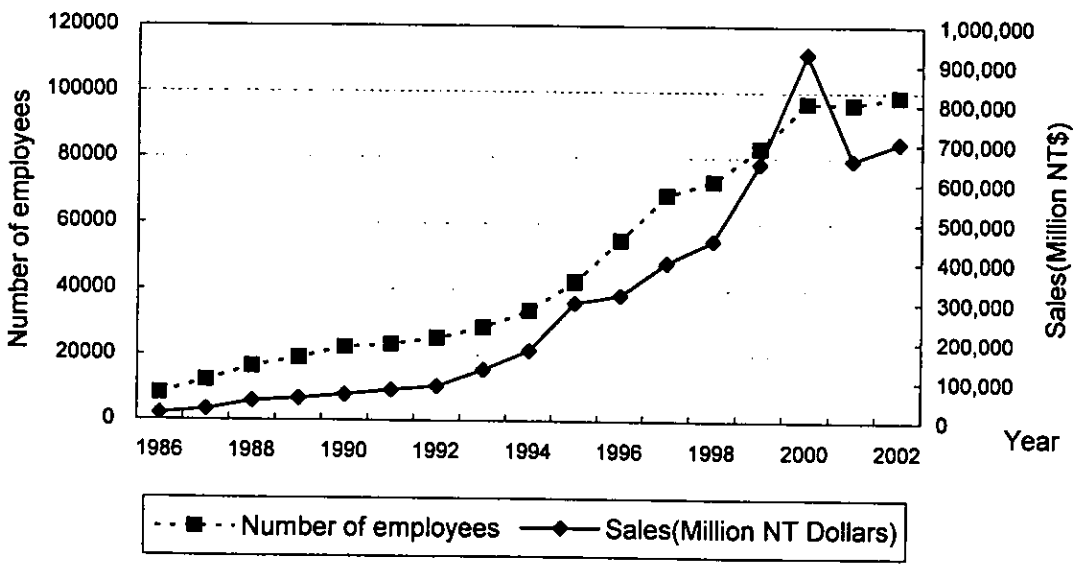
The HSIP at any rate provides an important lifeline for Taiwan's industrial base. Its overall sales in 2002 were 705.453 billion NT dollars, which accounted for 35.28% of the island's total manufacturing output. For the past twenty years, it has been undergoing different stages of development. If we ignore the abnormal ascent of overall sales for 1999 and 2001 so as to smooth the curve (Figure 6.1. and Figure 6.2), we can divide the development of the HSIP into three stages differentiated at 1987/88 and 1993/94 with references to Lou & Wang (2002) and Chen (2003). Lou & Wang (2002) divided the development of the HSIP into three periods based on the growth curve of sale values, with a starting period (1981-87), growing period (1987-1993), and transferring period (after 1993). It is coincident with the developmental stages based on trajectories of technology learning/development for the integrated circuit industry in Chen's study (2003), which include preparation (before 1974), technology import (1975-79), technology absorption and diffusion I (1979-82), technology absorption and diffusion II (1983-1988), technology deepening (1989-94), technology widening (1995-2000), and after

2000. This is because the industry of integrated circuits has contributed the largest share of the overall sales in the HSIP since the mid-1980s. Comparing Figure 6.1 and Figure 6.2, the trend in employee growth is more synchronized with the growth of the overall sales than the firms are to overall sales.



Source: The Hsinchu Science-based Industrial Park Annual Statistical Report (The Hsinchu Science-based Industrial Park Administration).

Figure 6.1 Growth of firms and annual sales for the HSIP, 1981-2002



Source: The Hsinchu Science-based Industrial Park Annual Statistical Report (The Hsinchu Science-based Industrial Park Administration).

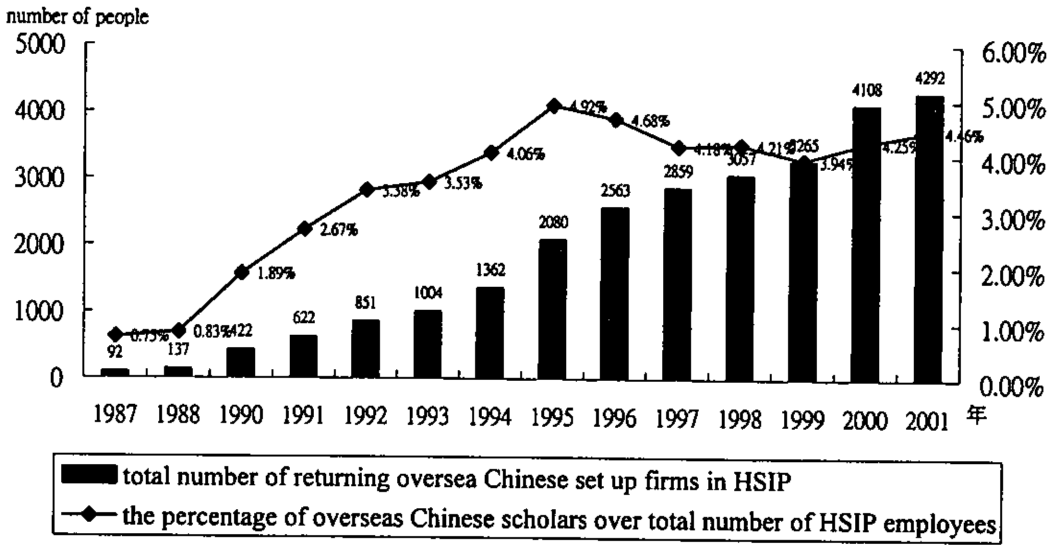
Figure 6.2 Growth of employees and annual sales for the HSIP, 1981-2002

6.4 Effects of Overseas Returnees on Human Resources of the HSIP

If a highly-skilled labor force is one of the most critical factors for the formation of a high-tech cluster, then successfully attracting overseas Chinese back to Taiwan has been admired as one of the deliberative policies by government here to achieve the successful development of a high-tech industry and the HSIP (Mathews, 1997; Lin, 1997). Many studies have well documented the contribution of overseas returnees to the success of the HSIP (Luo & Wang, 2002; San, 2002; Tsai & Tai, 2001; Hsu, 1997; Xue, 1997). Some have emphasized especially on their contribution to technology transfer and diffusion. Others highlight social capital, such as entrepreneurship and ethnic ties that enrich the entrepreneur milieu of the HSIP and intensify the spatial linkages between Hsinchu and Silicon Valley through ethnic ties.

The effects of overseas returnees on technology transfer and diffusion have been identified as the most critical factor for their contribution to the late coming high-tech cluster, such as in the HSIP since the very beginning. However, their composition in the overall human resources and their contributions need to be examined and clarified in more detail for several reasons.

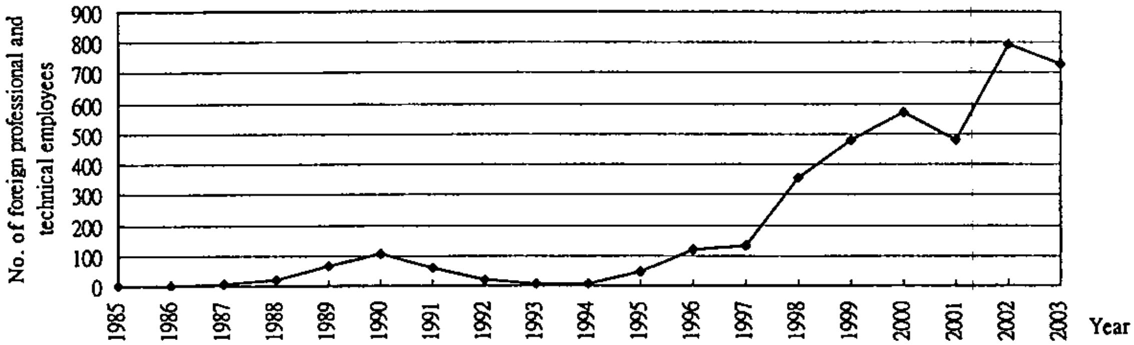
One reason is due to limited supply of Chinese high-tech human resources abroad, especially from the United States. Although the number of students who went abroad for degrees and returned has kept increasing for the past three decades, for those returning to Taiwan the proportion of natural science degrees has been dropping significantly from 56.4% in the 1970s, to 40.7% in the 1980s and 35.9% in the 1990s???(Tsai & Tai, 2001). We can easily find that a fair amount of Chinese engineers now in Silicon Valley are from mainland China rather than from Taiwan. Another reason is the competition of high-tech human resources among different industrial clusters. With the rapid emergence and growth of China's economy, Hsinchu is facing severe competition from Shanghai for high-tech human resources with Chinese ties. In short, a reliance on overseas returnees for technology transfer and diffusion may have its limitation due to competition in supply.



Source: Wang, et. al. (2002), pp.2-16.

Figure 6.3 The trend of overseas Chinese returning to HSIP to work, and the ratio over total number of employees in HSIP

From Figure 6.3, we see that the total number of returnees who went back to set up firms in the HSIP have kept increasing for the past two decades, from 92 in 1987 to 4,292 persons in 2001. In 1995, the number had a significant jump from 1,362 to 2,080. Nevertheless, the proportion of overseas returnees to total employees started to drop since then and has stayed at the range between 4.92% to 3.94%. If a reliance on the external influx of technology via human capital, i.e. that focused on discussing the human embodied technology, is an inevitable nature for a late coming high-tech cluster, then we can find that foreign professionals and technical employees have kept increasing steadily and significantly since 1995 as well. The highly-skilled human resources are not only from technology-advanced countries, but also from neighboring developing countries. Both indicate that there was some significant change in the HSIP in terms of human resources after the year 1995, at the stage of expansion or technology widening as discussed in the previous section.



Source: The Hsinchu Science-based Industrial Parks Administration

Figure 6.4 Foreign professionals and technical employees in the HSIP, 1985-2003

Table 6.3 Nationality of foreign professionals and technical employees in the HSIP, 2003/10

Nationality	U.S.	Japan	Malaysia	Korea	Philippine	Singapore	India	UK	German	Canada	France	Russia	Others
Total	199	122	87	60	39	37	30	29	16	16	15	13	64

Note: Nationality listed out, if more than 10 persons
Source: The Hsinchu Science-based Industrial Parks Administration

San's recent study (2001) demonstrates the contribution of overseas Chinese has varied in different job types and industries, which provides us a clearer and more detailed picture. Generally speaking, overseas returnees have the greatest contribution on product development and modification, and have less contribution in product sales and different types of management. In the job types of product development and modification, their importance has been highly recognized by the industries of integrated circuits and biotechnology, followed by precision machinery, telecommunications, and computer & peripherals. San's study demonstrates that a firm's characteristics, such as technology intensity, R&D input, and situation in market competition, all will influence a firm's tendency at hiring overseas returnees. A firm with a higher technology intensity tends to hire more overseas returnees. On the hand, a firm having more R&D input tends to hire less overseas returnees. Finally, for a firm in severe market competition and in a mature industry, the less overseas returnees seem to be able to contribute.

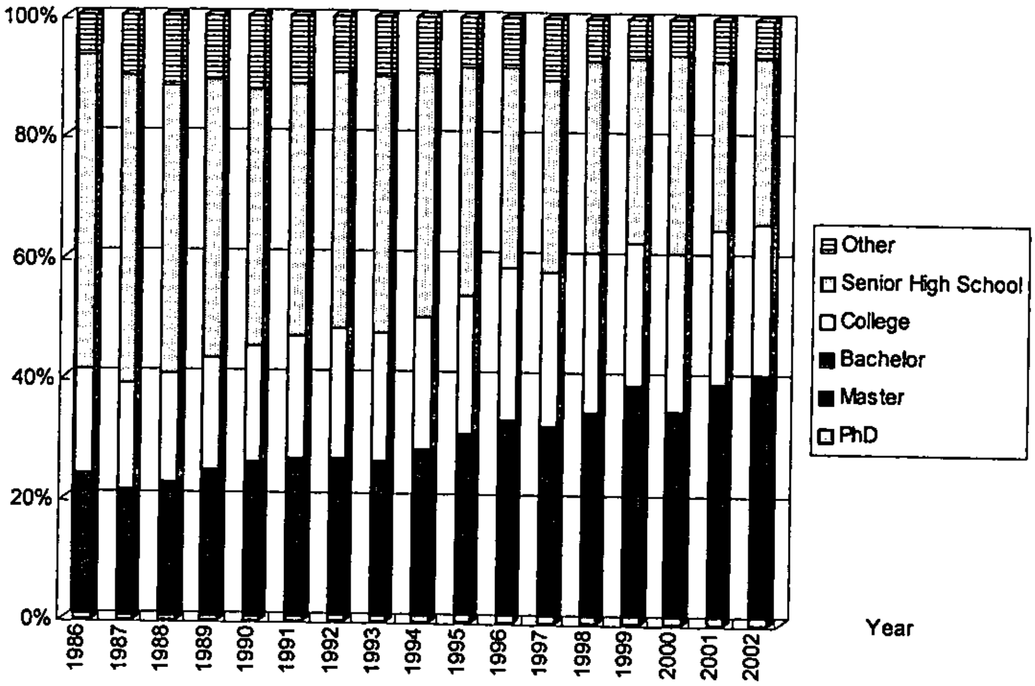
The contribution of overseas returnees to the development of the HSIP has been highly recognized since the early 1980s. The total number of returnees has kept increasing along with the growth of the HSIP. However, their proportions in the total labor force have begun to stabilize and even drop since 1995. Their contribution is mainly in technology transfer and diffusion, or more specifically, in product development and modification. Their employment and contribution vary among industries in the HSIP. As a result, the domestic labor force has played a far more important role in the success and future sustainability of the HSIP, which has not been fully documented by the literature. It is necessary to understand the contribution of the domestic labor force, so as to differentiate the structure of the labor force among industries.

6.5 Contribution of Domestic Labor Force

As indicated earlier, the HSIP has attracted the most intelligent manpower in Taiwan (Table 6.2). Looking at human resources in the HSIP by educational level, we find that the proportions of master degrees and junior college degrees have kept increasing since the mid-1980s and the proportions of senior high school degrees and others have decreased significantly. It is very clear that the labor force with a lower educational level, especially high school degrees, has been upgraded and replaced by junior college educated employees. In addition, employees with master degrees have become more significantly the backbone of the R&D labor force in the HSIP (Table 6.4).

To examine the composition of the current labor force in the HSIP, we find that there are nearly equal proportions of employees with foreign and domestic PhD degrees. Nevertheless, domestic master degree holders are the most important highly-skilled labor force in the HSIP, no matter in terms of amount or proportion.

There is no basic research nor systematic database that can be used to trace the differential contribution of domestic and foreign experts in the HSIP. A preliminary study by Chiu et al (2003) tried to test whether employees of the HSIP with foreign or domestic PhD degrees or their interactions have significant effects on increasing the numbers of patents and productivities for the HSIP. Their study temporarily concluded that foreign PhD employees seem to make a greater contribution than those with domestic PhDs on patenting, but there is no strong evidence on productivity. They also indicate that evidence from the impact of returnees on productivity is quite weak. At any rate, based on descriptive data and an exploratory study, such as Chiu et al (2003), there is no strong evidence to prove that the competition and continuous growth of the HSIP, a high-tech cluster, highly rely on the influx of an external labor force, although the numbers of overseas returnees, such as foreign professionals and technical employees, keep growing.



Source: The Hsinchu Science-based Industrial Park Annual Statistical Report (The Hsinchu Science-based Industrial Park Administration).

Figure 6.5 Structure of labor forces by education in the HSIP, 1986-2002

Table 6.4 Human resources by education in the HSIP, 2002

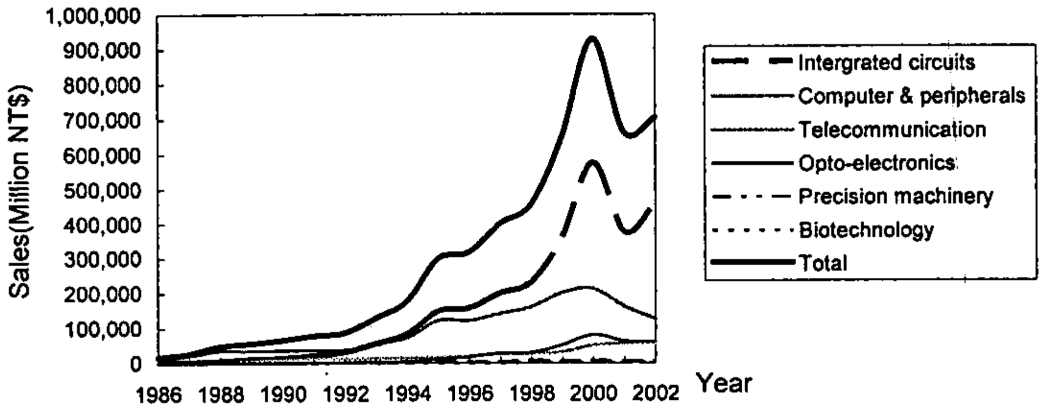
Education	PhD	Master	Bachelor	Junior college	High school	Others	Total
Domestic degree	627	14,266	18,277	23,611	26,612	6,060	89,453
Foreign degree	583	3,701	3,413	822	590	54	9,163
Total	1,210	17,967	21,690	24,433	27,202	6,114	98,616
Percentage	1.23	18.22	21.99	24.78	27.58	6.20	100.00

Source: The Hsinchu Science-based Industrial Park Administration

6.6 Cluster Dynamics and Differences among Industries

As for the nucleus of the Hsinchu high-tech cluster or Hsinchu-Taipei high-tech corridor, the HSIP has shown dramatic changes not necessarily in terms of industrial compositions, but in terms of industrial structure along with its development. Although the industries of integrated circuits and computers

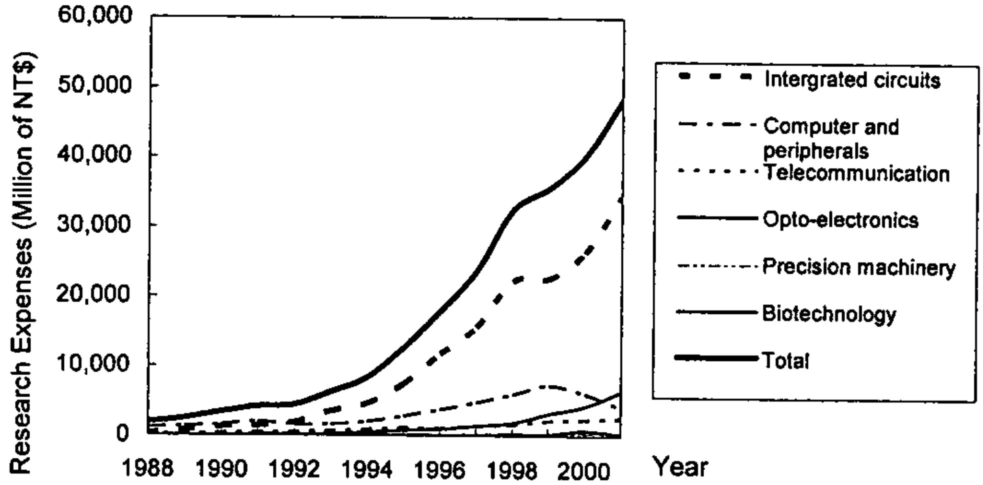
& peripherals have long been two major sectors in the HSIP since the mid-1980s, in 1993 integrated circuits started to supercede computers & peripherals in terms of overall sales and became the leading industry in the HSIP. We can also see that the overall sales for computers & peripherals began to decrease significantly. In the late 1990s, two industries, telecommunications and opto-electronics, both had marked growth as well. However, the growth trend of opto-electronics followed that of computers & peripherals for a little bit, though not significantly. This trend reflects the increasing path of the outward movement of the more labor-intensive part of those two industries to China according to our field investigation in China. This is also because computers & peripherals, as with a part of the opto-electronics industry, have more to do with the final end products and are more subject to market competition than others.



Source: The Hsinchu Science-based Industrial Park Administration

Figure 6.6 Changes of overall sales by industry in the HSIP, 1986-2002

This trend can be compared with the trends of R&D expenditures by industry in the HSIP. We find that the integrated circuit industry is the most technology-intensive of all. The R&D expenditures for computers & peripherals have not increased significantly along with the development of the HSIP and even dropped in the late 1990s, though it has long been the second major industry in the HSIP.

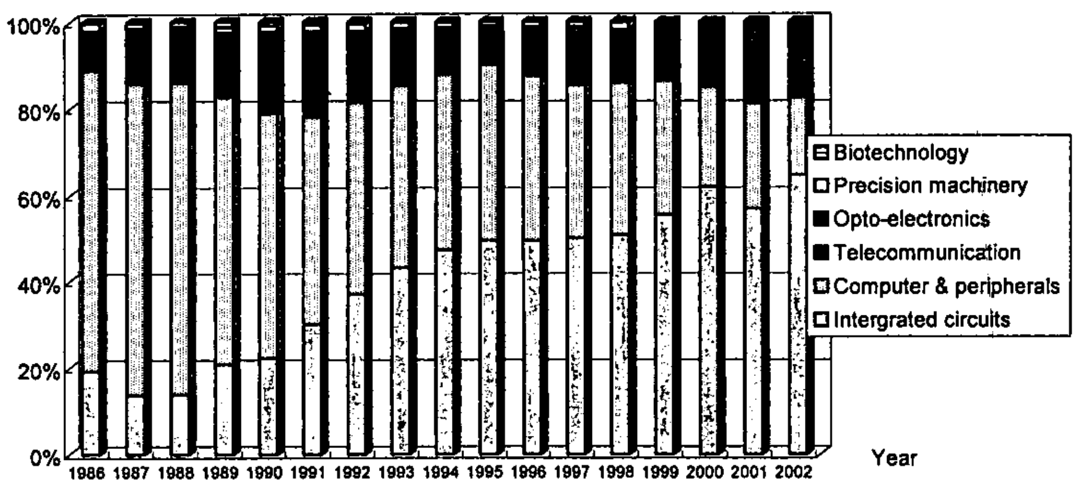


Source: The Hsinchu Science-based Industrial Park Administration

Figure 6.7 Changes of R&D expenditures by industry in the HSIP, 1988- 2002

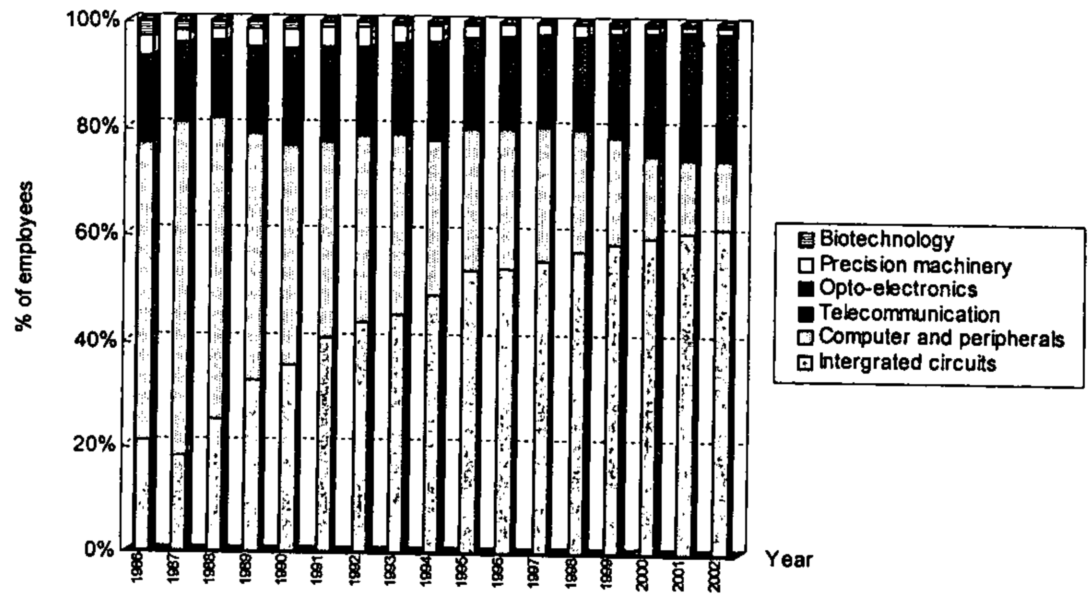
The relative importance of the industries in the HSIP, or industrial structure of the HSIP, can be seen from the following two figures (Figure 6.7 and Figure 6.8). Coinciding with the above discussion on stages of development for the HSIP, proportional changes of overall sales and employees both can be identified by periods differentiated by 1987/88 and 1993/94. Definitely, both trends are induced by the dynamics of the integrated circuit industry. Relatively speaking, in the first half decade of the 1990s both the proportion of overall sales and proportion of employees for the integrated circuit industry increased significantly and the growths stabilized in the second half of the 1990s. However, the proportions for overall sales and employees shrank significantly for the computers & peripherals industry. That is, the relative importance of computers & peripherals has decreased during the past decade, while there has been an increasing relative importance of the opto-electronics industry.

The above evidence has given us a very clear picture that there are great dynamics for the HSIP in the past one and half decades in particular. The integrated circuit industry replaced computers & peripherals as the most important industry in the HSIP and contributed half of the overall sales and hired around half of the labor force. Computers & peripherals, once the most important ingredient for the information industry in the HSIP and in Taiwan, shared only around one-fifth of the overall sales and labor force in the HSIP. The industries of opto-electronics and telecommunications are becoming more important in the HSIP. In fact, there is significant growth of the opto-electronics industry in Taiwan overall, which is not shown by data for the HSIP. It is a quick booming and even leading industry in Tainan's Science-based Industry Park and will be the major industry for the upcoming Taichung Science-based Industry Park.



Source: The Hsinchu Science-based Industrial Park Administration

Figure 6.8 Changes in the proportions of overall sales for industries in the HSIP, 1986-2002



Source: The Hsinchu Science-based Industrial Park Administration

Figure 6.9 Changes in the proportions of labor forces for industries in the HSIP, 1986-2002

If we go further to look at the high-tech intensity, both in terms of R&D personnel and expenditures, we find that bio-technology had the highest technology intensity of all industries in 2001, both in terms of expenditures and personnel (Table 6.5 and Table 6.6). Integrated circuits and opto-electronics had higher proportions of R&D expenditures to overall sales, while computers & peripherals and telecommunications had higher proportions of researchers to total employees. The former two relied more on capital than personnel, while the latter two relied more on personnel than capital for R&D activities. Table 6.5 also gives us a general picture for R&D inputs in the HSIP for different industries during 1992 and 2001.

Table 6.5 Percentages of R&D expenditures to overall sales by Industry for two science-based industrial parks in Taiwan, 1992-2001

Year	Total	Integrated circuits	Computers & peripherals	Telecom-munications	Opto-electronics	Precision machinery	Biotechnology
1992	5.1	6.1	4.1	4.6	8.8	10.0	8.5
1993	4.9	6.3	3.0	5.2	6.5	10.4	16.7
1994	4.6	5.5	2.8	6.6	9.3	6.5	19.1
1995	4.2	5.0	2.3	7.1	7.8	8.9	42.8
1996	5.6	7.4	3.1	5.8	5.6	6.7	27.5
1997	5.9	7.8	3.4	5.3	5.1	5.1	33.2
1998	7.1	9.6	3.7	6.1	6.3	6.4	41.7
1999	5.4	6.2	3.6	6.7	6.2	2.0	34.5
2000	4.2	4.5	2.9	4.6	4.6	5.1	65.1
2001	6.5	7.6	3.6	5.2	6.7	3.5	62.4

Source: National Science Council 2002, Indicators of Science and technology.

Table 6.6 R&D Manpower by industry for two science-based industrial parks in Taiwan, 2001

Type of Industry	R&D Manpower	Researchers	Technicians	Supporting personnel	Number of employees	Researchers as percentage of employees
Total	19,476 (100%)	14,064	3,782	1,630	105,782	13.3
Integrated circuits	9,491 (48.73%)	7,054	1,542	895	62,041	11.4
Computers & peripherals	4,449 (22.84%)	3,113	2,095	241	13,363	23.3
Telecommunications	2,156 (11.07%)	1,475	503	178	7,293	20.2
Opto-electronics	2,776 (14.25%)	1,943	574	259	20,751	9.4
Precision machinery	181 (0..93%)	145	25	11	1,296	11.2
Biotechnology	423 (2.17%)	334	43	46	1,038	32.2

Source: National Science Council 2002, Indicators of Science and technology.

Targeting human resources of the highly skilled, the domestic labor supply definitely will be the major source and a necessary condition for autonomous development, but a continuous brain drain from abroad is an unfortunate condition in this highly competitive and innovative global economy. In addition to the influx of overseas returnees, we find that there is a significant increase of foreign technical and professional staff as discussed above. Along with the changing industrial structure of the HSIP, the nationality distribution of foreign technical and professional employees also gives us a clear picture of the structure of the highly-skilled human resources in the HSIP. For the integrated circuit industry, more than half of the foreign high-skilled employees are from the United States, Japan, and other advanced countries. A great proportion is also from neighboring developing countries. For computers & peripherals and telecommunications, a significant number is from the United States, but the proportions are far less than that for the integrated circuit industry. Most of their foreign staff are from neighboring developing countries with cheaper salary levels. Opto-electronics follow the pattern of integrated circuits, though Japan and South Korea which have higher technology levels are more important in providing foreign human resources. This, in some way, indirectly reflects various contributions of domestic human resources among industries to the high-tech cluster, because overseas returnees and foreign technical and professional employees account for less than one-fourth of the researchers in the HSIP.

Table 6.7 Nationality of foreign professionals and technical employees by industry in the HSIP, 2003/10

Nationality	U.S.	Japan	Malaysia	Korea	Philippine	Singapore	India	UK	Germany	Canada	France	Russia	Others	Total
Integrated Circuits	147	97	49	51	24	27	3	24	11	5	5	1	38	482
Computer Peripherals	23	4	23	0	14	3	21	5	0	5	6	7	12	123
Telecom-Munications	20	1	6	0	0	1	5	0	0	2	1	4	13	53
Opto-Electronics	4	18	7	9	1	5	1	0	0	4	3	1	1	54
Precision Machinery	3	2	0	0	0	1	0	0	5	0	0	0	0	11
Bio-technology	2	0	2	0	0	0	0	0	0	0	0	0	0	4
Total	199	122	87	60	39	37	30	29	16	16	15	13	64	677

Source: The Hsinchu Science-based Industrial Parks Administration

6.7 Conclusion

Most studies on human resources of industrial clustering target mainly on the highly-skilled labor force and their effects on technology transfer and diffusion to sustain a certain industrial cluster. For a late coming high-tech cluster, such as the HSIP, the studies in the literature have highly emphasized on the contribution of overseas returnees and have ignored the critical role of domestic intelligence and knowledge, while neglecting to provide a dynamic analysis for a certain industrial cluster. This chapter provides a descriptive analysis on the structural change of the labor force in the HSIP, which is the nucleus of the Eastern Silicon Valley in Taiwan, with reference to developmental stages in the HSIP.

During the past two decades, the industrial structure of the HSIP has been undergoing dramatic changes. The contributions of an external highly-skilled labor force and the internal one have varied significantly by time as well as by industries. Although the highly-skilled labor forces are super mobile, we still can see that the HSIP keeps attracting overseas returnees and foreign technical and professional employees, who account for around one-fourth of the research staff in the HSIP. This cluster is the most important magnet to attract the most intelligent and youngest scientific brains in Taiwan.

Chapter 7 Entrepreneurship and Industrial Clusters : A Case Study of Chinese Taipei

7.1 Introduction

The main purpose of this paper is to investigate the role played by industrial clusters in the formation and development of entrepreneurship, with the empirical evidence for this study being obtained from a case study of the manufacturing industry in Taiwan. Drawing on Johannisson (1998), we regard entrepreneurship as the spirit to deploy relevant resources in pursuit of a market opportunity, independent of the origin or ownership of such resources. As a result of information problems, an economy is normally characterized by hidden profit opportunities yet to be uncovered; however, entrepreneurs are dynamic, willing to launch new ventures and take the necessary risks, since they are capable of identifying these opportunities and engaging in proper activities to realize the gains. Entrepreneurship is at the centre of economic progress, especially for developing countries lacking natural endowments, and Bygrave and Hofer (1991: 14) defined the entrepreneurial process as "involving all the functions, activities and actions associated with the perception of opportunities and the creation of organizations to pursue them".

What Constitutes Entrepreneurship?

According to Long (1983), three traits have to be included in the definition of entrepreneurship: (i) uncertainty and risk; (ii) complementary managerial competence; and (iii) creative opportunism. An entrepreneur must have the courage to assume the risk, to amass managerial competences, and to explore the hidden opportunities. Although the personal characteristics of individuals are important constituents of entrepreneurship, some environmental factors have been identified as necessary for the incubation of entrepreneurship, including political, economic and cultural factors.

In recent years, some studies have noted that external networks can represent an alternative mode of organization that enables entrepreneurial growth. Lechner and Dowling (2003), for example, emphasized the importance of external relations to the growth of entrepreneurial firms by examining the case of the IT cluster in Munich, Germany. It was argued that spatial proximity and long-term relations between firms are very important in improving market competitiveness within a region in which important roles are played by a wide range of networks including social, reputation, cooperative, knowledge, innovative and technology networks. External networks embodied in an industrial cluster provide firms within a region with a close supply-chain linkage, common technologies, a customer base and a pooled labor market. An industrial cluster is a practical means of linking neighborhood-based firms to the regional, and even global, economy.

Industrial clusters may effectively reduce market entry barriers and further incubate entrepreneurship. A few studies have indicated that an industrial cluster stimulates market entry into a region in which a number of firms have accumulated. This is because an industrial cluster is connected with suppliers of intermediate inputs, and is capable of creating knowledge spillover effects (Marshall, 1890). Industrial clustering effectively reduces the market entry barriers and drives a high rate of market entrance, which in turn, is associated with a high rate of innovation, which leads to improved productivity.

An industrial cluster also reduces the risks for business ventures. Labor pooling is an important feature of industrial clustering since it reduces the costs of hiring and discharging workers. The pooling of skilled workers also makes the mobilization of managerial resources much easier. Industrial clusters are often supported by a venture capital industry which finances the start-ups and helps innovators to realize their gains by organizing proper production processes. Moreover, industrial clusters provides industry-specific information, particularly that which is pertinent to technology, and which thus prevents an entrepreneur from making huge mistakes. An industrial cluster also represents a learning region which spawns innovation.

Within an industrial cluster, collective economic actors closely connected to one another possess shared technological narratives, affluent mutual trust and a willingness to cooperate (Solvell and Zander 1998: 409). Organizations involved in research and development (R&D), such as universities and government-sponsored research institutes, function as an intermediary source of new technology (Lundvall 1992: 13-14). As noted by Schumpeter, innovation underlines entrepreneurship, and all of the above factors are conducive to innovation. Industrial clusters also stimulates competition and emulation between individuals in their entrepreneurial achievements. Competition between classmates is often observed in the locations that are famous for industrial clusters, such as the Silicon Valley in the US and Hamamatsu in Japan, with achievements by alumni also being capable of inspiring younger graduates to embark on the course of entrepreneurial activities.

The remainder of this paper is arranged as follows. A brief literature review surrounding industrial clusters and entrepreneurship is presented in Section 2. In Section 3, we introduce the measurement of industrial clusters, and suggest the need for a content analysis of industrial clusters in order to better understand the relationship between market entry and industrial clusters. This section also presents a general picture, in the form of a case study of industrial clusters in Taiwanese manufacturing industries for the year 1992. We then look at the patterns of market entry over the periods 1992-95 and 1992-97.

Section 4 employs a quantitative model to examine the role of industrial clusters in reducing market entry barriers and incubating entrepreneurship, with the empirical results being presented in Section 5. In order to highlight the effect of industrial clusters in facilitating market entry, Section 6 takes a further look at industrial clusters in the Hsinchu Science-based Industrial Park (HSIP) and the Tainan Science-based Industrial Park (TSIP), both of which are in Taiwan, as well as other clusters in Latin America. This section also underlines inter-firm linkages as the core of industrial clusters and provides a discussion of the policy implications, which are especially relevant to the economies of Latin American. The findings of this study are summarized in the concluding section.

7.2 Literature Review

7.2.1 Regional Clusters and Inter-Firm Networks

As noted in Lechner and Dowling (2003), inter-firm networks do not work in a virtual space in which spatial proximity is unimportant. Both spatial proximity and long-term relations determine the quality of the relationship and the competitive advantage of firms, which are derived from close relations. Generally, the network relationship of firms enables them to enjoy advantages in terms of social networks, cooperative networks, marketing networks and knowledge-innovation networks.

Some factors underscore the inter-firm network embodied in regional clusters. First of all, drawing on Lechner and Dowling's (2000) study of the biotechnology cluster in Munich, Germany, we note that regional culture influences corporate culture in terms of both cooperation and competition. Given the time and energy constraints, spatial proximity is critical to building trust between firms over time, which stems mainly from frequent interactions and face-to face contact. Thus, it is argued that a network of entrepreneurial firms is regionally embedded, and the successful development of the industrial cluster will determine the competitiveness of firms within the cluster.

7.2.2 Agglomeration Externalities

The nature of the collectiveness of the cluster provides the firms within the cluster with some advantages. As in the earlier studies, the emergence of industrial clusters is recognized here as shaping and driving the competitiveness of firms within clusters at both national and global levels. This may be attributable to agglomeration externalities, three types of which are classified by Glaeser et al., (1992). The first type is Marshall-Arrow-Romer externality which highlights industrial specialization within a region. Each firm in the cluster enjoys the benefit from saving on investment costs by specializing within a narrow area of the value-added chain. Similar firms within the clusters find ways to differentiate themselves by locating unique market niches that have not been filled by other firms, whilst small firms can join together to fill a large contract that none of them could undertake alone. As such, these small businesses can be more competitive and successful in the long run by becoming a part of a dynamic cluster which fosters competition, collaboration and innovation amongst the participants.

The second type is Porter externality, which arises from regional specialization and the differentiation of products. This effect stems mainly from local rivalry between firms, which further fosters the rapid diffusion of knowledge and adoption of new ideas. In addition, the development of industrial clusters may lead to simultaneous competition and collaboration in offering innovative products and services, and to further establish a sustainable competitive advantage in the dimensions of technology, workforce, production methods, delivery time, quality and resource procurement.

The third type of externality is diversity externality, which is stimulated by the interchange of ideas between various types of activities within the region. As noted in Jovanovic and Rob (1989), new ideas can be derived from heterogeneous knowledge across firms and people.

Industrial agglomeration externalities enable firms within a cluster to enjoy higher growth and competitiveness, and these three types of externality have pointed to some important dimensions in the competitiveness of industrial clusters. This is because firms within a region can share a common dependence on research, innovation, knowledge and regional industry-specific assets.

Chell and Baines (2000) indicated that 'weak tie' networking is part of fundamental entrepreneurial behavior, since the interchange of entrepreneurial contact, knowledge and confidence are necessary in the pursuit of opportunities through the mobilization of resources, which include raising capital, labor and effort, for ventures with uncertainties. In short, entrepreneurship may be regarded as the inherent underpinning of networking activity.

7.3 Industrial Clusters and Market Entry for Taiwanese Manufacturing Industries

7.3.1 Measurement of Industrial Clusters

In this section, in order to examine the above assumptions, we measure the degree of spatial agglomeration for each manufacturing industry, along with its market entry rate. We set out to measure the level of spatial concentration of Taiwanese manufacturing industries for 1992 at town level. The geographical agglomeration index comprises of the intra-industry distribution of employment by plants, as the geographical Herfindahl index. The geographical agglomeration index is defined as follows:

$$GH = \sum x^2$$

where GH denotes the geographical Herfindahl index; and x is the locational share of employment for each industry. In the case of perfect agglomeration, GH approaches 1.

7.3.2 Measurement of Industrial Clusters for Taiwanese Manufacturing Industries

Based on the geographical Herfindahl index, we calculate the level of GH at town level and the 2-digit Chinese Standard of Industrial Classifications (CSIC) codes for 21 manufacturing industries. Table 7.1 summarizes the patterns of market entry in each manufacturing sector over two periods 1992-95 and 1992-97, in terms of firm size and the industrial distribution of new entrants.

Based on the early studies, two types of innovation stand out from a microeconomic perspective, 'entrepreneurial innovation' and 'managed innovation'. The emergence of entrepreneurial innovation relies mainly on the economic opportunities brought about by new technologies and scientific development. In this case, the entry of small, dynamic and rapidly growing firms is responsible for such innovation.

Table .7.1 Pattern of Market Entry in Taiwanese Manufacturing, 1992-95 and 1994-97

Unit: %

Industrial Sectors	1992-95		1994-97	
	Large Firms	Small Firms	Large Firms	Small Firms
Food Manufacturing	3.202	96.798	3.285	96.715
Textile mill products	3.544	96.456	3.887	96.113
Wearing apparel & accessories	3.327	96.673	4.403	95.597
Leather, fur products	4.294	95.706	4.615	95.385
Wood & bamboo products	0.761	99.239	0.792	99.208
Furniture & fixtures	1.200	98.800	0.875	99.125
Pulp, paper & paper products	0.704	99.296	0.847	99.153
Printing processing	0.734	99.266	1.131	98.869
Chemical materials	3.670	96.330	4.428	95.572
Chemical products	2.094	97.906	1.875	98.125
Petroleum & coal products	9.524	90.476	7.692	92.308
Rubber products	1.987	98.013	2.303	97.697
Plastic products	1.198	98.802	0.976	99.024
Non-metallic mineral products	3.365	96.635	3.093	96.907
Basic metal	2.384	97.616	2.191	97.809
Fabricated metal products	0.537	99.463	0.680	99.320
Machinery & equipments	0.932	99.068	0.907	99.093
Electrical &electronic machinery	4.201	95.799	3.426	96.574
Transport equipments	2.903	97.097	3.135	96.865
Precision instruments	2.770	97.230	2.796	97.204
Miscellaneous industry	1.487	98.513	1.503	98.497
Total	1.952	98.048	1.956	98.044

Source: Calculated for this study

In contrast to the case of entrepreneurial innovation, managed innovation is made by existing firms in the market and, as argued by Schumpeter, this type of innovation tends to be dominated by large firms with a monopoly in the market. In some sectors, such as petroleum and coal products, and leather and fur products, some large startup firms are not clearly associated with industrial sectors with capital intensity. The large shares of entry firms in three industrial sectors, fabricated metal products, machinery and equipment, and electrical and electronic machinery, may demonstrate that these booming industrial sectors attract a large share of new entry firms and absorb a larger share of employees. There is also clear evidence that a significant share of the startup firms tend to be SMEs. Parts of these new entry firms will undertake R&D investment in their subsequent established years, and such new entry firms, especially those that are small in size, may be regarded as entrepreneurial innovation firms. As is apparent from Table 7.1, some sectors are highly attractive to the entry of entrepreneurial firms. These industrial sectors include not only the high-tech industries, such as electrical and electronic machinery, chemical materials and chemical products, but also the more traditional and heavy industries, such as leather and fur products, and rubber products, indicating that the entry of entrepreneurial firms cannot be simply attributed to the industrial characteristics of R&D intensity.

Table 7.2 Industrial Spatial Agglomeration and Entry Rates in Taiwanese Manufacturing Sector

Industrial Sectors	GH Indicators* (1992)	1992-95 Total Firms	GH Indicators* (1994)	1994-97 Total Firms
Food Manufacturing	0.0107	20.7	0.0102	20.0
Textile mill products	0.0190	31.4	0.0190	30.3
Wearing apparel & accessories	0.0184	47.0	0.0186	39.3
Leather, fur products	0.0254	32.9	0.0326	31.5
Wood & bamboo products	0.0123	15.7	0.0132	19.1
Furniture & fixtures	0.0145	37.5	0.0140	27.2
Pulp, paper & paper products	0.0133	30.9	0.0130	28.8
Printing processing	0.0389	48.2	0.0397	47.6
Chemical materials	0.0335	32.6	0.0358	26.5
Chemical products	0.0205	25.7	0.0212	21.0
Petroleum & coal products	0.3119	43.8	0.2004	21.0
Rubber products	0.0256	26.9	0.0244	28.7
Plastic products	0.0125	32.8	0.0132	29.5
Non-metallic mineral products	0.0298	24.4	0.0276	24.1
Basic metal	0.0486	34.6	0.0448	30.1
Fabricated metal products	0.0192	47.8	0.0179	48.8
Machinery & equipments	0.0181	41.4	0.0180	36.3
Electrical &electronic machinery	0.0242	56.4	0.0246	53.0
Transport equipments	0.0204	38.6	0.0205	32.3
Precision instruments	0.0259	37.1	0.0255	29.0
Miscellaneous industry	0.0128	33.3	0.0184	27.8
Total number of new firms	-	25,822	-	24,277
Average Entry Rates (per cent)	-	37.40	-	35.08

*Note: * GH indicator denotes geographical Herfindahl index as the way to measure spatial agglomeration for each industrial sector.*
Source: Calculated for this study.

Of relevance to Table 7.1 is Table 7.2, which provides data on industrial geographical agglomeration, the number of incumbent firms for 1992 and 1994, and the entry rates of manufacturing firms for 1992-95 and 1994-97. Both the basic metal and petroleum and coal products industries reached an extraordinarily high level of industrial agglomeration in 1992 and 1994.

Since Taiwan is heavily reliant on imports for its energy consumption and natural resources, the firms within such industries generally gather together in certain harbor regions. Following on from the petroleum and coal products industry, the non-metallic mineral products, basic metals, transport equipment and chemical materials industries are significantly higher than the remaining industries in terms of the geographical agglomeration indicator. Table 7.2 shows that across industries, the entry rates for 1992-95 range from 15.7 percent (wood and bamboo products) to 56.4 percent (electrical and electronic machinery), with the average entry rate achieving 37.4 percent. Apart from the petroleum and coal products industry, comparatively high entry rates of large firms are driven by the wearing apparel and accessories industry and the electrical and electronic machinery industry. The average entry rate for 1994-97 was lower than that for 1992-95. Over the 1994-97 period, the wood and bamboo products industry was still the one with the lowest entry rate, at just 19.1 percent, whilst the electrical and electronic machinery industry was the one with the highest entry rate, at 53.0 percent.

Tables 7.1 and Tables 7.2 have drawn a brief picture of the geographical concentration and market entry rates across industries; however, we have not yet determined whether new start-up firms are significantly correlated with their incumbents, in terms of geographical deployment. We continue by performing a comparative approach to two types of industries based upon the locational choices of new start-up firms. We intend to identify two types of industries according to the degree of correlation between new start-up firms, in terms of their spatial distribution, and their incumbents. The first type of industry is characterized by the intention of new firms to locate their production bases close to their incumbent counterparts. All other sectors are regarded as the second type of industry. Based on the networking attributes of industrial clusters, if other conditions are given, new firms should be attracted to locate themselves into these clusters in order to share a common dependence on research, innovation, knowledge and regional industry-specific assets, demonstrating the evolutionary process of industrial clusters. The comparison of these two types of industrial clusters, in terms of their entry rates, may underpin the argument that the spatial agglomeration effect of firms can effectively drive new firm formation.

A two-stage approach is utilized to examine this hypothesis. First of all, tests are performed for independence and the Pearson correlation index in order to identify specific industrial sectors within Taiwan in which the spatial distribution of new firms is similar to that of incumbents across 336 towns. The χ^2 procedure is used to test the hypothesis of the independence of new firms and their incumbents with regard to their spatial distribution. The observed distributions are presented in Table 7.3, which provides what is generally known as a contingency table. In the contingency table test, χ^2 is employed in a goodness-of-fit test for the 93 manufacturing industries. The null hypothesis is that the spatial distribution of new firms is independent of the incumbent firms.

Table 7.3 Contingency Table (2 x 336) of Probabilities for an Industrial Sector

	Region 1	...Region j...	Region 336	Total
New Firms	$\pi_{1.1}$	$...\pi_{1j}...$	$\pi_{1.336}$	$\pi_{1.}$
Incumbents	$\pi_{2.1}$	$...\pi_{2j}...$	$\pi_{2.336}$	$\pi_{2.}$
Total	$\pi_{.1}$	$...\pi_{.j}...$	$\pi_{.336}$	1

Let π_{ij} denote the underlying bivariate probability distribution of firm group i in region j. The firm group comprises of new firms if i =1, and incumbents if i =2. Let π_i and π_j similarly denote the marginal probability distribution of firm group i and region j. It should be noted that the measures for the spatial distribution of incumbents are based on the numbers of employees. The null hypothesis of statistical independence may be stated precisely as:

$$Ho: \pi_{ij}=\pi_i \,.\, \pi_j$$

The Chi-square static for examining the null hypothesis is

$$\chi 2= \sum_{i}^{2}\sum_{j}^{336}\frac{(\pi_{ij}-\pi_i\pi_j)^2}{\pi_i\pi_j}n$$

where n is the sum of the number new firms and the incumbents.

The Pearson correlation indexes are further utilized to confirm the positive correlation between new firms and incumbents in their spatial distribution. According to both the Chi-square static and the Pearson correlation indexes, we can choose some industries as the first group, within which the Chi-square static is significant at the 5 per cent level, and in which the Pearson correlation indexes are positive.

In the second stage, we examine whether the market entry rates for the first group of industrial sectors are higher than those for the second group in the two periods. Table 7.4 shows that in the first period, 1992-95, the first group comprises of 24 industrial sectors, whilst the second group comprises of 69; the respective average market entry rates for the four years were 0.57 and 0.40. The first group is significantly higher than the second group at a significance level of 10 per cent. During the second period, 1995-97, the number of industrial sectors in the first group increased to 29, whilst the number in the second group declined to 64, with their respective average market entry rates for the three years reaching 0.40 and 0.25. The average market entry for the first group was significantly higher than that for the second group at a significance level of 5 percent. Thus, the empirical evidence from Taiwan's manufacturing sector indicates that the spatial agglomeration of incumbents, new firm formation, and locational choice are highly interdependent.

Table 7.4 Average Entry Rates for 1992-95 and 1995-97

Period	Group	Number of Industrial Sectors	Average Entry Rate	Std. Dev.	*t*-value
1992-95	1	24	0.57	0.61	1.95
	2	69	0.40	0.25	
1995-97	1	29	0.40	0.49	2.23
	2	64	0.25	0.18	

Source: Calculated by the authors

In brief, the empirical evidence from Taiwan's manufacturing industrial sectors generally supports the above arguments that the significant role played by industrial agglomeration is the reduction of entry barriers. Industrial clusters facilitate the diffusion of information relating to markets and technologies and also provide benefits for firms in terms of labor market pooling. These advantages of industrial clusters can help new entry firms to overcome the entry barriers and can also attract other firms to enter the industrial clusters. The determinants of the new-firm entry rate for each industrial sector cannot be totally explored by Table 7.4; therefore, the next section will apply a quantitative approach to this issue.

7.4 Determinants of Market Entry for Taiwanese Manufacturing Industries

In this section, we utilize the data bank of the Manufacturing Plant Census Survey of 3-digit CSIC codes for 93 industries to empirically examine the factors affecting firms' market entry decisions over the two periods of 1992-95 and 1992-97. *Entryr*, the dependent variable in this empirical model, is the entry ratio of the number of startup firms to the number of incumbent firms for each manufacturing sector. Considering that the dependent variable is a censored number in nature, we employ a Tobit regression in this study, with the empirical models being set as follows:

$$Entryr = F(GH, KL, CR4, IRD, IEX, MES, MARR, INDS).$$

The explanatory variables used in the above model are: the geographical agglomeration index (*GH*), capital to labor ratio (*KL*), industrial concentration (*CR4*), industrial R&D intensity (*IRD*), industrial export intensity (*IEX*), minimum efficiency scale (*MES*) of the firm, market room (*MARR*) and industrial scale (*INDS*). The explanatory variables used in the above model and the hypothetical impacts on *Entryr* are explained as follows:

Geographical agglomeration index (*GH*)

GH, the geographical Herfindahl index, is used to measure the extent of industrial agglomeration for each industrial sector. Firms within industrial clusters share a common dependence on innovation, knowledge and regional industrial assets. The spatial agglomeration also facilitates the interchange of entrepreneurial contact, knowledge and confidence, all of which are important in the pursuit of market and innovative opportunities. Furthermore, the networking relationship which is embodied in industrial clusters on the basis of their common background can help to generate reputation networks, which automatically lead to business relationships based upon trust. From the above examination of entrepreneurship, networking and industrial clusters, this paper utilizes the level of industrial clusters simply as a proxy for network strength. We assume that an industry associated with higher spatial agglomeration will have stronger network ties, leading to a higher market entry rate. Thus, the higher the geographical agglomeration for an industry is, the higher its market entry rate will be. We therefore hypothesize that the *GH* variable will have a positive impact on the *Entryr* variable.

Capital Intensity (*KL*)

KL is the ratio of the book value of fixed capital stock to labor compensation within an industry. Most of the literature generally regards the capital-labor ratio as a type of market entry barrier (Dune and Robers, 1991;

Rosenbaum and Lamort, 1992). This is because capital goods, such as machinery and factories are characterized by their natural indivisibility and inflexibility. Morrison (1997) argued that capital actually has a quasi-fixity nature, and that where a firm's production technology is more capital-intensive, it may, by nature, suffer from higher sunk costs. We expect that an industry with a higher capital-labor ratio will be characterized by greater entry barriers and therefore hypothesize that the *KL* variable will have a negative impact on the *Entryr* variable.

Industrial Concentration (*CR4*)

The industrial concentration variable, *CR4*, is defined as the share of the four largest firms measured for 1992 as a proxy for the degree of industrial concentration. Where an industry has a higher concentration, this suggests that it is more likely to be dominated by a few firms. In contrast, firms within the industry with a lower *CR4* value have much less monopolistic power and are therefore more likely to engage in keen competition. Chen, et al. (2002) used Taiwan's Consensus Databank for the period 1991-1996 to examine the entry and exit rates of manufacturing firms and suggested that the increase in the industrial concentration ratio over this period led to a decline in market entry. However, based on Jeong and Masson's (1990) research on market entry rates in Korea, it is suggested that a high concentration may lead to an expectation of either cooperation or retaliation for new entry firms, indicating that the effect on market entry by *CR4* is uncertain. Based on the findings of these studies, the coefficient of *CR4* in the entry equation remains uncertain.

Industrial R&D Intensity (*IRD*)

IRD is designed to measure the extent of opportunity innovation, with R&D intensity being used as a proxy for the knowledge stock of an industry. An industry with high R&D intensity may have greater room for the entry of new firms given its greater scope for the differentiation of products. Early studies, such as Orr (1974), provided some empirical evidence to suggest that high R&D intensity symbolizes the entry barriers within an industry. By contrast, Geoski (1994) observed a positive correlation for an industry between the rate of innovation and the entry rate. As pointed out by Marsili (2002), whether or not innovation in technologies of high, or increasing, opportunities is associated with entrepreneurial activities, is dependent upon the nature of knowledge. Without any solid stock of technologies, Taiwan's industries remain heavily reliant upon the transferred technological knowledge from overseas, whilst their innovative activities also focus on product engineering and continuous processes, characterized by low technological entry barriers in both knowledge and scale. Accordingly, we expect that those industries with higher R&D intensity will have lower entry barriers, and therefore hypothesize that the *IRD* variable will have a positive impact on the *Entryr* variable.

Industrial Export Intensity (*IEX*)

This study also examines whether industries with high export orientation will tend to drive the entry of new firms, with the empirical results seemingly contradicting the presumptions made in some of the early studies. Utilizing Taiwanese firm data for 1986 and the frontier production function, Aw and Batra (1998) suggested that the productivity-export correlation differs significantly across firms depending on their investment in technology, whilst Aw and Hwang (1995) pointed to the existence of a significant linkage between firm-level productivity and exporting activities. The latter study went on to develop an empirical model to shed light on the value-added differences between export-oriented and domestic market-oriented firms in the electronics industry in Taiwan, confirming the importance of learning mechanisms from export markets. Both studies may well suggest that export markets provide the impetus to attract the entry of new firms based largely upon the strong learning effects in improving productivity and technological diffusion; however, counteracting the learning effect of export markets is the keen competitive pressure which may well lead to market deterrent effects, particularly for small new firms. Thus, the effect of the export markets on market entrants is unclear.

Minimum Efficiency Scale (*MES*)

MES measures the ratio of the average size of the largest 50 per cent of firms to the average size of all firms, in terms of number of employees. In certain industries, these scale economies are a barrier to entry since it is unlikely that multiple businesses can all attain the minimum efficiency scale to be commercially viable. In most of the manufacturing sector, scale economies are unlikely to be as pronounced, relative to market demand, and thus, in the absence of any policy-induced constraints, such economic barriers to entry are likely to be relatively modest, and in some cases, quite low. This variable is designed to measure the entry barriers resulting from firms' production scales. *MES*, like capital intensity, is included in the entry equation proxies for entry barriers, and we presume that in the entry equation, the coefficient of *MES* will be negative.

Market Room (*MARR*)

As in Shapiro and Khemani (1987), and Rosenbaum and Lamort (1992), an industry experiencing growth usually has benefits of the potential market entry of firms. *MARR* is measured as the change in value of shipments over the period 1992-95 (1994-97) divided by shipments in the initial year, 1992 (1994). MARR is defined as the ratio of market room over the index of the minimum efficiency scale of a plant, which is measured by the ratio of the average scale of the top 50 per cent of plants to the average scale of plants, in terms of employees. The variable is measured as the value of market growth over the minimum efficiency scale at the initial years of 1992 and 1994, and can be used to describe the inducement conditions of an industry. We expect that the coefficients of *MARR* will have a positive impact on the market entry ratios.

Industrial Scale (*INDS*)

INDS refers to the scale of an industry in terms of the overall number of employees and is taken in natural logarithmic form. A larger scale industry may provide new entry firms with greater market share for the survivors. In addition, this study measures an industry's scale in terms of the number of employees; therefore, we may expect that an industry with a comparatively high *INDS* value can enjoy the advantage of labor pooling and also provide benefits for new entry firms with regard to cost savings on the sourcing of suitable labor. Accordingly, we presume that the coefficient of *INDS* will be positive in the entry equation.

We summarize our hypothesis of the impact of each of these explanatory variables, and provide the definitions of the corresponding summary statistics of these variables in Table 7.5.

Table 7.5 Variable definitions

	Definition	Expected sign	1992-95 Mean (Std. Dev.)	1994-97 Mean (Std. Dev.)
GH	Herfindahl index for geographical agglomeration, 1992 and 1994, respectively	+	0.062 (0.070)	0.695 (0.097)
KL	Capital-labor ratio, measured by the fixed capital stock over total labor compensation, 1992 and 1994, respectively	–	4.978 (2.935)	4.831 (3.001)
IEX	Industrial export intensity, 1992	?	2.340 (1.752)	
IRD	Industrial R&D intensity, 1992	+	0.038 (0.029)	
MES	Minimum efficiency scale, 1992 and 1994, respectively	–	1.729 (0.111)	1.953 (0.250)
MARR	Market room, 1992-95 and 1994-97, respectively	+	0.302 (0.734)	0.071 (0.138)
CR4	Industrial concentration, 1992 and 1994, respectively	?	0.304 (0.238)	0.305 (0.233)
INDS	Industrial scale in terms of employees (in natural logarithmic form), 1992 and 1994, respectively	+	9.243 (1.359)	9.352 (1.299)

Note: Data on the IEX and IRD are unavailable for 1994.
Source: Calculated for this study.

7.5 Empirical Results

The entry equation is estimated using structural variables, including inducements, entry barriers and geographical agglomeration, as the explanatory variables, with Tobit estimates for Equation (1) being generated for both the 1992-95 and 1994-97 samples. There are 93 observations in the sample, with the empirical results being presented in Table 7.6 which shows that $LR\ \chi^2$ reaches a significance level of 5 per cent and that the explanatory variables of both models have significant explanatory power. The empirical results may demonstrate two kinds of perspectives related to market entry, namely entry barriers and inducement conditions.

Entry Barriers

The hypothesis of entry barriers is examined in this study. As shown in Table 7.6, the coefficients on *GH* (industrial geographical agglomeration) are positive and statistically significant at the 5 per cent level in each of the entry equations. That is, an industry characterized by spatial agglomeration has a comparatively high market entry ratio. The evidence may confirm the presumption that industrial spatial agglomeration will lower entry barriers because the formation of an industrial cluster can drive the formation of production networking, thereby enhancing the diffusion of local knowledge. The development of industrial clusters not only benefits local incumbent firms in production specialization, knowledge sharing and labor market pooling, but also provides benefits for the potential entry of firms through the lowering of entry barriers.

Table 7.6 Empirical results of the Tobit estimations

	1992-95	1994-97
Constant	2.094**	0.358**
	(5.59)	(2.61)
GH	1.093**	0.610**
	(2.51)	(3.10)
KL	-0.036**	-0.011*
	(-3.48)	(-1.78)
IEX	0.006	0.003
	(0.37)	(0.27)
IRD	3.260**	1.250**
	(4.02)	(2.26)
MES	-1.415**	-0.175*
	(-5.48)	(-1.78)
MARR	0.079**	0.205*
	(2.22)	(1.83)
CR4	0.388**	0.165
	(2.77)	(1.38)
INDS	0.063**	0.018
	(2.63)	(1.05)
σ	0.220	0.140
Observation	93	93
$LR\,\chi^2$	61.05	23.63

*Note: * = Significant at the10 per cent level; ** = significant at the 5 per cent level.*

Table 7.6 also shows that capital intensity is included in the equation as a proxy for sunk costs. The variable is statistically significant. The negative coefficient of *KL* indicates that industries with greater capital intensity have a lower firm entry ratio. Some of the early studies, such as Bunch and Smiley

(1992), regarded R&D intensity as market deterrents; this is because access to an industry with R&D intensity has comparatively high capital and technological requirements, and the incumbents in such industries have a greater likelihood of effectively using market strategy to deter their potential competitors. However, in the empirical results of this paper, the coefficient of *IRD*, measured by the ratio of the number of R&D employees to total employees is statistically positive on the market entry ratio. These empirical results are similar to some of the other early studies, including Chen, et al. (2002), which stressed that industries with higher R&D intensity had comparatively broader room for driving the entry of new firms. As in the case of other newly-industrializing economies (NIEs), Taiwan lacks a solid technological knowledge base, but we can expect that entrepreneurs in Taiwan will generally demonstrate an ability to adapt. The task for entrepreneurs in identifying market opportunities can be classified into 'ordinary' and 'extraordinary' discoveries. Ordinary discoveries involve making a discovery whilst keeping the system largely unchanged. This kind of entrepreneurial activity merely exploits market opportunities and can be referred to as 'adaptive entrepreneurship'. In contrast to such adaptive entrepreneurship, extraordinary discoveries involve the uncovering of hidden opportunities in the market by entrepreneurs, leading to a fundamental change in the system. Obviously, such 'extraordinary entrepreneurship' comes close to the Schumpeterian idea of entrepreneurship.

Table 7.6 demonstrates that the coefficient of *IEX* in the entry equation is negative. This study lacks statistically significant evidence to explore whether an industry associated with high export orientation will tend to yield a market deterrent effect, a result which is also similar to Chen, et al. (2002), in which the coefficient of industrial export propensity was shown to be negative with marginal significance.

The coefficient of *MES* in the entry equation is statistically negative at the 5 per cent level, indicating that MES is important in determining the entry rate of firms. The minimum efficiency scale varies substantially across industries; however, entrepreneurs usually have to start up a new firm at a suboptimal scale (Audretsch, 1999). Table 7.6 also shows that the industrial concentration (*CR4*) has certain positive influences on market entry for 1992-95, but not for 1994-97. Similar to Jeong and Masson (1990) on the Korean case, and Masson and Shaanan (1987) and Rosenbaum and Lamort (1992) on the case of the US, the empirical results for the case of Taiwan support the argument of signals of expected 'cartel stability' or 'accommodation,' but do not seem to support the argument of strategic entry deterrence for highly concentrated industries. However, this empirical evidence may also underline Taiwan's policy reforms of the early 1990s, which pursued internationalization and liberalization by reducing institutional barriers of entry to concentrated markets, markets which used to be monopolized by state-own enterprises. The effects of the policy reforms on market entry seem somewhat weaker in the second period.

Inducement Conditions

The coefficients on market room (*MARR*) in Table 7.6 are significantly positive in the entry equations, indicating that the empirical results are consistent with our earlier assumption. Market room is the proportional increase in the number of firms at minimum efficiency scale that could take place due to growth in the market. The increase in market growth, referring to future potential, has to be tempered with the size of firms to fit into such markets. In Table 7.6, the coefficient of *MARR* is significantly positive in the entry equation, confirming our assumption.

Finally, one of the structural characteristics of industries, *INDS*, is measured by the industrial scale in terms of the numbers of employees. As in the assumption of this study, the coefficient of *INDS* is negative on market entry rate. Taking this in the context of networking, we may argue that the influence of industrial scale upon market entrants depends mainly on their networking relationship, as opposed to absolute scale. In this paper, *GH*, industrial spatial agglomeration, refers to the networking relationship of firms. As in Chell and Baines (2000), the advantage of firm owner-manager's networking is to draw upon information, advice and assistance from a large, diverse pool. Accordingly, given the extent of the networking relationship, an industry with greater industrial scale leads to higher market entry.

In summary, the empirical evidence from Taiwan's manufacturing industrial sectors is generally in line with other early studies on the identification of entry barriers and inducement conditions. The above sections underline the role of spatial agglomeration in market entry rate. Variances in market entry rates may also be explained by industrial concentration, market room, minimum efficiency scale and R&D investment. The important contribution of this study is the highlighting of the significant role played by industrial agglomeration in reducing entry barriers. An industrial cluster cannot be regarded simply as the spatial agglomeration of firms, but the formation of inter-firm business networking. Industrial clusters facilitates the diffusion of information on markets and technologies and also benefits firms in terms of labor market pooling. These advantages from industrial clusters also help new entry firms to overcome the entry barriers. There are, therefore, some important policy implications relating to entrepreneurship behind this work, especially for newly- industrializing countries in the age of the knowledge-based economy.

7.6 Formations and Mechanism of Industrial Clusters

This section will look at the formation and mechanism of industrial clusters by Taiwan as a case of study. In essence, the strategy of supporting high-tech industries through the establishment of science parks can be regarded as an industrial clusters policy; however, we should keep in mind that the function of science parks is more than just production as in ordinary industrial districts. Johannisson (1998) draws evidence from Sweden to testify to the importance of science-based parks for knowledge-based entrepreneurship. He found that in comparison with traditional entrepreneurs in industrial districts, knowledge-based entrepreneurs tend to set up local networks with an emphasis on professional ties to the science-based parks; that is, a science-based park functions as a base for the exchange of professional knowledge and technologies.

The Hsinchu Science-based Industrial Park (HSIP) in Taiwan was established in 1980 as a means of nurturing the high-tech industry, and for the past two decades, it has been very successful in incubating Taiwanese high-tech industries. Drawing on the Stanford Research Park, the government constructed the HSIP, in terms of the landscape and infrastructure, to encourage the market entry of new high-tech firms. As the 'Silicon Valley in the East,' so titled by Methewe (1997), the HSIP became successful in attracting overseas engineers to return to Taiwan to take up positions within the park and, with the aid of a government-sponsored research institute and two premier universities, a knowledge base was soon created that was to go on to drive innovation. A venture capital industry started to boom in the 1990s, giving rise to a large number of start-ups, with most firms within the HSIP positioning themselves as subcontractors to multinational enterprises or producing products to complement those made by the multinationals, thus establishing a vertical production networking relationship. Such a relationship has been extremely successful in enhancing the international market competitiveness of HSIP firms and their ability to gain access to the international markets for their high-tech products. Put in the perspective of the global value chain, the focus of the HSIP is on the mass production segment of the chain. Under this strategy, firms in the HSIP play the role of a warehouse of pre-commercialization technologies, with firms mainly undertaking product development research. The developmental process of the HSIP takes advantage of the cross-border movement of human skills.

Such successful experience was largely responsible for raising the government's confidence in adopting the same strategy to establish the second science-based industrial park in Tainan, the Tainan Science-based Industrial Park (TSIP). This park was established in 1996 in pursuit of the next stage of Taiwan's high-tech progress. During the period of the authoritarian regime, the state in Taiwan was able to efficiently provide the private sector with common production factors, such as water, energy, land and other infrastructures. However, it remains to be seen whether the experience of HSIP can be duplicated in the development of the TSIP. In comparing the establishment experiences of the two parks, three arguments are pursued by Jou (1998). Firstly, the driving force for the TSIP comes mainly from the private sector, rather than from the government. Secondly, in addition to central government, local government has also played an active and participative role in the process of establishing the TSIP. Finally, an issue of significant importance is that the TSIP can provide the impetus for the outreach of the networking relationship of Taiwan's high- tech industries from the north to the south of Taiwan. The distinction between the HSIP and the TSIP, in terms of developmental experiences, can mainly be attributed to their differences in initial conditions and establishment purposes.

Based on the case studies of industrial clusters within Latin America, some of the early studies raised a number of important issues. Looking at the three industrial clusters in Santa Catarina in Brazil, Meyer-Stamer (1998) highlighted the path dependence in regional development and argued that the stimulation of cooperation between firms and the shaping of the supporting environment were of the utmost importance, particularly under the new conditions of an opening market and increasing competitive pressure. The study of four industrial clusters in South Asia and Latin America by Schmitz (2000) suggested that even though local external economies were accrued cluster-wide, cooperation seemed to be conditional, whilst cooperation definitely improved the performance of the firms. Under the conditions of such global competition as are rife today, an extremely important policy issue for the governments of developing countries, including Latin America and Taiwan, is the determination of ways of promoting inter-firm cooperation within industrial clusters.

From a perspective of the global production network, successful industrial clusters are able to draw on some elements of the production chains from other locations, and the capacity for production specialization is critical for such regions in order for them to achieve sustainable industrial growth. Critical policy targets of NIEs should include the acceleration of inter-firm links within industrial clusters, and the achievement of close proximity to cross-border production networks, usually conducted by multinationals; i.e., the main aim of either horizontal or vertical inter-firm linkages is to facilitate the diffusion of various technologies and market information.

From the experiences of Taiwan, business networks may be embodied in personal or informal network relationships. Most of these entrepreneurs, especially in Taiwan's high-tech industries, share common experiences, which generates systems of shared norms. These common experiences include both their studies and their work backgrounds. That is, these entrepreneurs, in communities with a strong identity or highly institutionalized professions, often keep in touch with their educational origins. In addition, the networking relationships built upon their common background can generate reputation networks, which automatically lead to business relationships based on trust. In the case of incomplete information, it is quite natural for most firm owners to have started their business through such cooperative relationships.

Despite the concentration of manufacturing firms, the lack of an intermediate agency weakens network and inter-firm cohesion in these industrial clusters, resulting in the development of comparatively lower knowledge spillovers and less stimulation of inter-firm linkages and new firm creation. Industrial clusters may rely on such an intermediate agency to improve their systemic coordination so as to encourage entrepreneurship. Improving the quality of government-business coordination is critical to the competitive performance of an industrial cluster.

In addition, multinationals' foreign affiliates also play a critical role in industrial clusters, especially for a developing economy. For multinationals in a developing economy, many of the parts and components for industries are produced and traded in industrial clusters as elements of their global production networks. Most local suppliers are still limited to low value-added non-core activities in many of the developing countries, with the key technologies and high-value added components being imported mainly from the multinationals' other expatriate subsidiaries or from their home countries. Some foreign multinationals act as anchors to offer markets and technological support for foreign and local firms; however, owing to the poor network cohesion with domestic firms, multinationals' affiliates either source the parts or components from abroad, or are forced to internalize production of the parts or components. This results in the intra-firm division of labor replacing inter-firm cooperation within industrial clusters. Moreover, local firms undermine their competitiveness as the result of costly and poor quality supplies, causing multinationals to pursue very few industrial linkages to the local industrial of the host economies. Many developing countries generally suffer the weakness of a vertical division of labor between multinationals and local suppliers, which lead to limited knowledge spillover in industrial clusters.

In sum, successful industrial clusters are important for developing economies to nurture their entrepreneurship. In this era of globalization, infrastructure, quality coordination between the government and business, human capital, and the international linkages embodied in multinationals are the important conditions for a successful industrial cluster.

7.7 Conclusions

The purpose of this paper is twofold. First of all, drawing on Chell and Baines (2000) which stressed the importance of networking relationships in fundamental entrepreneurial behavior, and Lechner and Dowling (2000; 2003) which underlined the spatial proximity of industrial clusters as the essence of a firms' network relationship, this study presumes that firms' spatial proximity should have a positive influence on entrepreneurship. We use the database on Taiwan's manufacturing industry to examine the determinants of industrial market entry over the two periods, 1992-95 and 1994-97. The determinants are grouped into two sets, namely entry barriers and industrial inducement conditions.

In this study, market entry barriers are characterized by capital intensity, R&D intensity, export propensity, scale disadvantage, industrial concentration and spatial agglomeration, whilst the industrial inducement conditions include market growth, market room and industrial scale. Generally, the empirical results are in line with the earlier studies. The most interesting result is that an industrial cluster can effectively reduce market entry barriers, indicating that industrial clusters not only enhance firms' productivity, but also promote entrepreneurship. More specifically, clusters may induce entry in two forms, which are new start-ups by entrepreneurs and diversification by existing firms. There is no telling which form is more important in driving industry dynamics, but the factors that give rise to each form of entry may certainly be different.

From the empirical results, the R&D intensity in Taiwan's industry demonstrates a high market entry rate, indicating that even lacking a solid technological knowledge base, entrepreneurial activity in Taiwan may gradually shift from merely exploiting market opportunities and adaptive entrepreneurship, to extraordinary entrepreneurship, referring to the discovery of hidden opportunities in the market. Innovation is an important means of competition leading to constructive destruction; thus, when innovation ceases, competition degenerates into a price war. The main feature of modern industrial clusters may therefore be a shift from cost-saving competition to innovative competition, particularly in this era of the globalization of production and even international R&D investment. In the age of the knowledge-based economy, innovation actually stands out at the center of market competition.

Secondly, it is well accepted that industrial clusters cannot simply be regarded as firms' spatial agglomeration, since inter-firm linkage relationships must also be emphasized. A successful industrial cluster is able to facilitate the diffusion of technological and market information across clusters firms, effectively reducing transaction costs, and further driving entrepreneurship.

This paper underlines the important conditions for successful industrial clusters by drawing on the experiences of industrial clusters in Taiwan and Latin America. It particularly emphasizes that inter-firm linkages should play critical roles in industrial clusters. Some policy implications resulting from this research include the fact that support for new ventures should focus on emerging networks, linking firms together, rather than on individual firms. Furthermore, the aggressive pursuit of proximity should be seen as a necessary means of promoting mutual learning and joint knowledge creation through business-social-network exchanges, if local systems are to match the global organization of economic activity. For developing countries, in the era of globalized production, policies should be designed with the aim of leveraging multinationals' foreign affiliates within an industrial cluster so as to establish both local and cross-border industrial linkages.

Chapter 8 Subcontracting, Industrial Specialization and Industrial Clusters: the Case of High-tech Firms in the Hsinchu Science-based Industrial Park in Taiwan

8.1 Introduction

The liberalization of international trade has had a tremendous impact on the production models of many firms in many countries, with the production structure of many of these firms having changed accordingly. In recent years, subcontracting, outsourcing or industrial specialization have begun to replace existing production models of vertical integration, whilst the evolution of the production structure has been increasingly accelerated, largely as a result of improvements in transportation means and the development of the Internet, which have both substantially shortened the distance between national borders.

Owing to the rapid shortening of product life cycles in recent years and the demand for the diversification of products, the erstwhile 'big business,' known for its economies of scale, has faced an enormous challenge with regard to its inadequate production flexibility. Conversely, small and medium enterprises (SMEs) have honed their competitive edge by means of specialization, cutting into the market and seeking their particular niche. Scott (1993) suggested that in the past, business favored economies of scale, whereas today's focus within industrial organizations is centered on how to capitalize the external economies of scope. Therefore, firms involved in different production stages may join hands through industrial specialization to form a production network so as to fully explore the external economies of scope.

It has been argued in the literature that the success of Taiwan's computer industry can be attributed to the swiftness and flexibility of SMEs and their comprehensive subcontracting practices. Related studies in this area include Levy (1988) and Levy and Kuo (1991) on the comparison of keyboard and computer manufacturing between Taiwan and Korea; Huang (1995) on the study of Taiwan's computer industry; Kraemer (1996) on the study of Taiwan's software industry; and Kawakai (1996) on the development of Taiwan's computer industry and the structure of SMEs in Taiwan. These studies have argued that the industrial specialization of Taiwanese firms in the information technology (IT) industries has played a pivotal role in catapulting these firms into the international marketplace.

There has, however, been little discussion in the literature as to what the main motives are for high-tech firms in the IT industries to engage in such subcontracting practices, and it may also be worth exploring what effect the prevalence of such subcontracting practices has had on the overall industrial structure as well as on industrial clusters. In this study we will attempt to fill the gaps in the literature by examining these issues, with specific focus on the subcontracting behavior of high-tech firms in the Hsinchu Science-based Industrial Park (HSIP) in Taiwan. Our overall aim is to consider the key elements involved in the undertaking of such subcontracting practices by high-tech firms within the HSIP, whether subcontracting is a common practice for these firms, whether or not the practice of subcontracting provides a competitive edge for these firms, and whether the subcontracting operations of these firms enhances or enlarges the clusters effect of other firms within or around the HSIP.

In order to study these issues, we begin, in the next section of this paper, by setting up a theoretical model in an attempt to explain why subcontracting by firms can be an effective means of reducing production costs. In the subsequent section, we explain the survey results for firms within the HSIP, in terms of their various subcontracting activities as well as their major motivations for pursuing subcontracting behavior. This subcontracting behavior is examined in detail in the empirical models presented in the penultimate section, followed by a summary of the main findings and the conclusions drawn from this study in the closing section.

8.2 The Theoretical Model

Coase (1937) believed that vertical integration involved firms completing all of their relevant production processes internally, as opposed to purchasing inputs from the market. Based on Coase's concept of transaction costs, it can be inferred that when the costs for inter-firm transactions are high, vertical integration will become stronger, because in such circumstances, firms will tend to internalize their transaction costs by producing all of their inputs themselves, thereby reducing inter-firm transactions in relevant production inputs. However, as firms attempt to bring each and every economic activity into their internal organization, not only will operating costs rise significantly within the organization, but there will also be a substantial increase in the firms' internal communication and coordination costs which can ultimately undermine the competitiveness of the firm. Firms may therefore choose not to expand their own operational scale indefinitely, and instead, may choose to expand their internal scale of operations only to the extent that the additional marginal costs for related production activities, if brought within the organization, are equal to the costs of production activities if acquired from the marketplace, in other words, equal to the fees charged for similar services by other firms. This represents the optimal equilibrium point for firms to set up their endogenous production scale, i.e., the equilibrium point between endogenous production and subcontracting.

Chang (2001) argued that the mechanism of vertical specialization involves the division of an industry's production processes between the highest upstream point and the lowest downstream point in several layers, with each firm specializing in a certain stage, or a specific layer, of the manufacturing process. In such a way, the entire manufacturing process can be completed through subcontracting of all the relevant layers of production. Since industrial production is the result of a series of interacting and interlinked processes, due to consideration of various operational factors, it is inevitable that some firms may find it advantageous to have part of their production activities subcontracted out. Holmes (1986) noted that a subcontracting system integrates both the demand for speed and the supply of diversification which provides firms with flexibility and specialization advantages. Quinn and Hilmer (1994) argued that through strategic outsourcing, which allows firms to fully utilize their external resources, the competitiveness of firms can be greatly enhanced by their devotion to the development of core competences, whilst Zhao (2003) pointed out that firms will subcontract their non-specialized work for better quality, lower costs and more rapid production, so as to improve their overall level of efficiency.

Since a subcontracting system is one of the major features of industrial specialization, in the following theoretical examination, we will explore the industrial specialization behavior of firms, using transaction costs to explore a firm's minimum efficiency scale (MES). We will show that, under certain conditions, the MES of a firm engaging in subcontracting will be smaller than that of firms which do not engage in subcontracting. In addition, by extending the concept of transaction costs, we argue that when transaction costs are higher, firms will tend to cluster with fellow firms in order to effectively reduce these costs.

8.2.1 The Optimal Scale for Endogenous Production

In this subsection, we demonstrate, without consideration of external transaction costs, why the optimal scale for firms engaging in subcontracting may be smaller than the scale for those that are not engaging in subcontracting. We will show that when a firm subcontracts some of its production inputs and incorporates them into its internal endogenous production, its MES will be smaller than the MES of a firm which does not subcontract these activities. We argue that, as such, it will be mutually beneficial for firms to engage in industrial specialization, and begin by utilizing the cost function to show how specialized production can affect the size of the MES of a firm.

Let us consider a non-perfect competitive market, where there are S firms in the market, and these firms use n production inputs, $x = (x_1, \ldots\ldots, x_n)$, to produce a homogenous product y. The cost function of firm j is therefore:

$$C^j = C^j(y^j, w),$$

where y^j indicates the output of firm j and w indicates the vector of the input price or $w = (w_1, \ldots\ldots, w_n)$. Therefore, the market demand function is:

$$y = J(p, z),$$

where p indicates the product price, z indicates the vector of the external variables, such as prices or quantities of other inputs, and $\partial y / \partial p < 0$.[21] Now let us assume the input market is a competitive market and the input price that all firms face is equal; as such, from Shephard's lemma, we can determine the input demand function of a firm as:

$$x^j = \partial C^j(y^j, w) / \partial w \qquad j = 1, \ldots, s$$

where x^j represents the input demand vector of firm j; therefore, the profit maximization function for firm j is:

[21] Indicates that the demand function is a negative gradient.

$$\max[py^j - C^j(y^j, w) : y = J(p,z)]$$

and the overall supply of the industry is:

$$Y = \sum_{j=1}^{s} y^j \text{ 。}$$

Assuming that the cost function of the firm is a generalized Leontief cost function, then the corresponding firm's cost function is as in Equation (8-1):

$$C^j(y^j, w) = y^2 + yC^j(w) + G^j(w) \qquad j = 1, \ldots, s$$

$$= \frac{1}{2} b_{yy} y^2 + \sum_i \sum_j b_{ij} (w_i w_j)^{\frac{1}{2}} y + \sum_i b_i w_i \qquad i, j = M_1, \ldots, M_n \tag{8-1}$$

$$= \frac{1}{2} b_{yy} (y^u)^2 + b_{M_1M_1} w_{M_1} y^u + b_{M_2M_2} w_{M_2} y^u +$$

$$2b_{M_1M_2} \left(w_{M_1} w_{M_2}\right)^{\frac{1}{2}} y^u + b_{M_1} w_{M_1} + b_{M_2} w_{M_2}$$

where $C(y, w)$ indicates that the cost function of the firm comprises of its external variables, w, and its output, y, and this is the minimum cost for the firm to produce y. Under such a cost function, a firm may achieve its minimum production cost by virtue of internal rearrangement of w. The superscript ^{j} represents different firms in the market whilst subscripts $_i$ and $_j$ represent the firms' different production inputs to produce y; we also assume that the input market is a competitive market,[22] and that these inputs are divisible,23 therefore, industrial specialization can be generated (see Steinle and Schiele, 2002).

We further assume that the cost function of the firm satisfies the following four conditions: (i) a non-decreasing function of w_i, i.e., $\partial C(w,y)/\partial w_i = x_i(w,y) > 0$; (ii) wi is the first-order homothetic function of wi; (iii) the cost function is a concave function of w_i, i.e., $\partial^2 C(w,y)/\partial w_i^2 = \partial x_i(w,y)/\partial w_i \le 0$; 24 and (iv) w_i is continuous. The

[22] If the input market is non-competitive, then the larger firm may have better bargaining power in price negotiations with regard to the input price. As such, it can purchase the inputs at a lower price than that paid by smaller firms.

[23] If the inputs are not divisible, then subcontracting will not occur, regardless of how high the production costs are for the inputs.

[24] This is so because the input demand function is characterized by a negative slope.

maximization problem that the firm now faces is:

$$\max \pi[py^J - C^J(y^J, w) : y = J(p,z)]$$

For convenience of analysis, this study compares only two firms in the market. When all other conditions remain unchanged, we compare how the MES will change if different production arrangements are adopted. We assume that there are two firms, u and v, in the non-competitive product market, and that both firms use two production inputs M_1 and M_2, to produce product y of the same quality. Firm u produces both production inputs, whilst firm v produces only one production input, M_1, and subcontracts its requirements for the M_2 production input through the competitive input market. This study then uses the relative MES of firm u, the endogenous producing firm, and firm v, the subcontracting firm, to discuss the impacts upon their MES, as a result of both endogenous production and subcontracting.

8.2.2 Optimal Production Scale for an Endogenous Producing Firm

Assume that firm u is an endogenous producing firm, the maximization problem it faces in producing the two necessary production inputs in the manufacturing process are as shown in Equation (8-2):

$$\max \pi(p, w_{M_1}, w_{M_2}) = py^u - \{\frac{1}{2}b_{yy}(y^u)^2 + b_{M_1M_1}w_{M_1}y^u + b_{M_2M_2}w_{M_2}y^u + \quad (8\text{-}2)$$

$$2b_{M_1M_2}\left(w_{M_1}w_{M_2}\right)^{\frac{1}{2}} y^u + b_{M_1}w_{M_1} + b_{M_2}w_{M_2}\}$$

The first-order condition is the necessary condition for maximum profit, thus, after setting $\frac{\partial \pi}{\partial y^u} = 0$, we obtain Equation (8-3):

$$p = b_{yy}y^u + b_{M_1M_1}w_{M_1} + b_{M_2M_2}w_{M_2} + 2b_{M_1M_2}(w_{M_1}w_{M_2})^{\frac{1}{2}} \quad (8\text{-}3)$$

Equation (8-3) becomes the quasi-supply curve of the firm,[25] it is also the

[25] The marginal cost curve above the lowest point of the average variable cost is regarded as a firm's

marginal cost function of the firm. Therefore, we may infer that the marginal cost function of the endogenous producing firm u will be:

$$MC^u = b_{yy}y^u + b_{M_1M_1}w_{M_1} + b_{M_2M_2}w_{M_2} + 2b_{M_1M_2}(w_{M_1}w_{M_2})^{\frac{1}{2}} \tag{8-4}$$

and the average cost function will be as in Equation (8-5):

$$AC^u = \frac{1}{2}b_{yy}y^u + b_{M_1M_1}w_{M_1} + b_{M_2M_2}w_{M_2} + 2b_{M_1M_2}(w_{M_1}w_{M_2})^{\frac{1}{2}} + \frac{b_{M_1}w_{M_1}}{y^u} + \frac{b_{M_2}w_{M_2}}{y^u} \tag{8-5}$$

From microeconomic theory, we know that the marginal cost curve and the average cost curve join at a point where MC^u equals AC^u and, moreover, this interception point must pass the lowest point of the average cost. As such, we set $MC^u = AC^u$ and may therefore determine the corresponding MES output y^u_{MES} as follows:

$$\begin{aligned} b_{yy}y^u &= \frac{1}{2}b_{yy}y^u + \frac{b_{M_1}w_{M_1}}{y^u} + \frac{b_{M_2}w_{M_2}}{y^u} \\ \Rightarrow \frac{1}{2}b_{yy}y^u &= \frac{b_{M_1}w_{M_1}}{y^u} + \frac{b_{M_2}w_{M_2}}{y^u} \\ \Rightarrow y^u_{MES} &= 2\left(\frac{b_{M_1}}{b_{yy}}w_{M_1} + \frac{b_{M_2}}{b_{yy}}w_{M_2}\right)^{\frac{1}{2}} \end{aligned} \tag{8-6}$$

The y^u_{MES} in Equation (8-6) is the MES of firm u. In order to allow comparison with other firms that engage in subcontracting, we now analyze the MES of firm v, a firm which chooses subcontracting.

8.2.3 Optimal Production Scale for a Subcontracting Firm

Assume that firm v subcontracts one of its two production inputs, M_2, to other specialized firms, whilst manufacturing M_1 endogenously, and suppose that the firm engages in such subcontracting to other firms so that it can reduce the associated concatenation or linkage costs involved if it produces the two production inputs internally.[26] Thus, if a firm subcontracts part of its

supply curve. Quasi-supply is derived under the first-order condition which contains supply information; it therefore differs from the normal supply curve.

[26] Since the simultaneous production of two inputs may trickle additional production costs, which

production inputs to another firm, the cost function of a type v firm will involve only w_{M_1} and y^v in its production cost function, along with $w^*_{M_2}$, the unit purchasing price of input M_2 from the competitive market. As such, the maximization problem that firm v faces is as in Equation (8-7):

$$\max \pi(p, w_{M_1}, w_{M_2}) = py^v - C^v(w_{M_1}, y^v) - C^v(w_{M_2}) \quad (8\text{-}7)$$
$$= py^v - \left\{ \frac{1}{2} b_{yy}(y^v)^2 + b_{M_1M_1} w_{M_1} y + b_{M_1} w_{M_1} \right\} - b^*_{M_2M_2} w^*_{M_2} y^v$$

Based on the first-order condition, and setting $\frac{\partial \pi}{\partial y^v} = 0$, we can obtain Equation (8-8):

$$p = b_{yy} y^v + b_{M_1M_1} w_{M_1} + b^*_{M_2M_2} w^*_{M_2} \quad (8\text{-}8)$$

Similarly, Equation (8) is the quasi-supply curve of firm type v, and it is also the marginal cost function of the firm, as shown in Equation (8-9):

$$MC^v = b_{yy} y^v + b_{M_1M_1} w_{M_1} + b^*_{M_2M_2} w^*_{M_2} \quad (8\text{-}9)$$

whilst its average cost function is shown in Equation (8-10):

$$AC^v = \frac{1}{2} b_{yy} y^v + b_{M_1M_1} w_{M_1} + b_{M_2M_2} w_{M_2} + \frac{b_{M_1} w_{M_1}}{y^v} + \frac{b_{M_2} w_{M_2}}{y^v} \quad (8\text{-}10)$$

Based on $MC^v = AC^v$, we may determine the corresponding MES output y^u_{MES} for firm v, as follows:

$$b_{yy} y^v = \frac{1}{2} b_{yy} y^v + \frac{b_{M_1} w_{M_1}}{y^v}$$
$$\Rightarrow \frac{1}{2} b_{yy} y^v = \frac{b_{M_1} w_{M_1}}{y^v} \quad (8\text{-}11)$$
$$\Rightarrow y^v_{MES} = 2\left(\frac{b_{M_1}}{b_{yy}} w_{M_1}\right)^{\frac{1}{2}}$$

We can now compare Equations (8-6) to (8-11) to determine the relative size of the MES for these two types of firms, as shown in Equation (8-12):

---

would include all the relevant fixed and variable internal costs for the firm.

$$
\begin{cases}
y^u_{MES} = 2(\frac{b_{M_1}}{b_{yy}} w_{M_1} + \frac{b_{M_2}}{b_{yy}} w_{M_2})^{\frac{1}{2}} \\
y^v_{MES} = 2(\frac{b_{M_1}}{b_{yy}} w_{M_1})^{\frac{1}{2}}
\end{cases} \tag{8-12}
$$

$$
\Rightarrow y^u_{MES} - y^v_{MES} = 2(\frac{b_{M_1}}{b_{yy}} w_{M_1} + \frac{b_{M_2}}{b_{yy}} w_{M_2})^{\frac{1}{2}} - 2(\frac{b_{M_1}}{b_{yy}} w_{M_1})^{\frac{1}{2}}
$$

$$
\Rightarrow y^u_{MES} - y^v_{MES} = 2(\frac{b_{M_2}}{b_{yy}} w_{M_2})^{\frac{1}{2}} \geq 0 \qquad (Q\ b_{M_2} \geq 0 \text{ , } b_{yy} \geq 0)
$$

From Equation (12), we can see that firm v produces two production inputs, and where there is concatenation, or where linkage costs are involved, its MES would be higher in endogenous production than in subcontracting. We may therefore conclude that subcontracting may enable firms with smaller scale to compete in the market.

8.2.4 Subcontracting for Cost Reduction Purposes

The y^u_{MES} in Equation (8-6) is the MES output of firm u, which is also the optimal production scale as well as the lowest average cost point for the firm. Therefore, if we substitute Equation (8-6) into Equation (8-4), we can determine the lowest production cost under the MES for a firm adopting endogenous production:

$$
Q\ MC^u = b_{yy} y^u + b_{M_1M_1} w_{M_1} + b_{M_2M_2} w_{M_2} + 2b_{M_1M_2}(w_{M_1} w_{M_2})^{\frac{1}{2}}
$$

$$
\Rightarrow MC_{y^u_{MES}} = b_{yy}[2(\frac{b_{M_1}}{b_{yy}} w_{M_1} + \frac{b_{M_2}}{b_{yy}} w_{M_2})^{\frac{1}{2}}] + b_{M_1M_1} w_{M_1} + b_{M_2M_2} w_{M_2} + 2b_{M_1M_2}(w_{M_1} w_{M_2})^{\frac{1}{2}} \tag{8-13}
$$

$$
\Rightarrow MC_{y^u_{MES}} = 2b_{M_1}^{\frac{1}{2}} b_{yy}^{\frac{1}{2}} w_{M_1}^{\frac{1}{2}} + 2b_{M_2}^{\frac{1}{2}} b_{yy}^{\frac{1}{2}} w_{M_2}^{\frac{1}{2}} + b_{M_1M_1} w_{M_1} + b_{M_2M_2} w_{M_2} + 2b_{M_1M_2}(w_{M_1} w_{M_2})^{\frac{1}{2}}
$$

Similarly, by substituting Equation (8-11) into Equation (8-9), we may find the lowest production cost under the MES for firm v, a firm engaging in subcontracting, as shown in Equation (8-14):

$$
Q\ MC^v = b_{yy} y^v + b_{M_1M_1} w_{M_1} + b^*_{M_2M_2} w^*_{M_2}
$$

$$
\Rightarrow MC_{y^v_{MES}} = b_{yy}[2(\frac{b_{M_1}}{b_{yy}} w_{M_1})^{\frac{1}{2}}] + b_{M_1M_1} w_{M_1} + b^*_{M_2M_2} w^*_{M_2} \tag{8-14}
$$

$$\Rightarrow MC_{y^{*}_{MES}} = 2b_{M_1}^{\frac{1}{2}} b_{yy}^{\frac{1}{2}} w_{M_1}^{\frac{1}{2}} + b_{M_1M_1} w_{M_1} + b^{*}_{M_2M_2} w^{*}_{M_2}$$

Now we may compare the relative size of the marginal costs of these two types of firms as follows:

$$\begin{cases} MC_{y^{*}_{MES}} = 2b_{M_1}^{\frac{1}{2}} b_{yy}^{\frac{1}{2}} w_{M_1}^{\frac{1}{2}} + 2b_{M_2}^{\frac{1}{2}} b_{yy}^{\frac{1}{2}} w_{M_2}^{\frac{1}{2}} + b_{M_1M_1} w_{M_1} + b_{M_2M_2} w_{M_2} + 2b_{M_1M_2}(w_{M_1} w_{M_2})^{\frac{1}{2}} \\ MC_{y^{*}_{MES}} = 2b_{M_1}^{\frac{1}{2}} b_{yy}^{\frac{1}{2}} w_{M_1}^{\frac{1}{2}} + b_{M_1M_1} w_{M_1} + b^{*}_{M_2M_2} w^{*}_{M_2} \end{cases} \quad (8\text{-}15)$$

$$\Rightarrow MC_{y^{*}_{MES}} - MC_{y^{*}_{MES}} = 2b_{M_2}^{\frac{1}{2}} b_{yy}^{\frac{1}{2}} w_{M_2}^{\frac{1}{2}} + b_{M_2M_2} w_{M_2} + 2b_{M_1M_2}(w_{M_1} w_{M_2})^{\frac{1}{2}} - b_{M_2M_2} w^{*}_{M_2}$$

Assuming that $b_{M_2M_2} = b^{*}_{M_2M_2}$, i.e., the usage of individual inputs does not differ between these two types of firms, we obtain:

$$\Rightarrow MC_{y^{*}_{MES}} - MC_{y^{*}_{MES}} = 2b_{M_2}^{\frac{1}{2}} b_{yy}^{\frac{1}{2}} w_{M_2}^{\frac{1}{2}} + b_{M_2M_2}(w_{M_2} - w^{*}_{M_2}) + 2b_{M_1M_2}(w_{M_1} w_{M_2})^{\frac{1}{2}} \quad (8\text{-}16)$$

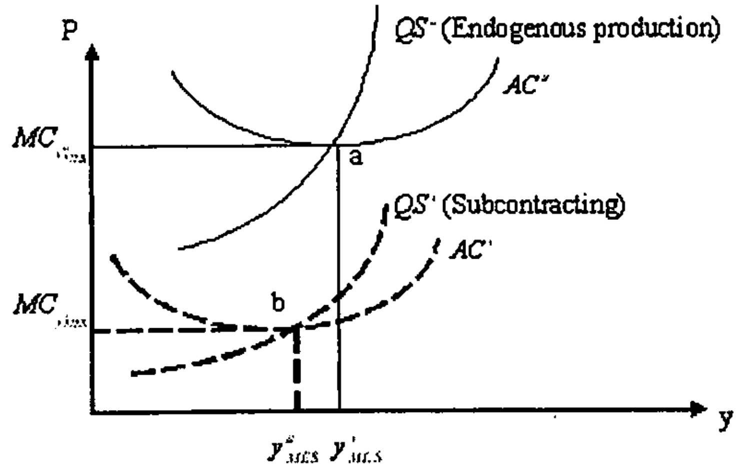
where w_{M_2} is the production cost for input x_{M_2} by a firm opting for endogenous production, and $w^{*}_{M_2}$ is the purchase cost for input x_{M_2} for a firm opting to engage in subcontracting from other firms in the market. Moreover, when the input market is a perfect competitive market, w_{M_2} is no smaller than $w^{*}_{M_2}$, and when $b_{M_1M_2} > 0$ we can observe that the marginal costs $(MC_{y^{*}_{MES}})$ for a firm opting for endogenous production will be higher than those for a firm opting to engage in subcontracting. The argument is as shown in Equation (8-17):

$$\Rightarrow MC_{y^{*}_{MES}} - MC_{y^{*}_{MES}} = \underset{(+)}{2b_{M_2}^{\frac{1}{2}} b_{yy}^{\frac{1}{2}} w_{M_2}^{\frac{1}{2}}} + \underset{(+)}{b_{M_2M_2}(w_{M_2} - w^{*}_{M_2})} + \underset{(+)}{2b_{M_1M_2}(w_{M_1} w_{M_2})^{\frac{1}{2}}} \geq 0 \quad (8\text{-}17)$$

$$\Rightarrow MC_{y^{*}_{MES}} \geq MC_{y^{*}_{MES}}$$

It becomes clear from Equation (8-17) that when a firm engages in subcontracting of production, it can lower its marginal costs. Since we assume that the product market is a non-competitive market, firms engaging in subcontracting of production are thus more competitive than those opting for endogenous production in the product market. We can use Figure 8.1 to illustrate our argument.

Figure 8.1 Costs for endogenous production firms and subcontracting firms



Within this figure, the full lines represent the supply line and average cost curve for firms engaging in endogenous production, where the MES point is at point a; the dotted lines represent the supply line and average cost curve for firms engaging in subcontracting of production, where the MES point is at point b. Comparing points a and b, we can see that the MES for firms opting for subcontracting is lower than that for firms opting for endogenous production. As such, type u firms will be less competitive than type v firms. The above analysis is based on the assumption that a concatenation or linkage cost is generated due to the simultaneous production of two inputs by a firm opting for endogenous production. If, however, the linkage costs for these two inputs become negative, i.e., $b_{M_1M_2} < 0$, then Equation (8-17) evolves into Equation (18):

$$MC_{y^{v}_{MES}} - MC_{y^{u}_{MES}} = 2b_{M_2}^{\frac{1}{2}} b_{yy}^{\frac{1}{2}} w_{M_2}^{\frac{1}{2}} + b_{M_2M_2}(w_{M_2} - w^{*}_{M_2}) + 2b_{M_1M_2}(w_{M_1} w_{M_2})^{\frac{1}{2}} \qquad (8\text{-}18)$$

(+) (+) (-)

In the above circumstances, the marginal costs of firms engaging in subcontracting of production may be higher or lower than those of endogenous production firms. The existence of $b_{M_1M_2} < 0$ may be due to the fact that economies of scope may emerge as a result of the simultaneous production of the two production inputs.[27] In addition, if the transaction costs of subcontracting between firms are higher, those firms involved may bring related production activities into their own internal production operations.

The analysis in this section has shown that under certain specific conditions, firms may lower their MES through subcontracting so as to gain easier access to the market and enhance their competitive edge in the market. In addition, the above results also suggest that as long as a firm is specialized within a certain layer of production, or in a certain type of production technology, it stands a chance of competing in the market.

Firms can also lower their production costs by subcontracting, reducing considerably their marginal costs at their MES, as indicated in Figure 8.1. Nonetheless, Scott (1993) argued that although specialized production may have the advantage of risk and cost reductions, there may, nevertheless, be an increase in transaction costs due to complex and unpredictable interactions. Therefore, the probable response measures that firms might take would be to shorten the transaction process, as well as the geographical distance between the transaction partners, thus effectively cutting down the costs of both transactions and transportation. Such considerations could of course help to intensify the degree of industrial clusters.

8.3 Data Analysis

From the theoretical model, as described in the previous section, we have shown that firms may lower their production costs by subcontracting part of their production activities. In reality, however, it remains to be shown whether subcontracting really does lower costs. In addition, apart from cost reduction, there may well be other considerations that lead firms to resort to subcontracting. These issues require further clarification. In this section,

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[27] The total cost for firms that produce two or more products is lower than the total cost of the different individually produced products. The reason lies in the by-product that a product generates, or the use of a certain type of knowledge that produces different products, or by use of computer aided design (CAD) or computer aided manufacturing (CAM) which lowers both the design costs and production costs of different products.

therefore, we rely upon the results of a questionnaire survey to carry out our empirical analysis. To begin with, we first examine the primary reasons why firms rely upon subcontracting rather than endogenous production, followed by analysis of the relevant factors affecting the degree of subcontracting, i.e., the subcontracting ratio, and whether such subcontracting behavior is common practice in the industries examined.

For our empirical study, we examine high-tech firms in the Hsinchu Science-based Industrial Park (HSIP) in Taiwan for three major reasons: (i) the HSIP is the most successful example of high-tech industrial clusters in Taiwan, and has in fact become a major focus for the study of high-tech firms in Taiwan; (ii) by studying the subcontracting behavior of high-tech firms, we can gain an in-depth understanding of how it affects the competitive advantage of high-tech firms and whether it has any impact on industrial clusters; (iii) since this study conducts a census of all the high-tech firms in the HSIP in Taiwan, the survey results can be regarded as representative.

8.3.1 Survey Method and Sampling Structure

This survey began in early November 2002 and ended in mid-January 2003. The questionnaire, which contained basic information on the surveyed firms as well as information relating to market entry barriers, was mailed to all of the 334 high-tech firms in the HSIP. As discussed earlier, this study set up three variables to capture the various characteristics relating to industrial specialization, namely, the subcontracting ratio, the depth of subcontracting and the duration of subcontracting. The surveyed firms were specifically asked about their knowledge of the subcontracting behavior of their foreign counterparts and also the reasons why subcontracting was necessary. At the end of the survey, a total of 90 usable samples were collected, giving an effective return rate of 28.30 per cent.[28] Statistics on the questionnaires returned are provided in Table 8.1, from which we can see that the IC industry accounted for the highest number of returned samples, with 36 of the 90 copies returned.

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[28] The return ratio is calculated from computation of the original number of firms within each industry listed in the administration bureau of the HSIP. We found that 16 firms were not contactable for various reasons, as such, after deducting these 16 firms from our survey population, our sample return rate increased to 28.30 per cent.

By proportion, however, with the exceptions of the communications and IC industries, the return rates for all other industries exceeded 30 per cent, whilst the biotech industry showed a 50 per cent return rate, the highest of all.

8.3.2 Basic Characteristics of the Surveyed Firms

The basic information collected by the survey included variables such as the age of the firm (*Age*), the stage of production (*Stage*), registered capital (*Capital*), the number of employees (*labor*), the firm's export ratio (*EX*), R&D to total sales ratio (*RD*) and size of the firm (*Size*).

Table 8.1 Return sample statistics

Industries	Number of Samples Returned	Number of Firms listed in the HSIP	Return Ratio (%)
Precision Instrument	4	12	33.33
Biotech	9	18	50
Computer Peripherals	16	52	30.78
Opto-electronics	18	58	31.03
IC	36	134	26.87
Communications	7	60	11.67
Total	90	334	27

Note: Number of effective samples = 90.
Source: Findings of this study.

For the purpose of comparison, Table 8.2 categorizes the total sample, the sample of firms engaging in production subcontracting, and the sample of those not engaging in production subcontracting.

Table 8.2 Basic characteristics of firms in the HSIP

Variable	Definition of Variable	N=90 All Samples	N=80 Firms with Subcontracting	N=10 Firms without subcontracting	Max. and Min. Value
Age	Number of years established as at the end of 2003.	8.30 (4.95)	8.15 (4.94)	9.50 (5.10)	22 1
Stage	The firm's current stage of production.	1.72 (0.77)	1.73 (0.76)	1.57 (0.98)	3 1
Capital	Registered capital (in NT$ million).	2,443.24 (9,093.89)	2,717.60 (9,630.30)	303.20 (465.29)	67,000 12
Labor	Number of employees (persons).	243.54 (608.50)	262.71 (637.56)	68.63 (109.65)	3,982 10
EX	Ratio of exports as a percentage (%).	47.40 (35.54)	49.86 (34.66)	27.67 (38.38)	100 0
RD	Spending on R&D as a proportion of sales revenue (%).	54.875 (152.75)	43.32 (115.69)	146.00 (320.59)	999 0
Size	Scale of firm: = 1 for less than 50 persons; = 2 for 51 to 250 persons; = 3 for more than 251 persons.	1.93 (0.63)	1.99 (0.59)	1.37 (0.74)	3 1

Notes:
1 *Number of effective samples = 90.*
2 *Figures in parenthesis are the standard deviation.*

The results of Table .8.2 are summarized as follows. The *Age* variable refers to the number of years that the surveyed firm has operated within the HSIP; this produces an average value of 8.3 years, suggesting that the majority of the surveyed firms were established in the mid-1990s. As to the stage of production, we set the *Stage* variable as being equal to 1 if the surveyed firm reported that its primary product came under the upstream section of the industry, with 2 or 3 being assigned if the primary product came under the midstream or downstream section of the industry, respectively. The *Stage* variable mean was 1.72, placing most of the firms in the HSIP somewhere between the upstream and midstream stage of their respective industries.[29] We can also see from Table 8.2 that those firms operating without subcontracting were mainly upstream firms.

The information on registered capital comes directly from the Administration Bureau of the HSIP with the average value being NT$2,443.24 million. Table 8.2 shows that the registered capital for those firms engaging in subcontracting was far higher that for those without subcontracting. This suggests that it is the larger firms in the HSIP that are engaging more in subcontracting. The number of employees variable, Labor, also indicates that it is the larger firms, those hiring more workers, that are engaged more in subcontracting. The average export ratio (*EX*) was 47.40 per cent, indicating that just over a half of the products manufactured by the firms in the HSIP are for domestic consumption. With the majority of the firms in the HSIP being in the midstream or upstream section of their industry, intra- and inter-industry trading is therefore commonplace. The *EX* variable statistics also reveal that firms with higher export ratios tend to have a higher propensity for engaging in subcontracting.

As regards spending on R&D (*RD*) as a proportion of revenue, the mean for the *RD* variable was 54.88 per cent, and it is interesting to find that firms engaging in subcontracting actually have lower R&D ratios than those without subcontracting. Finally, with respect to the firm size variable (*Size*), this can be measured in terms of total assets, profit, sales amount or the number of employees. Following our examination of the quality of the data for each possible approach, it was decided that this study should utilize the number of

[29] There were 39 upstream firms (47.56%), 27 midstream firms (32.93%) and 16 downstream firms (19.51%).

employees as a proxy for the firm scale variable. In compiling the Size variable, we set it as being equal to 1 for firms with 50 employees or less, equal to 2 for firms with 51 to 250 employees, and equal to 3 for firms with 251 employees or more. Table 8.2 shows that the average value of the Size variable is 1.93, which again suggests that smaller firms have less involvement in subcontracting activities.

To summarize, the statistics in Table 8.2 clearly show that there are significant differences between those firms that engage in subcontracting and those firms that do not. The preliminary statistical results suggest that it is the larger firms, characterized by their higher export ratios, greater total numbers of employee, and higher amounts of registered capital, that are more involved in subcontracting.

8.3.3 Preliminary Analysis of Firm's Subcontracting Behavior

In this subsection, we first explore the motives of the long-standing firms and newly- established firms to see if there are any differences in their subcontracting behavior. We further examine the differences between those firms in the HSIP and comparable firms in the US, Japan and Korea, to see if there are any significant differences between the practices of firms within their respective industries in different countries.

8.3.4 Motives for Firms Engaging in Subcontracting

We find that 88.89 per cent of firms in the HSIP are engaged in some form of subcontracting of their production, which makes it an extremely common practice within the HSIP.[30] However, the question remains as to what the factors are that lead firms to take the decision to engage in subcontracting. As we can see from Table 8.3, the survey results indicate that the most common reasons were 'there are already other manufacturers in this field so it does not pay, cost-wise, for us to do the same' and 'to reduce cost and to save on capital investment'; in percentage terms, these reasons accounted for 66.67 per cent and 62.82 per cent, respectively. Clearly cost-saving considerations are very important factors leading firms to engage in subcontracting. The survey results

[30] There were 80 firms that had outsourced components, raw materials and services, or subcontracted

provided in Table 8.3 also show that subcontracting can enable firms to access much needed marketing channels, R&D technology, innovative ability and professional knowledge, not to mention savings in the otherwise extraordinarily high level of fixed-capital investment required for machinery and equipment. These survey results help to confirm that the primary reason for firms engaging in subcontracting is to lower all related fixed and variable factors of investment input, whilst concatenation or linkage costs may also be reduced, an assertion that we emphasize in our theoretical model.

Table 8.3 Reasons for firms engaging in subcontracting in lieu of endogenous production

Reasons for Subcontracting	Frequency	Ratio of Valid Samples (%)
There are already other manufacturers in this field so it does not pay, cost-wise, for us to do the same	52	66.67
To reduce cost and to save on capital investment	49	62.82
The company may engage in more specialized production	44	56.41
Insufficient ability to produce the needed components and raw material	31	39.74
Standard components already exist in the market	22	28.21
To reduce fixed personnel expenses	22	28.21
To reduce the risk of unstable work volume	16	20.51
To be more responsive to market demand	12	15.38
To be closer to the 'central plant'	11	14.10
To shorten plant setup time	7	8.97
Others	3	3.85

Note: A total of 78 valid samples were returned in the survey; however, since the questions were multiple choice, the total response statistics exceed 78.
Source: Findings of this study

It is important to note that the survey results show that 'specialized production' also plays a major role in consideration by firms, since it accounted for 56.41 per cent of the responses, and ranked in third place. The survey results clearly suggest that besides being more cost competitive, when firms engage in subcontracting they are also aiming at becoming more specialized producers in the market. Scott (1993) argued that specialized production may lower a firm's operation risks and enhance its comparative advantage; however, as more firms engage in subcontracting and industrial specialization, the transaction costs will rise due to the rapid increase in inter- and intra-industry trade transactions. Scott noted that firms have a strong incentive for clusters so as to reduce all the relevant transaction costs. We shall

part of their semi-finished products to other firms, accounting for 88.89% of the total sample.

examine this issue in more detail in the 'Empirical Results' section of this paper.

8.3.5 Business Models and Subcontracting Motives of Newly-Established Firms

As part of this study, the surveyed firms were asked whether, to their knowledge, there had been any newly-established domestic firms in their industries over the past two years in direct competition with them, and if so, whether these new competitors were also adopting subcontracting as their business model in order to successfully compete with them. They were further asked to comment why, in their opinion, these new entrants had chosen subcontracting. The survey results found that 89.66 per cent of the surveyed firms reported that the new entrants in their respective industries were engaging in subcontracting of production, with the probable reasons for choosing this as a business model being reported in Table 8.4. By comparing the statistics in Table 8.3 with those in Table 8.4, we can see that the reasons are almost identical, with new entrants also seeking to save costs and pursue specialized areas of production. As such, the survey results suggest that, in their respective industries, industrial specialization has become the most important strategy for most of the firms surveyed.

Table 8.4 Possible reasons for newly-established firms engaging in subcontracting of production in lieu of endogenous production

Reasons for Subcontracting by Newly-established Firms	Frequency	Ratio of Valid Samples (%)
There are already other manufacturers in this field so it does not pay, cost-wise, for us to do the same	53	67.95
To reduce cost and to save on capital investment	47	60.26
The company may engage in more specialized production	33	43.23
Insufficient ability to produce the needed components and raw material	31	39.74
Standard components already exist in the market	22	28.21
To reduce fixed personnel expenses	19	24.36
To reduce the risk of unstable work volume	15	19.23
To be more responsive to market demand	13	16.67
To be closer to the 'central plant'	10	12.82
To shorten plant setup time	5	6.41
Others	4	5.13

Note: A total of 80 valid samples were returned in the survey; however, since the questions were multiple choice, the total response statistics exceed 80.
Source: Findings of this study

8.3.6 International Comparison of Subcontracting

The firms surveyed in this study were also asked to indicate whether the subcontracting practices that they were observing and reporting in their respective industries seemed more or less popular as compared to the adoption of subcontracting in the US, Japan and Korea. The survey results are summarized in Table 8.5, which shows that after subtracting any respondents indicating 'do not know,' [31] as many as 48.15 per cent of the respondent firms reported that in their industry in the US, subcontracting was indeed a more common practice than in Taiwan,[32] whilst 90.74 per cent of the surveyed firms reported that subcontracting in the US was at least as popular as in Taiwan. For Japan, 31.03 per cent of the surveyed firms reported that in their industry subcontracting was a more common practice there than in Taiwan whilst 63.79 per cent of the firms surveyed believed that subcontracting in Japan was at least as popular as in Taiwan. For Korea, 41.48 per cent of the firms surveyed believed that subcontracting was a more common practice there than in Taiwan, whilst 45.10 per cent of the firms surveyed believed that subcontracting in Korea was at least as popular as in Taiwan.

Table8.5 Status of production subcontracting in the US, Japan and South Korea

Comparison of Taiwan and the US		Comparison of Taiwan and Japan		Comparison of Taiwan and Korea	
Status	Frequency	Status	Frequency	Status	Frequency
Do not know	36 (4.0)	Do not know	32 (35.56)	Do not know	39 (43.33)
The US is not popular comparatively	5 (5.56)	Japan is not popular comparatively	21 (23.33)	Korea is not popular comparatively	21 (23.33)
Similar to Taiwan	23 (25.56)	Similar to Taiwan	19 (21.11)	Similar to Taiwan	23 (25.56)
The US is rather popular	16 (17.78)	Japan is rather popular	14 (15.56)	Korea is rather popular	7 (7.78)
The US is even more popular	10 (11.11)	Japan is even more popular	4 (4.44)	Korea is even more popular	0 (0.0)

Note: Figures in parenthesis are percentages.
Source: Findings of this study

The comparison between the US, Japan, Korea and Taiwan, suggests that subcontracting is most common in the US, followed by Japan, then Taiwan,

[31] Indicates that firms have insufficient knowledge of the status of foreign countries where fellow manufacturers use subcontracting or outsourcing.
[32] [(16+10)/ (90-36)]*100=48.15%.

with subcontracting seemingly least popular in Korea. One possible reason for its lack of popularity in Korea may be the country's more vertically-integrated industrial structure, although it is already well understood that Korean *chaebols* tend to have all of their manufacturing processes within their internal endogenous production systems.

8.4 Empirical Results

We have shown, through our theoretical analysis in the second section of this paper, that firms may lower their production costs through subcontracting and, in the third section, by analysis of the survey results, we have determined that the primary goal of subcontracting is to lower both fixed capital investment and overall production costs. We have also seen that there are significant differences between those firms opting to engage in subcontracting and those firms opting not to do so. In order to fully explore the possible reasons behind these firm's subcontracting decisions, in this section we adopt a regression model to examine factors affecting these decisions.

In our theoretical model, we have shown that production by subcontracting may lower a firm's MES; therefore, it may be interesting to examine whether an industry which exhibits a greater propensity for subcontracting practices will also be an industry in which barriers to market entry are lower; an ordered Probit model will be employed to test this relationship. Finally, in the third part of our empirical analysis we will specifically examine whether subcontracting and industrial specialization can exert even greater effects on industrial clusters.

In order to undertake the abovementioned empirical analysis, we list all of the relevant descriptive statistics for both the dependent and independent variables in Table 8.6, where the definitions of each variable are also explained. We shall also explain each of these variables in more detail as we proceed with our discussion.

8.4.1 Determination of the Extent of Subcontracting

In this section of our analysis we examine the relevant factors affecting the extent of a firm's subcontracting activities. We use subcontracting ratio (*Ratio*)

Table 8.6 Definition and descriptive statistics of variables

Variable	Definition of Variable	N=90 Mean (Std. Dev.)	Max. Value	Min. Value
$Ratio_i$	Indicates, in the manufacturing process, the ratio of the costs paid for outsourced/subcontracted raw materials, components, semi-finished products and specialization services, as a percentage of the most important products of a firm.	58.38 (25.45)	100	10
Length	Length of subcontracting period (years).	5.368 (4.06)	18	0
Trend	Subcontracting trend: = 1 indicates $Ratio_i$ will progressively reduce in future; = 2 indicates $Ratio_i$ will not be stable in future; = 3 indicates $Ratio_i$ will remain stable in the future; = 4 indicates $Ratio_i$ will progressively increase in the future.	3.026 (0.87)	4	1
$Plant_i$	If a firm's main reason for engaging in subcontracting was 'reduction in costs and savings on capital investment' then $Plant_i$ would be set at 1; otherwise 0.		1	0
Std_i	If a firm's main reason for engaging in subcontracting was because 'standard components already existed in the market,' then Std_i would be set to 1; otherwise 0.		1	0
$Cost_i$	If a firm's main reason for engaging in subcontracting was because 'There are already other manufacturers in this field so it does not pay, cost-wise, for us to do the same,' then $Cost_i$ would be set to 1; otherwise 0.		1	0
otfirm	Indicates whether subcontracting is a popular practice amongst other firms in the industry in which the firm is located. If the surveyed firm reported that it was 'very popular,' then *otfirm* would be set at 4; if 'commonplace' was reported, then *otfirm* would be set at 3; if 'there are only a few firms that do,' then *otfirm* would be set at 2; if 'no' was reported then *otfirm* would be set at 1.		4	1
Easy	Indicates whether the surveyed firm considered it easy for a new firm to enter the industry in which it is located. *Easy* = 1 indicates that it is not easy; = 2 indicates it is fair; = 3 indicates it is easy; = 4 indicates that it is very easy.	1.53 (0.79)	4	1
$Neighbor_i$	If a firm's main reason for locating within the Park was because it wished to be in the same neighborhood as fellow firms in the industry, then $Neighbor_i$ would be set at 1; otherwise 0.		1	0
CT	Contact intensity (by eight methods of contact, namely, telephone, fax, face-to-face contact, EDI, e-mail, Internet, EFT, and others); indicates how many of these methods the surveyed firm had adopted to get in touch with other collaborating firms. *CT* = 0 indicates none of the abovementioned, *CT* = 8 indicates that all of these methods had been adopted.	3.35 (0.96)	6	1
EC	Contact Intensity through information technology. *EC* = 0 indicates that the surveyed firm had not used any one of the four e-tools, namely, EDI, e-mail, Internet and EFT, to make contact with other collaborating firms; *EC* = 4 indicates that the surveyed firm had utilized all four of these e-tools.	1.40 (0.68)	4	0
TW_i	Local procurement as a percentage of total subcontracting value			
DT_i	The geographical distance between the surveyed firm's most important collaborating business partner, measured by shipping costs for a standard object.	9.40 (5.17)	26.7	4.2

Note: Average value and standard deviation are rounded to two digits after the decimal point.
Source: Findings of this study

as a proxy for industrial specialization. *Ratioi* represents the subcontracting ratio of firm *i*. The statistics provided in Table 8.6 indicate that the average value of the subcontracting ratio for all firms surveyed was 58.38 per cent, whilst the explanatory variables affect a firm's subcontracting ratio include 'savings on capital investment' (*Plant*), 'standard components already exist in the market' (*Std*) and 'there are already other manufacturers in this field so it does not pay, cost-wise, for us to do the same' (*Cost*). The subcontracting trend (*Trend*) and the duration of subcontracting activities by the firm (*Length*), which affect the subcontracting ratio of a firm, are also examined.

We also include in the empirical model an industrial dummy (IO), the export ratio level (*EX*), and the size of the firm (Size) to determine whether these will affect the subcontracting ratio of firms. We can now set the empirical model as follows:

$$\log Ratio_i = \alpha_0 + \alpha_1 Trend_i + \alpha_2 Length_i + \alpha_3 Plant_i + \alpha_4 Std_i + \alpha_5 Cost_i + \alpha_6 IO1_i + \alpha_7 IO2_i + \alpha_8 IO3_i + \alpha_9 IO4_i + \alpha_{10} IO5 + \alpha_{11} EX_i + \alpha_{12} Size_i + \varepsilon_i \quad (19)$$

where $Ratio_i$: indicates that in the manufacturing process, the ratio of costs paid for outsourced/subcontracted raw materials, components, semi-finished products and specialization services, as a proportion of the primary products of a firm; α_i is the estimation coefficients for the explanatory variables; and ε_i is the error term.. Since the range of $Ratio_i$ is between 0 and 100, this study takes the logarithm for its empirical estimation.

Explanatory Variables

(1) *Subcontracting trend and length:* Trendi is the subcontracting trend, which indicates whether or not the firm plans to continue to subcontract part of its production processes in the future; if the firm believes that the ratio will increase, the variable is set at 4; if steady, the variable is set at 3; if unsteady, the variable is set at 2; if the ratio is to be reduced, the variable is set at 1. The *Lengthi* variable indicates how long the surveyed film has

been engaging in subcontracting, measured in years.[33] This study expects that the greater the value of the subcontracting trend, and the longer the duration of a surveyed firm's subcontracting, the greater the subcontracting ratio will be. As such, this study hypothesizes that both α_1 and α_2 should be positive.

(2) *Standard components and cost variable*: Planti determines whether the surveyed firm reported that 'reduction in costs and savings on capital investment' were primary concerns in the firm's adoption of subcontracting; if yes then Planti would be set as equal to 1, otherwise 0. Stdi indicates whether the reason for subcontracting was that 'standard components already exist in the market'; if yes then Stdi would be set as equal to 1, otherwise 0. Costi indicates whether the reason for subcontracting was that 'there are already other manufacturers in this field so it does not pay, cost-wise, for us to do the same'. If the surveyed firm responded yes, then variable Costi would be set as equal to 1; otherwise 0.

Our survey reveals that 66.67 per cent of the surveyed firms indicated that the primary reason for them engaging in subcontracting was that 'there are already other manufacturers in this field so it does not pay, cost-wise, for us to do the same'; 62.82 per cent reported that the reason for engaging in subcontracting was for 'cost reductions and savings on capital investment,' and 28.21 per cent reported that it was due to the fact that 'standard components already exist in the market'. In light of the above survey results, we may infer that costs and specialization are the two primary factors considered by firms with regard to subcontracting. In addition, our theoretical model also points out that under certain conditions, subcontracting may lower the production costs of a firm. As such, we hypothesize that α_3, α_4 and α_5, will all have positive impacts on *Ratioi*.

(3) *Industrial Dummy:* as we saw from Table 8.1, there were six major industries in the HSIP. *IO*1 = 1 indicates that the firm is in the semiconductor industry, *IO*2 = 1 indicates that the firm is in the computer

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[33] The figure is computed up until December 2002. In addition, it is interesting to note that the average age of the surveyed firms in the sample was 8.3 years whilst the average length of subcontracting practices for these firms was 5.37 years, which suggests that, on average, the survey firms adopted

peripherals industry, $IO3 = 1$ indicates that the firm is in the communications industry, $IO4 = 1$ indicates that the firm is in the opto-electronics industry, and $IO5 = 1$ indicates that the firm is in the precision instruments industry. The estimation coefficients for these industrial dummy variables represent their relative performance when compared to the reference group, i.e., the biotech industry. From our survey, we find that the communications industry has the highest subcontracting ratio, at 67.5 per cent, followed by the 65.55 per cent of the computer peripherals industry, the 58.80 per cent of the IC industry, the 57.35 per cent of the opto-electronics industry, the 55.75 per cent of the precision instruments industry, and the 45.0 per cent of the biotech industry. As such, this study hypothesizes that the estimation coefficients for α_6 to α_{10} will all be positive.

(4) *Export Ratio:* EX_i signifies the export ratio of the surveyed firm's primary product. Since those firms that have a larger export ratio face keener international competition, and thus, come under tremendous pressure to cut down their production costs, we hypothesize that the variable EX_i will have a positive impact on $Ratio_i$ and that the estimates of α_{11} will be positive.

(5) *Size of firms:* The variable $Size_i$ indicates the size of a firm. Since the larger the size of a firm, the more it aims to bring its production activities into its organization's internal operations. As such, the ratio of subcontracting should tend to be lower, and we hypothesize that the estimates of α_{12} will be negative.

Having discussed our prediction for each of the explanatory variables, we now present our empirical results on the determination of the subcontracting ratio (Ratio) in Table 8.7. As the Table shows, the subcontracting trend (Trend) has a significant positive impact upon the ratio of subcontracting, which indicates that the subcontracting ratio will increase as the surveyed firm plans to increase its subcontracting in the future. This is consistent with our hypothesis.

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subcontracting at a point approximately three years after their establishment.

Table 8.7 Empirical results of subcontracting ratio (log Ratio)

Variable	(1)	(2)	Expected Sign
Intercept	2.57589 (7.63)***	2.65631 (8.22)**	
(Trend)	0.12452 (1.75)*	0.14611 (2.14)**	(+)
(Length)	0.00234 (0.14)	0.00406 (0.24)	(+)
(Plant)	0.23957 (1.79)*	0.22574 (1.74)*	(+)
(Std)	0.01933 (0.11)	-	(+)
(Cost)	0.15351 (1.17)	-	(+)
IC (*IO*1)	0.72581 (2.90)***	0.69376 (3.24)***	(+)
Computer Peripherals (*IO*2)	0.68642 (2.49)**	0.66097 (2.68)**	(+)
Communications (*IO*3)	0.76342 (2.34)**	0.74450 (2.30)**	(+)
Opto-electronics (*IO*4)	05.4445 (2.15)**	0.51235 (2.22)**	(+)
Precision Instruments (*IO*5)	0.46175 (1.43)	0.43091 (1.35)	(+)
(EX)	0.00479 (2.28)**	0.00439 (2.14)**	(+)
(Size)	-0.06490 (-0.58)	-0.06173 (-0.59)	(-)
N	59	59	
$\bar{R}^2$	28.42%	29.47%	

Notes:

1. *t-statistics in parenthesis.*
2. **** indicates the estimated coefficients have reached a 1 per cent significance level, ** indicates the estimated coefficients have reached a 5 per cent significance level, * indicates the estimated coefficients have reached a 10 per cent significance level.*

As to the variable on the duration of subcontracting ($Length_i$), this is not significant in the table, which suggests that the previous duration or history of existing subcontracting activities does not affect the firm's current subcontracting ratio. Furthermore, the empirical results in Table 8.7 confirm that if the surveyed firm considers that subcontracting can reduce its costs and capital investment, this will induce more subcontracting because the estimation coefficient for the $Plant_i$ variable is positive and significant, which is in line with our hypothesis and our theoretical argument. However, our empirical results do not confirm that the Std_i and $Cost_i$ variables will have any significant positive impact on the subcontracting ratio. As for the industrial dummies, our empirical results confirm that, with the exception of the precision instruments industry, all other industry dummy variables are positive and highly significant, thus confirming our hypothesis. These results suggest that subcontracting activities within the IC industry, computer peripherals industry, communications industry and opto-electronics industry are all significantly higher than in the biotech industry.

To summarize, our empirical results, as presented in Table 8.7, show that the primary factors affecting the subcontracting ratio of firms are the firm's future subcontracting plan (the $Trend_i$ variable) and whether the firm considers that subcontracting can be an effective means of saving costs and reducing its capital investment (the $Plant_i$ variable). In addition, our empirical results confirm that firms which are more export oriented will tend to have greater subcontracting activities. Again, the above empirical results are also in line with our argument that when firms face higher cost reduction pressure, by way of international competition, they will more actively engage in subcontracting so as to effectively reduce their production costs. Last, but not the least, our empirical results fail to confirm that the size of the firm can be an important factor in determining the extent of a firm's subcontracting decisions. However, the results do confirm that the extent of subcontracting can be quite different amongst different industries.

8.4.2 Empirical Examination of the Extent of Entry Barriers

In order to examine the impact that the prevalence of subcontracting has on the ease of market entry, in our questionnaire we explicitly asked the surveyed firms to indicate whether it was easy for new entrants to enter their respective industries. As we have seen in Table 8.6, the variable *EASY* has four possible choices ranging from 'not easy,' 'fair,' 'easy,' to 'very easy' with respective values of 1, 2, 3, and 4 being assigned to each possible choice. The mean of the *EASY* variable is 1.53, indicating that in general, it is not easy for new firms to enter the market. In the following analysis we use this variable to examine the relevant factors determining the extent of the entry barriers. It is important to note that the *EASY* variable is a discrete variable which contains discrete values ranging from 1 to 4. As such, when conducting our empirical estimation, the ordered Probit model will be applied to our empirical estimation, which is as specified below:

$$EASY_i = \gamma_0 + \gamma_1 Ratio_i + \gamma_2 Trend_i + \gamma_3 Length_i + \gamma_4 otfirm_i + \gamma_5 Size_i + \gamma_6 Stage_i + \delta_i \quad (20)$$

where $EASY_i$ indicates whether or not the surveyed firm considered that in their own industry, new entrants could easily enter the market to compete with existing firms. If the firm considered that it was very easy for new firms to enter the market then the *EASY* variable would be set at 4; if easy, the variable would be set at 3; if fair, the variable would be set at 2; if not easy, then the variable would be set at 1.

8.4.3 Explanatory Variables

(1) *Subcontracting ratio, subcontracting trend and length:* $Ratio_i$ indicates the ratio, as a percentage, of the cost of outsourced or subcontracted raw materials, components, semi-finished products and specialization services paid by the surveyed firm for its primary product. $Trend_i$ indicates whether the surveyed firm will continue to engage in subcontracting activities in the future. $Length_i$ indicates the history of the subcontracting activities of the surveyed firms. As indicated in the literature, based upon the activities of SMEs in the computer-related industry in Taiwan, there is a possibility that industrial specialization can effectively promote market entrance. In our empirical model we therefore hypothesize that variables $Ratio_i, Trend_i$ and $Length_i$ will all have a positive impact on the ease of entrance for new firms; thus, the estimation coefficients of γ_2, γ_3 and γ_4 are all expected to be positive.

(2) *Subcontracting practices in the industry:* The *otfirm* variable defines whether or not subcontracting is regarded as a popular practice amongst other firms in the industry in which the surveyed firm is located. If the surveyed firm considered that it was quite popular amongst member firms in the industry, then the *otfirm* variable would be set at 4; if the surveyed

firm reported that the popularity of subcontracting practice was fair, the variable would be set at 3; if the surveyed firm reported that subcontracting was not a popular practice and that only a certain number of firms adopted it, then the variable would be set at 2; and if the surveyed firm reported that none of the firms in the industry were adopting subcontracting, then the *otfirm* variable would be set at 1. It is hypothesized that as subcontracting practice becomes more popular, firms with more specialized technology or skills may enter the market more easily thereby lowering the industry's overall entry barriers. As such, we hypothesize that the estimated coefficient of γ_6 will be positive.

(3) *Characteristics of the firms:* This study argues that the characteristics of a firm can also affect its judgment on the ease of entry. Therefore, in our empirical model we have included the size of a firm $(Size_i)$ and the stage of production $(Stage_i)$ in the estimation.

Table 8.8 Extent of entry barriers, dependent variable (EASY)

Name of Variables	(1)	(2)	Expected Symbol
Constant Term	2.07243	1.50092	
(*intercept*)	(1.42)	(1.71)*	
Subcontracting Ratio	0.0189891	0.0144644	
(*Ratio*)	(2.00)**	(1.78)*	(+)
Subcontracting Trend	0.0398873		
(*Trend*)	(0.11)	-	(+)
Subcontracting Length	0.136283	0.0900926	
(*Length*)	(2.07)**	(2.22)**	(+)
Subcontracting by Firms within the	0.353776	0.18499	
Industry (*otfirm*)	(1.84)*	(1.80)*	(+)
Size of Firms	-0.113013		
(*Size*)	(-0.28)	-	
Stage of Production	-0.281445	-0.0775436	
(*Stage*)	(-0.76)	(-0.31)	
μ_1	2.8671	2.83622	
	(4.86)***	(5.73)***	
μ_2	3.86142	3.70351	
	(6.13)***	(7.22)***	
N	59	67	
log L	-47.67562	-53.77817	

Notes:

1. t-statistics are in parentheses.

*2. *** indicates the estimated coefficients have reached a 1 per cent significance level, ** indicates the estimated coefficients have reached a 5 per cent significance level, * indicates the estimated coefficients have reached a 10 per cent significance level.*

Table 8.8 summarizes the empirical results of our examination of entry barriers, showing that the subcontracting ratio variable (*Ratio*) has a significant and positive impact on the ease of entry for firms. The results therefore confirm that the higher the subcontracting ratios for firms within an industry, the lower the barriers to the entry of new firms. This result is consistent with the literature on industrial specialization in Taiwan which shows that it has greatly lowered entry barriers, thereby inviting many new firms to enter the market.

Table 8.8 also shows that the length of the subcontracting period, as well as the popularity of subcontracting, will all positively and significantly affect the ease of entrance; these results are in line with our hypotheses. In sum, the empirical results in Table 8.8 confirm that an increase in the extent of subcontracting, an increase in the popularity of subcontracting, or an increase in the duration of subcontracting, will all effectively reduce the barriers to entry for new firms.

8.4.4 Empirical Results on Clustering Effect

In an industry where production is highly specialized, firms are increasingly subcontracting many of their non-core production activities in order to reduce costs and regain their competitive edge. However, along with such intensifying subcontracting activities, there will inevitably be a rapid surge in both transaction costs and transportation costs, imposing new challenges upon firms. To effectively overcome such problems, firm may choose to cluster together in order to minimize these rising costs and enhance their subcontracting network. It can therefore be argued that the prevalence of the subcontracting system may enhance the clustering effect of firms.

In this section of the paper we test this argument using the survey results obtained from this study. It is important to note that the clustering effect has already been formed amongst firms within the HSIP; therefore, the focus of our study will not be on why the firms clustered there, but rather on explaining what the relevant factors were in determining the geographical distance that the surveyed firms have between themselves and their major upstream or downstream collaborating partners. We argue that the prevalence of the subcontracting system will push, or provide more opportunities for, firms to look for upstream or downstream collaborating firms that are already nearby, or are locating nearby, and consequently the clustering effect around the HSIP will be enhanced and enlarged.

To examine such a hypothesis, this study divides the island of Taiwan according to its fifteen major administrative districts and then utilizes the freight fee charges between the HSIP and each of the fifteen districts as a proxy for geographical distance.[34] We then obtain from the survey results the location of the surveyed firms' primary downstream or upstream collaborating partners. Having gained this important information from the survey, we then assign a value for the 'distance' proxy variable, *DT*, for each of the surveyed firms in accordance with the freight rate between the HSIP and the administration district in which the collaborating firm is located. We then use the following regression model to examine the relevant factors in determining *DT*.

$$DT_i = \kappa_0 + \kappa_1 CT_i + \kappa_2 EC_i + \kappa_3 Neighbor_i + \kappa_4 Ratio_i + \kappa_5 Length_i + \kappa_6 Trend_i + \kappa_7 TW_i + \tau_i \tag{21}$$

where (*DT*) is a proxy dependent variable for geographical distance between the surveyed firm and its most important upstream or downstream collaborating firm; with the independent variables comprising of contact intensity (*CT*) between the firms, the status of electronic contact between the firms (*EC*), subcontracting ratio (*Ratio*), subcontracting duration (*Length*), subcontracting trend (*Trend*) and the ratio of local purchase (*TW*), and η_i as the error term in the estimation. We explain these variables and their possible impacts on *DT* as follows:

8.4.5 Variable Definitions

(1) *Geographical distance between the surveyed firm and its most important collaborating partner: DTi* is the proxy variable for geographical distance

[34] The fifteen administrative districts are: Keelung, Taipei City, Taipei County, Taoyuan, Chungli, Hsinchu (and the Science-based Industrial Park), Miaoli, Taichung, Changhua, Yunlin, Chiayi, Tainan, Kaohsiung, Pingtung and the foreign countries.

between the surveyed firm and its most important domestic collaborating partner. In compiling this variable we obtain the relevant information from the Administration Bureau of the HSIP on the freight rates for 1,500-kilo cargo originating from Hsinchu to various destinations in Taiwan and then convert this into a freight rate per kilo.

(2) *Contact intensity and electronic status: CTi* refers to the contact intensity between firms. This study includes eight possible contact methods in the questionnaire, which are telephone, fax, face-to-face contact, EDI, E-mail, Internet, EFT, and others. We then count how many of these methods are adopted. If all methods are adopted then the *CTi* variable would be set as equal to 8; if none of these methods are used the variable would be set as equal to 3, and so on.

It is argued that *CTi* may have both positive and negative impacts on *DTi,* because, on the one hand, if the surveyed firm and its collaborating partner utilize more methods to contact each other, suggesting that all the possible methods have been attempted in order to enhance the communication mechanism, then it can be hypothesized that there is a genuine need for closer clustering. Consequently, *CTi* may have a negative impact on *DTi*. On the other hand, however, the development of more and better communication mechanisms may well suggest that geographical distance may no longer impose barriers to inter-firm collaboration; therefore, it could be equally hypothesized that *CTi* may have a positive effect on *DTi*. Whether *DTi* will be positively or negatively affected by *CTi* remains to be examined empirically and thus we are unable to hypothesize here on its potential impact.

We have, nevertheless, included in this study an additional proxy variable for contact intensity, which is aimed specifically at electronic means of communication. As we have seen above, the *CTi* variable comprises of eight possible means of communication; of these, EDI, E-mail, Internet and EFT can be regarded as IT communication methods. In our empirical model we examine whether the intensity of the utilization of these IT communication methods will have any significant impact on *DTi*. If the surveyed firm utilizes all of these IT communication methods to facilitate its business operations, then the EC_i variable would be set at 4, and if none were used, then the variable would be set at 0. However, similar to the reasons discussed above, we are unable to project the possible impact of EC_i on *DTi* without further empirical study.

(3) *The neighboring factor:* $Neighbor_i$ records whether or not, by locating itself in the HSIP, a firm could get closer to other collaborating firms. If the surveyed firm responded, yes, then the $Neighbor_i$ variable would be set at 1, otherwise 0. We hypothesize that if the surveyed firm chose to locate itself in the HSIP so as to get closer to its primary business collaborator, then the variable $Neighbor_i$ will have a significant negative impact on *DTi*.

(4) *Subcontracting ratio, subcontracting length and subcontracting trend:* $Ratio_i$ indicates the subcontracting ratio of a firm. The higher the subcontracting ratio, the greater the propensity for subcontracting; therefore, there is a clear need for closer clustering. As such, we hypothesize that the variable $Ratio_i$ will have a significant negative impact on *DTi*, and its corresponding regression coefficient κ_4 is expected to be negative. *Lengthi* represents the surveyed firm's subcontracting duration. The longer the duration of subcontracting for a firm, the wider the range of subcontractors becomes; therefore, κ_5 is expected to be positive. *Trendi* represents the surveyed firm's projection of its future subcontracting activities. The higher the projected trend, the higher the subcontracting ratio will be in the future, which will consequently lead to closer clustering amongst member firms within the industry. The estimated coefficient of κ_6 is expected to be negative.

(5) *Proportion of local purchase: TWi* represents the ratio of local purchase as a proportion of overall subcontracting value. *TWi* is introduced in our empirical model in order to examine whether or not an increase in domestic procurement through subcontracting will shorten the geographical distance of the collaborating firms, or whether the surveyed firms tend to engage more in local subcontracting, and therefore choose those suppliers that are more closely located. In this study we hypothesize that firms will opt for

the latter, and therefore expect that the estimated coefficient of κ_7 will be negative.

Having discussed the possible impacts of all the relevant explanatory variables, we now summarize our empirical results in Table 8.9, which shows that variables *CT* and *EC* are not significant in models (1) and (2), whereas *CT* is significant in model (3). We therefore find empirical evidence to show that an increase in the methods of communication used between firms, or in other words, an increase in the needs of communication between firms, will shorten the geographical distance between them, which will enhance or enlarge the clustering effect within or around the HSIP. This result is consistent with our hypothesis.

Table 8.9 Empirical results on collaboration distance

Name of Variables	(1)	(2)	(3)	Expected Symbol
Constant Item	16.38991	15.09776	14.20509	
(*intercept*)	(2.97)***	(3.19)***	(3.54)***	
Contact Intensity	-1.74649	-1.90241	-1.40278	(?)
(*CT*)	(-1.09)	(-1.23)	(-1.82)*	
Electronic Status	0.32002	0.80913	-	(?)
(*EC*)	(0.13)	(0.37)		
Neighboring Factor	-2.86923	-2.87090	-2.91768	(-)
(*Neighbor*)	(-1.67)	(-1.72)*	(-1.76)*	
Subcontracting Ratio	-0.05024	-0.05480	-0.05087	(-)
(*Ratio*)	(-1.49)	(-1.72)*	(-1.72)*	
Subcontracting Length	0.64803	0.59420	0.58122	(+)
(*Length*)	(2.08)**	(2.07)**	(2.08)**	
Subcontracting Trend	-0.55419	-	-	(-)
(*Trend*)	(0.47)			
Proportion of Local Purchase	-0.02928	-0.03044	-0.02903	(-)
(*TW*)	(-1.24)	(-1.31)	(-1.29)	
N	53	54	54	
$\bar{R}^2$	15.60%	18.12%	20.73%	

Notes:

1 t-statistics are in parenthesis.

*2. *** indicates the estimated coefficients have reached a 1 per cent significance level, ** indicates the estimated coefficients have reached a 5 per cent significance level, * indicates the estimated coefficients have reached a 10 per cent significance level.*

Table 8.9 shows that the regression coefficient for the subcontracting ratio (*Ratio*) variable is negative and significant, which suggests that the higher the subcontracting ratio of a firm, the keener the firm will be to shorten the distance between itself and its suppliers. This empirical result also suggests that industrial specialization may well increase the transaction costs of the firms concerned and will place pressure on the firm to look for neighboring suppliers which can ultimately become collaborators. This result is also consistent with the argument of Scott (1993).

Our empirical results also show that the subcontracting duration of the surveyed firm, (*Length*), will significantly and positively affect the distance between collaborating firms, which suggests that the longer the subcontracting history, the more experienced the firm will have become in selecting its collaborating partners, and the geographical distance between all of these collaborating firms will therefore be wider.

Table 8.9 also shows that the variable, *Neighbori*, is negative and significant in models (2) and (3) of our estimation, which confirms our hypothesis. This result suggests that the clustering effect will occur in two possible ways; firstly, firms will choose their location in such a way as to be closer to their major collaborating partners, and secondly, the prevalence of subcontracting will induce these firms to choose their collaborating partners in such a way that those located nearby will be considered, which will of course ultimately enhance the clustering effect around the HSIP. However, as subcontracting firms gain more experience and a longer history of subcontracting, they may actually enlarge the scope of their collaborating partners, and thus, the geographical distance between the collaborating partners may subsequently widen.

8.5 Conclusions

Amid ever increasing competition and product diversification in international trade, ways of effectively responding to rapid market fluctuations and lowering production costs have become key issues for firms striving to regain their competitive edge. In this study, we find that subcontracting can be an effective operational model for cost reduction, providing firms with enhanced competitive edge. In addition, along with the rapid improvements in information and communications technology, and the promotion of e-commerce, the interactions between collaborating firms have intensified, and have also expanded the practice of subcontracting.

It is important to note that the prevalence of subcontracting has a profound impact on industry. In terms of industrial structure, it can lead to industrial specialization which will not only effectively reduce the production costs for a firm but can also effectively reduce the entry barriers for the new firms, thereby enhancing industrial competitiveness as a whole, and revitalizing industries through the rapid introduction of new firms. In this study, we have conducted an in-depth survey of all the registered firms in the Hsinchu Science-based Industrial Park (HSIP) in Taiwan in order to gain an understanding of their subcontracting behavior. In our empirical investigation, we start by examining why the high-tech firms in the HSIP engage in subcontracting, and try to determine the relevant factors that guide a firm's subcontracting decisions.

If there are two production inputs to be produced endogenously, and concatenation or linkage costs exist in producing both of these inputs, then it is shown in our theoretical model that a decision to subcontract one of these production inputs to other firms could be an effective strategy for a firm to lower its MES, and so become more competitive in the market. Our empirical evidence confirms that 'savings on capital investment' and 'effectively reducing production costs' are primary factors leading to a firm's decision to adopt subcontracting. Consequently, it is shown, both theoretically and empirically, that subcontracting is an effective means of reducing production costs, and as such, when a firm faces strong competitive pressure to lower costs, it may adopt subcontracting, or extend the degree of its existing subcontracting. This assertion is also confirmed by the evidence that high exporting firms in the HSIP are more likely to have higher subcontracting ratios. As for the possible impact that subcontracting may have on entry barriers, the second part of our empirical study has shown that an increase in the prevalence of subcontracting will significantly encourage the potential entrance of new firms, as our empirical evidence shows that the degree of subcontracting can effectively reduce entry barriers.

The above empirical evidence is meaningful for industrial policy reference since it suggests that as the subcontracting practice become more (less) popular and member firms in the industry have higher (lower) subcontracting ratios, then the relevant industry's structure will be a more (less) open one and it will be more (less) favorable for new firms to enter the market. Finally, in the third part of our empirical study, we confirm that the prevalence of subcontracting can have a significant and positive impact in terms of enhancing industrial clustering. This evidence is consistent with the assertion of Scott (1993), that firms may cluster together in order to lower their corresponding transaction costs.

In summary, cost reduction is a primary consideration for firms opting for subcontracting and this can subsequently have a very profound impact. Our empirical study has shown that not only can it lower the entry barriers for new firms in the high-tech industries, but it can also consolidate the clustering effect amongst these high-tech firms; as such, it can affect both the industrial structure and the choice of location. This study has focused primarily on high-tech firms in the Hsinchu Science-based Industrial park in Taiwan. Whether our empirical results can effectively transfer to other non-high-tech firms in Taiwan will remain to be seen; however, our theoretical model suggests that so long as there is a possibility for firms to reduce their production costs through subcontracting, the practice of subcontracting will prevail, and all the subsequent impacts associated with subcontracting, such as the lowering of entry barriers and enhancement of industrial clustering will be likely to emerge. Furthermore, such a theoretical assertion is not limited purely to high-tech firms.

Chapter 9 Industrial Cluster and Firm's Productivity:A Case Study of Chinese Taipei's ICT Industry

9.1 Introduction

Over recent decades, an ever-increasing amount of attention has been paid to the role played by industrial clusters in facilitating regional economies (Kuchiki and Tsuji, 2004) or in driving high technology industries (Bresnahan and Gambardella, 2004). The bulk of the research has focused on evidence provided by aggregate or micro data, examining the critical features shared by the various economies, such as significant investment in capital equipment and the strength of their orientation towards export markets.

As in the literature surrounding this issue, industrial clusters matter in terms of firms' performance. Industrial clusters may refer to firms' business environments in terms of vertical relationships for suppliers-clients, labor pooling, infrastructures, and innovative capacity. This will determine firms' performance. (Hoogstra and Dijk, 2004) Issues relevant to industrial clusters and firms that have been raised in recent years include the effects of industrial clustering on firms' market entry, innovation activities, and growth. Generally speaking, most research provides evidence highlighting how industrial clusters generate positive effects on regional firms. (1) Baptista and Swann (1999) show how the formation of an industrial cluster can effectively reduce entry barriers and facilitate market entry; (2) Gemser and Wijberg (1995) and Baptista and Swann (1998) indicate that industrial clusters enable firms to be more innovative; (3) Storey (1994), Barkham, et al. (1996), Lechner and

Dowling (2000), Lechner and Dowling (2003), and Hoogstra and Dijk (2004) provide evidence that argues that regional environments matter in driving firms' growth. However, less attention has been paid to research issues concerning the effect of industrial clusters on firms' productivity growth.

The rapid growth of Chinese Taipei's ICT industry since the middle 1980s has generated increasing amounts of research into firms' productivity differences within this sector. A number of economists have attributed some proportion of successful economic performance to the effective penetration of the export markets for manufactured products, with some studies indicating the existence of a significant linkage between productivity growth and export expansion. This important linkage can be explained from at least three perspectives: scale economies, trade exposure and the learning effect. A number of subsequent works have provided new insights to enrich this framework, with many of them reaching similar general conclusions. Some researches set up models to estimate TFP dynamic in Chinese Taipei's manufacturing sector, stressing the importance of export scale economies on productivity growth, and highlighted the market selection and learning effect of exports through an empirical study (Chen and Tang, 1990; Aw, 2002; Aw and Batra, 1998; Yang, 2002). However, most of them fail to notice the industrial clusters, business environments of firms, may effectively influence their productivities.

The purpose of this paper is to use the micro data on Chinese Taipei's electronics industry for 1999 to highlight the influence of business environments, industrial clusters, upon the productivities at a plant level. In other words, this study explores the productivity differences for individual plants by taking into account their heterogeneity, including individual plants' attributes, such as sizes, production technologies, R&D investment, and the attributes of their business environments, such as regional R&D intensities, various externalities.

Two significant results feature in this study: Firstly, we propose a new approach to classifying industrial clusters based on the Euclid distance between any two firms within a relevant industrial sector. For pursuing the optimal populations of industrial cluster, we follow some critical of cluster analysis, a multivariate analysis. To some extent, in classifying industrial clusters, this research overrides the traditional studies, which heavily rely upon administrative region. Secondly, apart from traditional research of firms' productivities, which over-stress firms' own heterogeneities, this study highlights the roles played by regional business environments. Our empirical results may also offer an insight into the reasons why successful industrial clusters can enhance firms' competitiveness; that is that, in addition to the incentives provided by competition to seek out improvements to productivity levels, regional externalities can also benefit firms through important spillover effects.

The outline of this research is as follows. The next section reviews the theoretical relationship between industrial cluster and productivity. We provide a statistical approach to outline the deployments of the ICT industrial sector, and to measure various attributes of Chinese Taipei's various ICT industrial clusters for 1999. Section 3 introduces the model used for our estimations and a description of its determinants of the firm's TFP pattern. The data used, and the results obtained, are presented in Section 4, which goes on to assess the economic implications of the results. The conclusions of this study are drawn together in the final section.

9.2 Industrial Clusters and Productivity Differences

9.2.1 Theoretical Backgrounds for Defining Industrial Clusters

An industrial cluster is defined as "geographical concentrations of industries that gain performance advantages through co-location (Doeringer and Terkla, 1995: 225)." This definition of clusters is similar to that of agglomeration economies. These include the geographic or spatial clustering of economic activity, use of common technology, the presence of a central actor (i.e., a large firm, research center, etc.), and the quality of the firm network (Jacobs and DeMan, 1996).

The role of social infrastructure in defining industrial clusters is a theme prevalent in the literature. Information flow is critical in an effective industrial cluster, and, in order to facilitate information exchange, a social infrastructure is required. While the characteristics of a cluster may be present, it is not necessarily an effective cluster; an effective cluster must also include social interaction, trust, and a shared vision in order to create the dynamic nature of a cluster (Jacobs and DeMan 1996, Saxenian, 1994).

The definition of the vertical and horizontal industrial clusters is useful to identify key dimensions of industrial clusters. Rosenfeld (1997) underlines criteria for defining a cluster, including the scale of employment as the size of the cluster, the economic or strategic importance of the cluster, the range of products produced or services used, and the use of common inputs. Most authors argue for a broader definition of clusters that are defined by both horizontal and vertical relationships, and include both direct and indirect linkages. Researchers have relied on simply defining industrial clusters as a concentration of employment in a single industry. As argued in Jacobs and

DeMan (1996: 425), "there is not one correct definition of the cluster concept...different dimensions are of interest."

Porter (1990) championed the "Diamond of Advantage," in which four factors determines a competitive advantage for firms. The four corners of the diamond include factor conditions, demand conditions, industry strategy/rivalry, and related and supporting industries. Porter used this diamond to determine which firms and industries had competitive advantages, and his emphasis of the importance of related and supporting industries encouraged interest in clusters. Porter recognized that the majority of economic activity takes place at the regional level. Thus, his ideas are commonly applied to cities and regions. The bulk of Porter's thesis mainly deals with the competitive advantages of clustering for industries. Porter provides a simple definition of two types of clusters: vertical clusters, and horizontal clusters. Vertical clusters are made up of industries that are linked through buyer-seller relationships. By contrast, horizontal clusters include industries with sharing a common market for the end products, use a common technology or labor force skills, or require similar natural resources (Porter, 1990).

Generally speaking, even though there are several common themes in the definition of an industrial cluster, most of the definitions of industrial clusters reference the geographic scope of the cluster and spatial proximity. In defining the geographic scope of industrial clusters, most literature indurate that there is no uniform definition of the appropriate geographic scope of a cluster (Rosenfeld 1996, Jacobs and DeMan 1996, Jacobs and DeJong 1992).

9.2.2 Geographical Identification of ICT Industrial Clusters in Chinese Taipei

One of the common approaches to identifying clusters is based on quantitative techniques, including location quotients and input-output (I-O) analyses (Rosenfeld 1997). I-O analyses and other quantitative tools have also been the basis for identifying clusters in several other studies, including the Twin Cities Industrial Cluster Project (State and Local Policy Program 1998) and UNC-Chapel Hill's study of North Carolina's industries (Bergman, Feser and Sweeney 1996). I-O analyses are useful to identify clusters, but they may fail to outline the geographical border of a cluster. Moreover, the above approach cannot examine the effect of an industrial cluster upon the performance of a firm.

In this study, we employ the cluster analysis, one of multivariate analyses, and the coordinate of each Chinese Taipei's ICT firms in terms of the T2-degree transverse Mercator[35] to delineate the geographical boundaries of various ICT industrial clusters. Cluster Analysis is a multivariate analysis technique that seeks to organize information about variables so that relatively homogeneous groups or clusters can be formed. In this paper, the so-called homogenous or similar groups are in terms of their geographical locations.

In this way, the classification of ICT industries includes computer, communication, and audio/video electronic productions. Two main supporting industries for ICT are the electronics components industry and the electronic equipment industry. Both supporting industries are of importance in the vertical relationship for ICT production. In the process of geographical clustering, firms belonging to the electricity and electronic industrial sectors are included. The average linkage method is employed in the process of

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[35] Chinese Taipei's maps have only two coordinate ways: longitude/latitude and 2-degree transverse Mercator（二度分帶）

clustering firms based on their geographical deployment and weighted by number of employees in order to highlight the spatial agglomeration of labor pooling.

The data are drawn from "the annual manufacturing-plant survey in 1999" conducted by the Statistical Division under Ministry of Economic Affairs (MOEA), Chinese Taipei, in 2000, and published in 2001. In this study, there are 2,054 establishments classified as belonging to the ICT industry, 2,368 establishments to the electronics components industry, and 3,285 to the electronic equipment industry. The survey's data provides geographical information at the village level, helping us to outline the boundaries of ICT clusters.

Milligan and Cooper (1985) proposed that the three criteria that performed best in these simulation studies with a high degree of error in the data were a pseudo F statistic developed by Calinski and Harabasz (1974), a pseudo t2 statistic by Duda and Hart (1973), and the cubic clustering criterion by Sarle (1983). In large samples that can be divided into the appropriate number of hypercubes, the assumption, in which a uniform distribution on a hyper-rectangle will be divided into clusters shaped roughly like hypercubes, gives very accurate results. The CCC can be used for estimating the optimal number of population clusters. Accordingly, the study refers to the optimal population of ICT cluster in Chinese Taipei to CCC, as well as the pseudo-F statistic and pseudo-t2 statistic. As shown in Figure 1, this optimal population is 8.

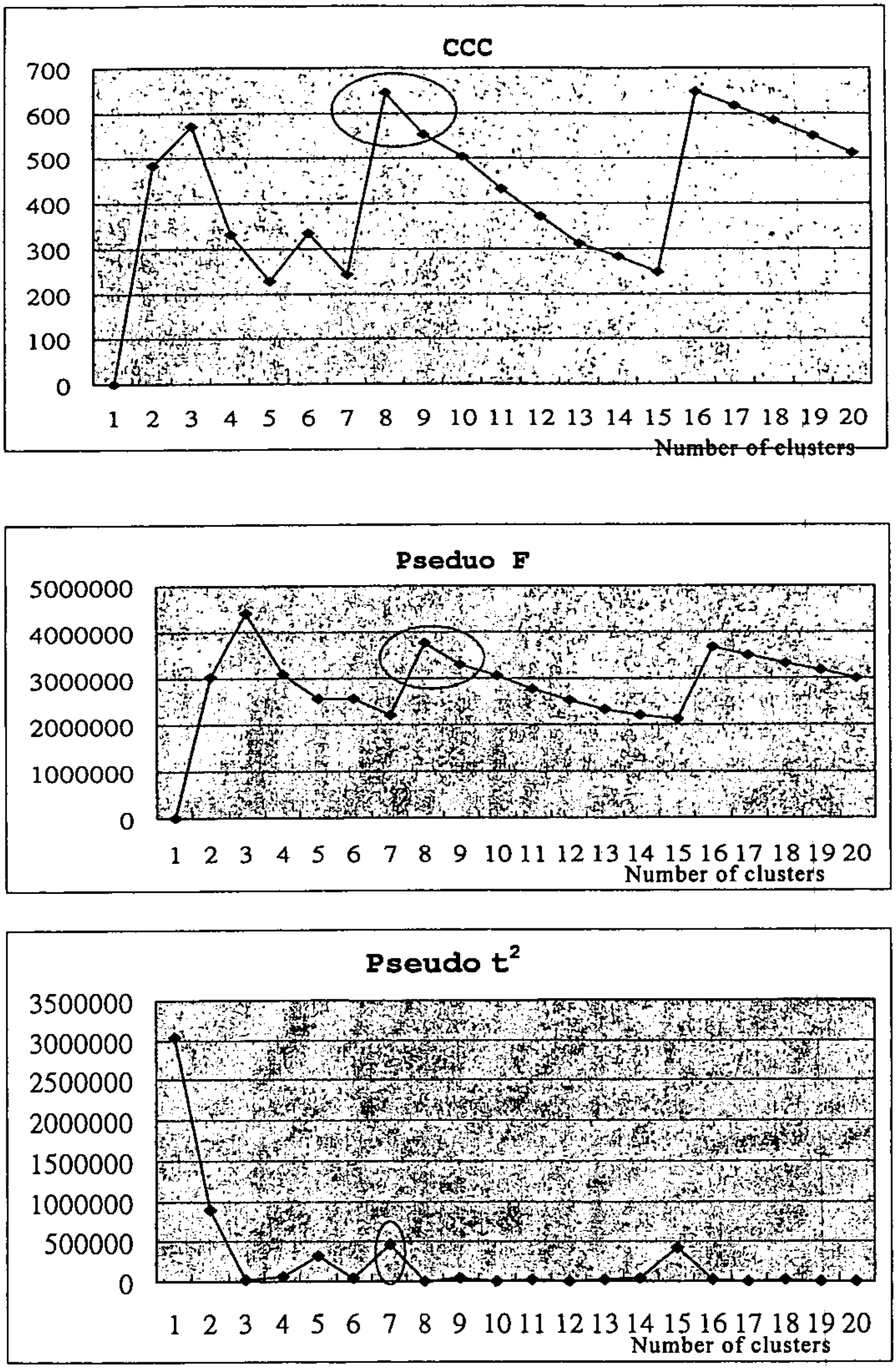


Figure 9.1 CCC, Pseudo-F, and Pseudo-t2 for Chinese Taipei's Electronic firms' Spatial Clustering

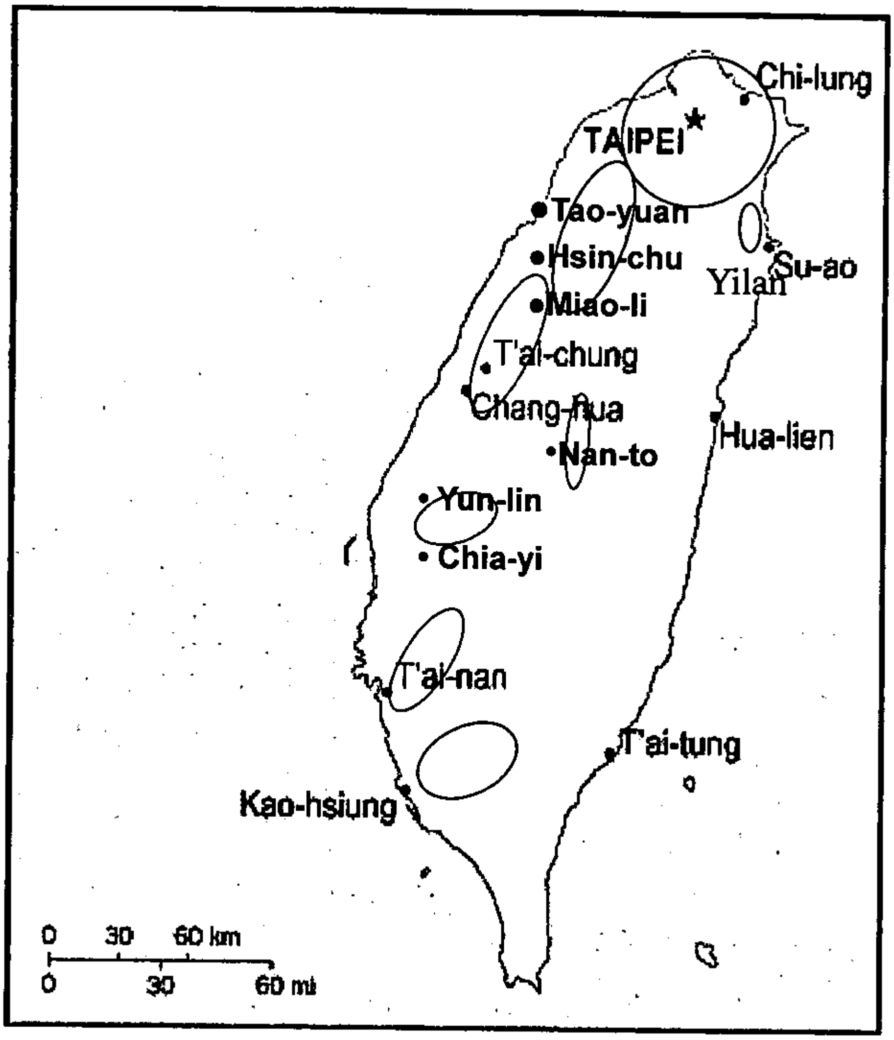


Figure 9.2 Deployment of ICT industrial clusters in Taiwan

Figure 2 shows the geographical deployments of 8 ICT industrial clusters in Chinese Taipei. The most northern ICT industrial cluster includes Taipei city and county, Chilung city, and part of Tao-yuan county in the geographical bundle. The geographical region of the other ICT industrial cluster in the northern Chinese Taipei includes parts of Tao-yuan county, Hsin-chu county and city, and parts of Miaoli county.

There are three ICT clusters located in central Chinese Taipei. The first ICT cluster consists of Tai-chung county, and parts of Miaoli and Chang-hua counties. The second ICT cluster in Central Chinese Taipei includes Nan-tou and part of Chang-hua counties. The other ICT cluster located in central Chinese Taipei geographically includes Yun-lin and Chia-yi counties. Figure 2 addresses two ICT industrial clusters located in southern Chinese Taipei, which are Tai-nan and Kao-hsiung counties. Finally, the only ICT cluster in eastern Chinese Taipei is deployed in Yilan County.

Table 1 displays the various features and geographical boundaries of these industrial clusters for ICTs. The most northern ICT industrial cluster consists of 1,508 plants and 106,683 employees, the largest industrial cluster in scale. The total R&D intensity, which is defined as R&D expenditure per capita, is NT$191.55, and capital labor intensity NT$1,658.60. In this cluster, the share of small firms is 32.32%, and the average TFP is 0.009%. The other ICT industrial cluster in the northern Chinese Taipei consists of 173 ICT plants and 51,140 employees. Its R&D intensity and capital-labor ratio are NT$552.56 and 8,536.34. This cluster is characterized by active innovation activities, and is the location of the globally reputed Hsin-chu Science Park.

The first ICT cluster in central Chinese Taipei with Tai-chung, and parts of Miaoli and Chang-hua is featured in a lower R&D intensity. The second ICT industrial cluster with Nan-tou and part of Chang-hua is mainly agglomerated by large-scale firms, and 3,226 employees were hired by just nine ICT firms in this cluster. The last ICT cluster located in central Chinese Taipei, in Yun-lin and Chiayi counties, has a lower R&D intensity.

There are two southern ICT industrial clusters, in Tai-nan and Kao-hsiung counties. The two ICT clusters in southern Chinese Taipei employ 3,032 and 6,814 people at 54 and 93 establishments, respectively. In eastern Chinese Taipei, there is one ICT cluster, in Yilan county. It has attracted only seven establishments and hires 243 persons. This industrial cluster is younger and has higher productivity growth than the others.

9.2.3 Firm-Level TFP for ICT Industrial Sector

We further used the same data set on Chinese Taipei's ICT industry to construct an index of firm-level TFP for each firm in 1999. By using the TFP index, our aim is to measure cross-firm productivity pattern. The TFP of a firm is estimated in the following equation, which is based upon the multilateral index developed by Good et. al. (1996):

$$TFP_{ft} = [(\ln Y_{ft} - \overline{\ln Y_t}) + \sum_{k=2}^{t}(\overline{\ln Y_k} - \overline{\ln Y_{k-1}})] \\ -\frac{1}{2}[\sum_{i=1}^{n}(w_{kft} + \overline{w_{it}})(\ln X_{kft} - \overline{\ln X_{ft}}) - \sum_{k=2}^{t}\sum_{i=1}^{n}(\overline{w_{ik}} + \overline{w_{ik-1}})(\overline{\ln X_{ik}} - \overline{\ln X_{ik-1}})], \tag{9-1}$$

where each firm f uses the set of inputs X_{kft} and the input weights W_{ift} to produce a single output Yft. In this equation, $\overline{\ln Y_t}$, $\overline{\ln X_{ft}}$ and $\overline{w_{it}}$ refer respectively to the average values of output, input and input weight for all firms in year t. This index measures the proportional difference in TFP for firm f in year t relative to the representative firm in the base year. In this paper, we use 1999 as the base time period and consider four types of inputs (n=4); these are, material, energy, labor and capital. Due to the research focusing the TFP difference for 1999, Equation (9-1) can be simplified as Equation (9-2),

$$LnTFP_{ft} = [(\ln Y_{ft} - \overline{\ln Y_t})] - \frac{1}{2}[\sum_{i=1}^{n}(w_{kft} + \overline{w_{it}})(\ln X_{kft} - \overline{\ln X_{ft}}). \tag{9-2}$$

Table 9.1 presents the average productivity differences for 1999 across industrial clusters. The averages TFP level of various clusters ranges from -0.013 (Kao-hsiung) to 0.218 (Yilan).

Table 9.1 Overview of Eight ICT clusters in Chinese Taipei

Regional Deployment of clusters	Number of establishments	Number of employees	R&D intensity (per capita R&D expenditure, NT$)	Capital labor ratio	Average TFP
Taipei, Chi-lung city, and part of Tao-yuan,	1,508	106,683	191.55	1,658.60	0.009
Part of Tao-yuan, Hsin-chu, part of Miaoli	173	51,140	552.58	8,536.34	0.090
Part of Miaoli, Tai-chung, and part of Chang-hua	184	15,555	61.28	2,325.32	0.015
Yun-lin and Chiayi	26	1,276	43.49	919.20	0.041
Part of Chang-hua and Nan-tou	9	3,226	304.47	1,432.61	0.054
Tai-nan	54	3,032	42.52	2,014.15	0.112
Kao-hsiung	93	6,814	116.55	1,101.28	-0.013
Yilan	7	243	124.90	188.94	0.218

**: Share of SMEs refers to the share of firms with number of employee under 100 to total number employees for their correspondent industries.*
Source: Calculated by the authors.

9.3 Model for Examining Firms' Productivity

Based on a traditional productivity framework, this section presents an empirical model to examine whether the productivity pattern confronted by each firm, can not only be attributed to the underlying conditions of firm size, capital intensity, and other firm specific characteristics, but also their regional environments. Our empirical model comprises an equation describing the productivity difference for 1999 as a function of observable firm's attributes and their regional advantages. The dependent variables are firm's TFP indicator for 1999, taken as a logarithmic value.

Drawing on the 'size-R&D-productivity' framework,' this section presents an empirical model to examine whether the TFP pattern confronting each firm is attributable to the underlining the conditions of firm-specific attributes and regional-specific conditions. The firm's own attributes upon the productivity considered in this paper are as follows:

(1) SIZE refers to firm size measured by the number of employees and taken as a logarithmic form. The variable is used as a proxy for economies of scale. Based on Chinese industry data set, the empirical evidence from Liu and Wang (2003) suggests a positive relationship between firm size and TFP, to support the hypothesis that the existence of scale economies leads to a higher TFP.

(2) LKL is the capital intensity measured by the ratio of the book value of operational fixed assets to the number of employees for 1999. This is measured in terms of new Taiwan dollar per thousand people. LKL is taken as a logarithmic value in this paper, and we attempt to apply the dataset on Chinese Taipei's ICT industry to an examination of whether

LKL has a positive coefficient in the TFP equation. Capital goods, such as machinery or factories, are characterized by their indivisible and inflexible nature. Morrison (1997) argued that capital is actually quasi-fixity in nature; therefore, as a firm's production technology is more capital intensive, it may suffer higher adjustment costs. Following Morrison's argument, since capital itself is characterized by its inflexible and indivisible nature, we may see capital-intensive firms suffering higher adjustment costs than labor-intensive firms when undertaking such adjustment.

(3) RD is R&D intensity measured by per capita R&D expenditure, as the ratio of R&D expenditure to number of employees. Luh and Chang (1997) and Hanel (2000) addressed the important linkage between R&D and TFP growth. Taking the dynamic and spillover attributions of R&D into account, Luh and Chang (1997) estimated the contribution of R&D to the TFP dynamic in Chinese Taipei's manufacturing sector. It pointed to the accumulation of R&D investment making an explicit contribution towards manufacturing growth. The empirical evidence from Liu, et al., (1999) demonstrated that R&D investment enables plants to accelerate their growth. Drawing on the above arguments, we hypothesize that the coefficients of RD on the TFP equation will be positive.

In addition to firms' own attributes, their regional business environments should have a critical influence upon the productivity of firms. In order to explore the effect of regional-specific attributes on productivity, we draw on the recent work on geographical agglomeration by Aw (2002) and Yang (2002) to consider three regional attributes: regional innovation activities, Porter's externalities, and the Marshall-Arrow-Romer externality. In this study, we empirically examine the effect of three types of agglomeration externality on the productivity of regional firms:

(4) ARDR is regional R&D intensity measured by the ratio of total R&D expenditures of regional ICT firms to total shipments, expressed as a percentage. This variable is to proxy the extent of regional innovation activities or the agglomeration effect of corporate R&D activities. It is well recognized that the attributes of innovation activities are of regional spillover effect. Accordingly, we suppose that firms based in the region with high knowledge spillovers are able to enjoy higher performance in TFP.

(5) COM is Porter's externalities. Drawing on Glaeser et al., (1992), we measure Porter's externalities for an industrial cluster by the ratio of number of regional firms to the total number of employees in the region.[36] The Porter externality arises from regional specialization and the differentiation of products. This effect stems mainly from local rivalry between firms, which further fosters the rapid diffusion of knowledge and the adoption of new ideas. The development of industrial clusters may lead to simultaneous competition and collaboration in offering innovative products and services, and further establish a sustainable competitive advantage in the dimensions of technology, the workforce, production methods, delivery time, quality, and resource procurement. To some extent, we it is reasonable to assume that a region with high competition pressure forces companies to boost productivity more aggressively. Accordingly, we expect the coefficient of COM in the TFP equation to be positive.

[36] Glaeser et al., (1992) adjusted Porter's externalities by the ratio of firms in industry to worker in industry. However, this paper looks at ICT industry only. The adjuster terms can be ignored.

JO is Marshall-Arrow-Romer externality. Following Glaeser et al., (1992), we measured Marshall-Arrow-Romer externality by the ratio of number of regional ICT industry employees to the number of regional employees in the electrical components and equipment industries. The Marshall-Arrow-Romer externality highlights industrial specialization within a region. Each firm in the cluster enjoys the benefits of saving investment costs by specializing within a narrow area of the value-added chain. Similar firms within the clusters find ways to differentiate themselves by locating unique market niches that have not been filled by other firms.

We set a regression of the TFP equation of firms in a trans-log format and summarizing the above discussion in Equation (9-3):

$$TFP = F(SIZE, RDL, LKL, ARD, ARDR, COM, JO). \quad (9\text{-}3)$$

Equation (9-3) can be rewritten as the equation as follows:

$$TFP = \alpha_0 + \alpha_1 SIZE + \alpha_2 RDL + \alpha_3 LKL + \beta_1 ARDR + \beta_2 COM + \beta_3 JO + \varepsilon, \quad (9\text{-}4)$$

where ε refers to the error terms. The TFP patterns of firms are examined in the next section, with particular focus on the role of the business environments in generating the productivity patterns.

9.4 Empirical Results

We now turn to an examination of the determinants for ICT productivity in Chinese Taipei for 1999. To re-evaluate the determinants of the TFP, firm and regional—specific attributes are taken into consideration in this paper, with a summary of the variable definitions being provided in Table 9.2. There are 2,054 samples used in the empirical study.

Table 9.2 Variable Definitions and Sample Statistics

Variables	Definitions	Mean	Std. Dev.
TFP	TFP for 1999	-0.236	0.608
SIZE	Firm size in terms of number of employees, taken natural logarithm	3.233	1.427
RDL	Firm's R&D intensity, per capita R&D expenditure, in terms of NT thousand	0.086	0.245
LKL	Capital-labor ratio for each firm, taken natural logarithm	6.552	1.359
ARDR	Regional R&D intensity, per capita R&D expenditure, in terms of NT thousand	0.0573	0.018
COM	Regional Porter's externalities, measured by the ratio of number of regional firms to the total number of employees in the region.	1.169	0.383
JO	Marshall-Arrow-Romer externality, measured by the ratio of number of regional ICT employees to the number of regional employees for the electrical components and equipment industries.	0.306	0.155
# of observations		2,054	

Source: The data of "the annual manufacturing-plant survey in 1999," MOEA.

Table 9.3 Estimation of ICT firm's TFP in Chinese Taipei, 1999

	(1)	(2)
Constant	0.613***	0.980***
	(4.71)	(16.66)
SIZE	0.113***	0.112***
	(11.44)	(11.76)
RDL	0.183***	0.173**
	(2.34)	(2.28)
LKL	-0.248***	-0.249***
	(-25.58)	(-25.66)
ARDR	2.236***	-
	(2.45)	
COM	0.137***	-
	(2.63)	
JO	0.223***	-
	(3.72)	
$\bar{R}^2$	0.381	0.376
F test	83.20***	205.13***
Log-Likelihood	-1401.348	-1410.586
Breusch-Pagan $\chi^2(1)$	283.03	278.21***
Number of Observations	2,054	2,054

Notes:

a All regressions include three dummy variables for three-digit SIC industries.

b Figures in parentheses are t-statistics calculated by coefficients and White standard errors.

*c *** represents statistical significance at the 1 percent level, ** at the 5 percent, and * at the 10 percent*

Table 9.3 presents the GLS empirical results of the TFP regression. One common problem uncounted in a cross-sectional estimation is heteroskedasticity. The Breush-Pagan χ^2 statistics indicate the existence of significant heteroskedasticity problems in the linear model. This study applies the White (1980) method of estimation with heteroskedasticity in the least squares model with the unknown variance-covariance matrix.

The overall indications from the empirical results presented in Table 9.3 point to the important role played by regional attributes in determining ICT firm's TFP. These results may indicate that the collectiveness of the cluster provides firms with some advantages. As in earlier studies, the emergence of industrial clusters is recognized as shaping and driving the competitiveness of firms within clusters at both national and global levels. Two out of three types of agglomeration externalities classified by Glaeser et al., (1992) is supported empirically.

Capital intensity in terms of their correlation to firms' TFP is underlined in this research. The coefficient of LKL is negative and statistically significant, revealing that firms with greater capital-intensity have lower productivities. This is because capital intensity is quasi-fixed in nature and firms with high capital intensity have a lower capability of achieving optimal factor allocation. The empirical results on the capital intensity accord with other empirical works, such as Sharma et al. (2000) on Nepal, Yean (1997) on Malaysia, and Datta (2003) on the telecommunication sector in the US, that firms with higher capital intensities usually suffer the risk of over-investment and have lower productivities.

Table 9.3 also presents the empirical results of R&D intensity, the coefficient of which is positive and significant on the TFP, indicating that firms undertaking R&D investment will reap subsequent rewards in terms of their own TFP. The empirical results for RD are generally consistent with earlier studies, such as Luh and Chang (1997), Datta (2003), and Liu and Wang (2003), in which R&D investments are viewed as important sources for improving TFP.

The empirical result shows that the effect of ICT firms' size on TFP is significant, indicating economies of scale (Liu and Wang, 2003; Datta, 2003). In other words, there exist scaled economies in which a firm or a plant with a higher scale can enjoy a higher TFP.

Theoretical attempts, such as Alfred Marshall, to formalize agglomeration effects have focused on three mechanisms that yield positive feedback loops: inter-firm technological spillovers, specialized labor, and intermediate inputs. In this paper, parts of the argument can be supported. Table 9.3 shows that the coefficient of ARDR, regional innovation activities and inter-firm technological spillovers, upon firms' productivity is statistically significant and positive. The empirical result is in line with our assumption productivity can be improved through regional innovative activities. To some extent, the empirical results may enrich the content of the 'site-selection' literature that has focused mainly on the geography of new R&D facilities and investment by MNCs, for example. (Frost and Zhou, 2000, Dambrine, 1997; Voelker and Stead, 1999) MNCs tend to locate their R&D in relatively technologically specialized host regions, as a means of gaining access not only to foreign centers of excellence, but also of taking advantage of localized knowledge spillovers for enhancing their productivities.

Table 9.3 further shows the coefficient of COM to be significant and positive in the TFP equation, indicating that regions with more competitive pressure force regional firms to boost productivity more aggressively. That is, Porter's externalities, stemming from regional rivalry, lead to simultaneous competition and collaboration in offering innovative products and services, and further establish a sustainable competitive advantage in the dimensions of technology, workforce, production methods, delivery time, quality, and resource procurement.

Table 9.3 further shows the coefficient of JO to be significant and positive in the TFP equation, indicating that regions with more specialized labor benefit productivity. Each firm in the cluster with higher JO enjoys the benefit from saving investment costs by specializing within a narrow area of the value-added chain. The empirical results are in line with the body of literature on industrial clusters, in which a pooled market for workers with specialized skills, argued by Alfred Marshall's external economies.

Finally, we further perform a model specification test to examine whether the regional factors matter for the determination of firms' productivity. The null hypothesis is that the regional factors play no role for firms' TFP. The empirical outcomes in Table 9.3 are shown in column (2). The alternative hypothesis is that some regional factors have effect upon firms' productivities. In other words, based on Equation (4), we can formalize the above idea as follows,

H_0: $\beta_1 = \beta_2 = \beta_3 = 0$

H_a: at least $\beta_i \neq 0$, i=1, 2, 3.

We solve for a log-likelihood $\chi^2(3)$=18.476, for which the statistically significantly result rejects the null hypothesis at 1 percent. This empirical result shows that the regional factors in industrial clusters cannot be ignored in calculating productivity.

9.5 Conclusions

This paper uses micro data on Chinese Taipei's electronics industry to measure their TFP in exploring how companies' heterogeneities and regional conditions effect them. The purpose of this paper is to study whether, beside firms' size, production technologies, and R&D investments, the roles played by the attributes of industrial clusters relate to the firms' productivities.

Apart from the traditional approach based on administrational regions, we propose a multivariate-cluster analysis to conclude the optimal populations of ICT industrial sectors and outlining the boundaries of each industrial clusters. Various regional attributes stemming from industrial clusters can be explored in this study.

Furthermore, a firm's total factor productivity equation is employed to empirically examine whether, in addition to firm-specific factors, regional factors can be significant determinants. A general conclusion from our empirical examination is that firms with higher-capital intensity have lower productivities. This may indicate that capital intensity is quasi-fixed in nature, and that firms with higher capital intensity suffer from the difficulty of promoting allocative efficiency with regard to their production factors. The economic implication behind this finding is that encouraging the adoption of capital-intensive production methods, as a means of driving firms' competitiveness seems to come at the cost of a loss of productivity for firms.

Evidence that there are regional advantages, rooted in industrial clustering, to firms' productivity within the ICT industry is significant. That is, firms within a region with various abundant externalities of an industrial cluster enjoy higher productivity. Industrial agglomeration externalities enable firms within a cluster to enjoy higher growth and competitiveness, and these three types of externality have pointed to some important dimensions in the competitiveness of industrial clusters. There are three types of externalities considered in this paper: innovational, Porter's, and Marshall-Arrow-Romer externalities. Generally, a $\chi 2$ test for ICT industrial clusters in Chinese Taipei was performed to witness that each firm's competitiveness cannot be only attributed to its own attributes, but also its regional conditions, including innovational activities, market competition, and specialization.

The policy implication of the empirical results is as follows: Firms within a region can share a common dependence on research, innovation, knowledge and regional industry-specific assets. With respect to public policies, governments' investment in regional innovation (R&D) systems seems to be increasingly important for promoting firms' TFP for the knowledge-based economy. Furthermore, empirical evidence also shows that competition pressure within industrial clusters enables regional firms to improve their productivity more aggressively. This implies that regional market deregulation to reduce market entry barriers can result in the facilitation of regional advantages.

Chapter 10 Location Choice of New Firms: The Case of Taiwan's Electronics Industry

The purpose of this chapter is to study the agglomeration effects in the development process of Taiwan's electronics industry. By examining the firm-level data obtained from the census of manufacturers from 1990 to 1999, we hope to detect the existence of agglomeration effects, or the lack thereof, and to estimate the magnitudes if they do exist. In particular, we will investigate how location choice of newly established firms is affected by geographical concentration of the industry. By agglomeration, we mean a correlation between the location choice of new firms and the geographical distribution of existing firms: the more existing firms are concentrated in one location, the more that location is likely to be a preferred location for new entrants.

According to Alfred Marshall (1989), agglomeration arises because of external benefits of geographical concentration of firms from the same industry. These external benefits, in turn, arise from the emergence of specialized suppliers, labor pooling effect and knowledge spillovers. Paul Krugman (1990) applied the agglomeration effect to international trade to explain the shifting of comparative advantage over time. He pointed out that government policies can set off an agglomeration process, in addition to natural conditions. In the world of Marshall and Krugman, agglomeration represents a concentration of firms which are horizontally differentiated and are competing and cooperating with one another at the same time.

The benefit of horizontal differentiation comes mainly from variety. Variety intensifies competition and stimulates innovation. Competition and innovation, in turn, drive the evolution of the industry. Because of differentiation and continuous innovation, firms learn from each other by locating in the same region. Competitors locating nearby also makes information accessible to relevant parties that interact with the industry on a constant basis. This also imposes a discipline on the industry players as those who fail to play by the rule will be easily identified and sanctioned. The recently developed network theory has emphasized the importance of trust in the operations of the industry. Trust reduces transaction costs in any contractual or non-contractual arrangements between firms. Locating in the same region facilitates the development of trust. Recent development experience in the knowledge intensive industries such as the biotechnology industry has demonstrated the benefits of geographical proximity to the knowledge centers of the industry, which are often premier universities or research laboratories where important innovations often occur. The more the role of innovation in the industry, the more that industry is to be concentrated geographically because knowledge accumulation is apparently characterized by increasing returns.

In contrast with Marshall-Krugman's view, Chandler (1990) emphasized the vertical relationship between firms in a geographically concentrated area. Chandler highlighted the benefits arising from division of labor and the savings of transportation costs due to geographical proximity.

Vertical differentiation allows finely defined specialization along the commodity chain. Specialized suppliers offer products to a variety of downstream users, allowing themselves to realize economies of scale and economies of scope. A machine tool specialist can serve different kinds of producers of information products, making itself a platform for technology integration. Vertical specialization also allows the specialized producers to weather business cycles. As one sector of the industry is on the down-side, the other sector of the industry may be on the upside, hence they cancel out the business fluctuations. Vertical specialization also lowers the entry barriers to new firms as it reduces the capital requirement to enter the industry.

Vertical differentiation also facilitates information exchanges, particularly between suppliers and buyers. For example, innovations by a component producer can be quickly transmitted to a final product producer because of their cooperative working relationship. Market intelligence received by a final goods producer can be quickly fed back to components producer to improve the products. Strategic alliances are usually vibrant in an industry cluster characterized by vertical differentiation. These alliances are very good conduits for organizational learning between the partners. Locating vertically differentiated producers in one area reduces the transport costs. But more importantly, it provides an opportunity for a production method characterized by flexibility and promptness. The well-known "just-in-time" production method normally requires relevant producers to locate in proximity. Flexibility and promptness are the key words in modern-time competition, particularly in buyer-driven commodity chains.

Of course, both horizontal differentiation and vertical differentiation may coexist in an industry cluster. They tend to reinforce each other: a horizontally differentiated industry tends to encourage vertical disintegration and vice versa.

Empirical evidence on geographical concentration of industries is abundant but only a few studies have focused on the location choice of new firms. Krugman often referred to US industrial concentration in New England as a prime example of agglomeration. In fact, the US industrial belt extending from New England to Midwest came into being towards the end of the 19th century and the area continued to be the nucleus of US industrial activity until World

War II. The origin of the industrial belt can be traced back to the textile industry in which water is an essential resources for production and New England is rich in water resources. As the industry expands, skilled labor is an important resource that affects the location choice of textile plants. However, recent studies (e.g., Lanaspa and Sanz 2003) have found the US industries have generally tended to reduce their degree of concentration geographically. Along with the dispersion of the industry, there has been an alternation of industrial landscape, called by Suarez-Villa (1992) as "regional inversion," in which newly emerged areas such as Florida, Texas, or California are growing to the detriment of the old industrial belt. The driving forces for the transformation of the industrial landscape was a general decline of the industrial sector in the US as it was replaced by the service sector, and the increasing competition form foreign imports.

Recent concentration of information industry in the US also attests to the agglomeration phenomena (Saxenian 1994). The rise of the information industry in Silicon Valley and adjacent regions has attracted great interests among scholars. The Silicon Valley experience demonstrates a new mode of industrial organization that differs from the traditional modes such as those typified in New England. After comparing the Silicon Valley with the industrial cluster along Route 128 in Boston area, Saxenian concludes that Silicon Valley is superior in its flexible organization and its ability to use external resources for competition. Outsourcing is prevalent in Silicon Valley, allowing the production activity to be vertically disintegrated. Not only is the production activity out-sourced, production resources are also out-sourced. For example, venture capital industry is vibrant in Silicon Valley, allowing the new start-ups to share their risks and future returns with potential investors. Innovation is a very important part of the industrial development in Silicon Valley and the venture capital industry supports the innovative activities. Instead of water resources, capital market and knowledge appear to be the underlying forces for industrial concentration. But the pooling of skilled labor still played an important role in the development of Silicon Valley. If New England demonstrates the case of horizontal differentiation, then Silicon Valley seems to demonstrate a case of vertical disintegration.

The positive effects of agglomeration have also been proved in the literature. Wallsten (2001), for example, found a positive effect of agglomeration on innovations of small and medium enterprises. Cicerone (2002) found geographical concentration of employment to have a positive effect on labor productivity. Carlino (2001), Cook (2001) found positive effect of knowledge spillover arising from agglomeration.

The study that is closest to our own study to be presented in the following is the study by Carlton (1983) on location choice of the US industry in 1967-1971. Three sets of variables are included in the study: one set represents factor costs, another set represents local resources, and the third set represents the agglomeration effects. The study found energy cost, electricity cost to be important determinants of location choice, but wage rate is not. State tax (as locality is defined at the state level) is also found to be insignificant in new plants' location choice. The availability of a pool of technical experts in the state matters only to the technically sophisticated industries. The coefficients on the variables measuring agglomeration economies are usually large and statistically significant. The importance of agglomeration economies is greater for the industries whose average plant size is smaller. This suggests that agglomeration economies are more beneficial to small firms than to large firms. Although it is surprising to find taxes (either income tax or property tax) to be inconsequential to location choice of new plants, Crozet et al. (2004) study on FDI in France also found foreign investors to be insensitive to tax incentives.

10.1 Geographical Concentration

We first estimate the degree of geographical concentration of the electronics industry at the four-digit industry level. Three indices are used to estimate the concentration level. The first is the Herfindahl index defined as follows:

$$H = \sum_i S_i^2$$

where Si is the employment share of the industry in geographical zone i. In this chapter, we divide Taiwan into 23 geographical zones in line with the county-city borders (16 counties, 5 cities, plus Taipei and Kaohsiung).

The second index is Gini coefficient as is used in measuring income distribution. The third index is Ellison-Glaeser index as defined by Ellison and Glaeser (1997):

$$EG = \frac{\sum_i (S_i - X_i) - (1 - \sum_i X_i^2) z}{(1 - \sum_i X_i^2)(1 - z)}$$

where Si is the employment share of a particular industry in zone i, Xi is the employment share of all industries in zone i, and z is Herfindahl index defined as industrial concentration ratio measured by plant size distribution.

The rationale of EG index is to measure the geographical concentration of a particular industry against the overall industrial concentration of the economy and adjust for the level of seller concentration. For example, if Taipei accounts for a half of Taiwan's industrial employment, it is not surprising to find that the computer industry is also concentrated in Taipei. The EG index also adjusts for the level of seller concentration (z), for an industry dominated by a small number of firms is also likely to be geographically concentrated.

The average estimates of three indices for 1990-1999 are listed in Tables 10.1 and 10.2. It can be seen that in terms of Herfindahl index, the electronic tubes industry is most concentrated geographically. This is followed by the data storage devices (such as CD-R and CD-ROM), semiconductor industry, and audio/video parts, in that order. The least geographically concentrated industries are passive electronic components (such as resistors, capacitors) and other electronic parts. The Gini coefficients produce a similar ranking of geographical concentration. In particular, the top-five concentrated industries are the same with only the third place and the fourth place reversed.

Table 10.1 Geographical Concentration, Herfindahl Index and Gini Coefficients1990-1999 Average

Industry	Code	Herfindahl Index	Gini Coefficient	Ellison-Glaeser Index
Electronic tubes	3171	0.333	0.302	0.0099
Data storage device	3142	0.285	0.239	-0.0475
Semiconductors	3172	0.184	0.146	0.0763
Audio/video parts	3153	0.183	0.166	0.0281
Other computer parts	3149	0.171	0.132	-0.0265
Other communication equipment	3169	0.148	0.105	-0.0165
Other audio/video parts	3159	0.145	0.117	0.0452
Other computer parts	3145	0.144	0.106	0.0183
Communication equipment	3162	0.136	0.104	0.0081
Optoelectronic devices	3173	0.134	0.106	0.0244
Fixed-line communication equipment	3161	0.126	0.094	0.0302
Data processing peripherals	3144	0.123	0.083	-0.0051
Data processing equipment	3141	0.123	0.091	-0.0026
Video equipment	3151	0.122	0.092	0.0127
Audio equipment	3152	0.111	0.096	0.0080
Data processing terminals	3143	0.096	0.059	-0.0075
Passive electronic components	3174	0.066	0.046	0.0048
Other electronic parts	3179	0.054	0.032	0.0054

Source: Author's calculation.

Table 10.2 Geographical Concentration and Entry Rate 1990-1999

Code	Industry	Ellison-Glaeser Index	Number of Firm 1990	New Entrants 1992-1999	Entry Rate	Growth of Sales*
3172	Semiconductor	0.0763	42	443	10.55	63.28
3159	Other audio/video parts	0.0452	298	1172	3.93	0.77
3161	Fixed-line communication equipment	0.0302	218	760	3.49	1.67
3153	Audio/video parts	0.0281	433	857	1.98	0.31
3173	Optoelectronic devices	0.0244	78	309	3.96	7.25
3145	Other computer parts	0.0183	226	1049	4.64	4.81
3151	Video equipment	0.0127	50	179	3.58	-0.24
3171	Electronic tubes	0.0099	110	128	1.16	0.66
3162	Wireless communication equipment	0.0081	85	556	6.54	1.95
3152	Audio equipment	0.0080	243	326	1.34	-0.45
3179	Other electronic parts	0.0054	1319	4113	3.12	2.85
3174	Passive electronic omponents	0.0048	810	1945	2.40	1.77
3141	Data processing equipment	-0.0026	135	331	2.45	7.81
3144	Data processing peripherals	-0.0051	263	1004	3.82	0.99
3143	Data processing terminals	-0.0075	125	322	2.58	0.66
3169	Other communication quipment	-0.0165	-	156	-	-
3149	Other computer parts	-0.0265	151	1220	8.08	5.11
3142	Data storage device	-0.0475	54	290	5.37	11.61

*Note: * Growth of sales is measured by the change in sales in nominal terms.*
Source: Author's calculation.

The Ellison-Glaeser index produces a different result, with the semiconductor industry ranked as the most geographically concentrated industry, followed by other audio/video parts (industry code 3159), optoelectronic devices (industry code 3173), and other computer parts (industry code 3145), in that order. Electronic tubes and data storage devices are ranked very low because both industries are also very high in terms of seller concentration. Both industries are also geographically concentrated in the industrial heartlands of Taipei and Taoyuan counties. In comparison, the semiconductor industry is concentrated in Hsinchu Science-based Industrial Park and adjacent regions and hence scores the highest EG index.

Ten years are probably too short to detect the trend of geographical distribution of the industry. It appears, however, that the more geographically concentrated industries are also those newly emerged industries such as semiconductors and optoelectronic devices, and the most geographically dispersed industries are also those matured industries, such as audio and video equipment, computer terminals (including monitors) and passive electronic components. It seems to suggest that knowledge spillover is an important benefit of agglomeration. When the industry matures, and knowledge flows slow down, producers start to look for cheaper production bases just to remain competitive and consequently the industry begins to disperse. But more research is needed to confirm this conjecture.

It terms of EG index, we can detect an obvious downward trend of geographical concentration in the following industries: computer terminals (code 3143), audio equipment (code 3152), and audio/video parts (code 3153). On the other hand, an upward trend of geographical concentration can be detected for the optoelectronic devices (code 3173).

Figure 10.1 shows the trend of Ellison-Glaeser index over time for the semiconductor (code 3172), and Figure 10.2 shows the trend for the optoelectronics industry (code 3173). It can be seen that both are upward moving. The optoelectronics industry starts with a lower EG index than the semiconductor industry, but both moved to the range of EH=0.060 in 1999. In 1990-1999, the number of semiconductor producers increased by 10.548 times while that of the optoelectronics industry increased by 3.962 times. Both industries were geographically concentrated in a few regions. For example, the semiconductor industry concentrated in Hsinchu county and Hsinchu city while the optoelectronics industry in Taoyuan county. The reason for GH index to increase is the increase in the number of firms that lowers the industrial concentration. In fact, if we look at the Herfindahl index and Gini coefficient, there was only a slight change in 1990-1999. For example, the Herfindahl index for the semiconductor industry increased slightly from 0.14877 in 1990 to 0.18648 in 1999; and for the optoelectronics industry, it decreased slightly from 0.13918 to 0.11616. The government established Tainan Science-based Industrial Park in the middle of the 1990s to diversify the high-tech firms to the South of the island. The Tainan Park successfully attracts a cluster of optoelectronics firms but has not been as successful in attracting semiconductor firms. This explains why the Herfindahl index has risen for the semiconductor industry but has fallen for the optoelectronics industry. The Gini coefficient shows a similar pattern. But the EG index has increased in both cases because of the increase of plants in the face of geographical concentration. This suggests that initial geographical distribution is very important in determining the landscape of the industrial location.

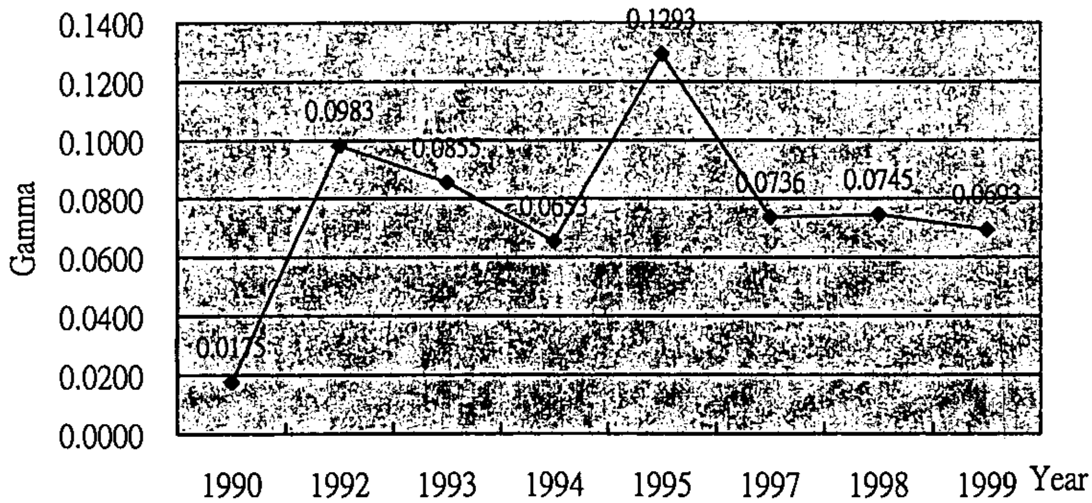


Figure 10.1 Ellison-Glaser Index: Semiconductors

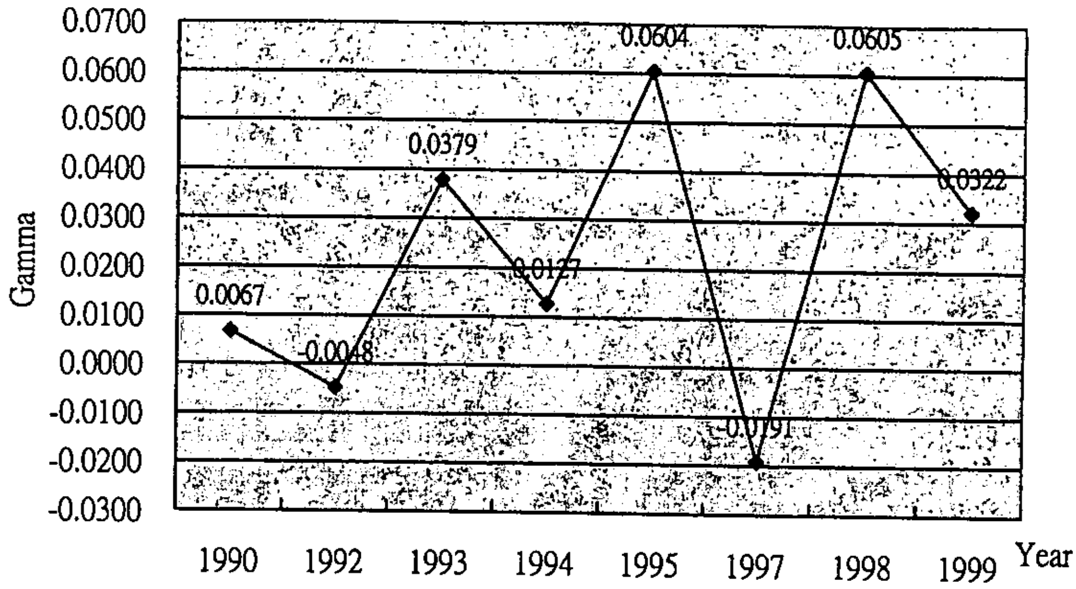


Figure 10.2 Ellison-Glaser Index: Optoelectronics

In contrast, Figure 10.3 shows the trend of EG index of computer terminals (code 3143), and Figure 10.4 shows that of audio equipment (code 3152). Both are apparently declining industries, although new plants never stopped from entering the industry. In the computer terminal industry, new entrants in 1990-1999 amounted to 2.576 of existing firms in 1990, and in the audio equipment industry, the entry rate was 1.342. Along with the decline, industrial concentration increases, which reduces the EG index. If we look at Herfindahl index and Gini coefficient, both show little change for the computer parts industry, and even an increasing trend for the audio equipment industry. For example, for the computer parts industry, the Herfindahl index was 0.1009 in 1990, and 0.09723 in 1999; for the audio equipment industry, the Herfindahl index was 0.06449 in 1990, and 0.11894 in 1999. At least for the audio equipment industry, industrial concentration has also led to an increase in geographical concentration in terms of Herfindahl index and Gini coefficient. EG index, however, shows a declining trend in geographical concentration after discounting for industrial concentration.

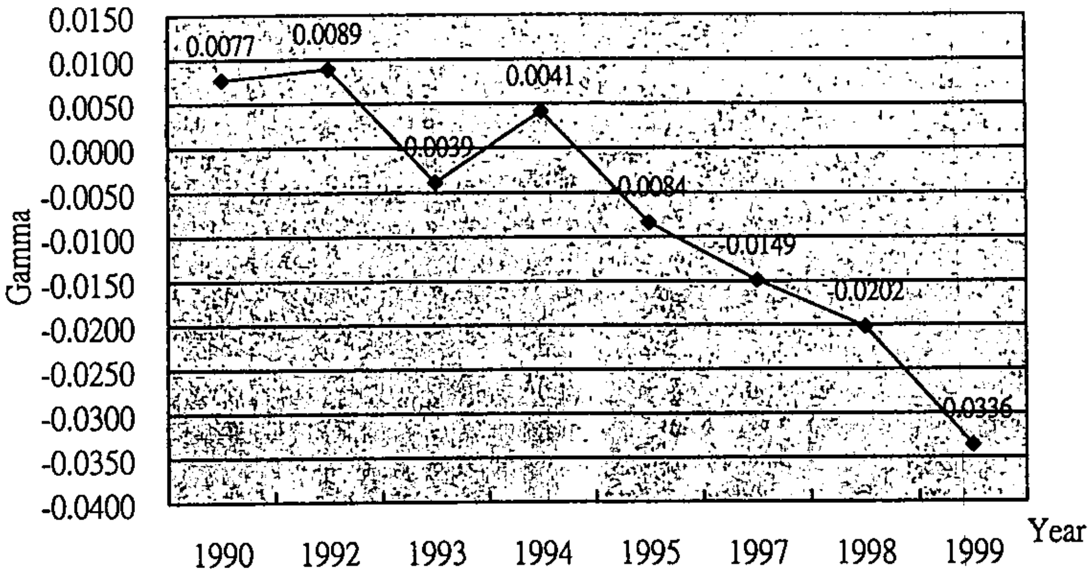


Figure 10.3 Ellison-Glaser Index: Computer Terminals

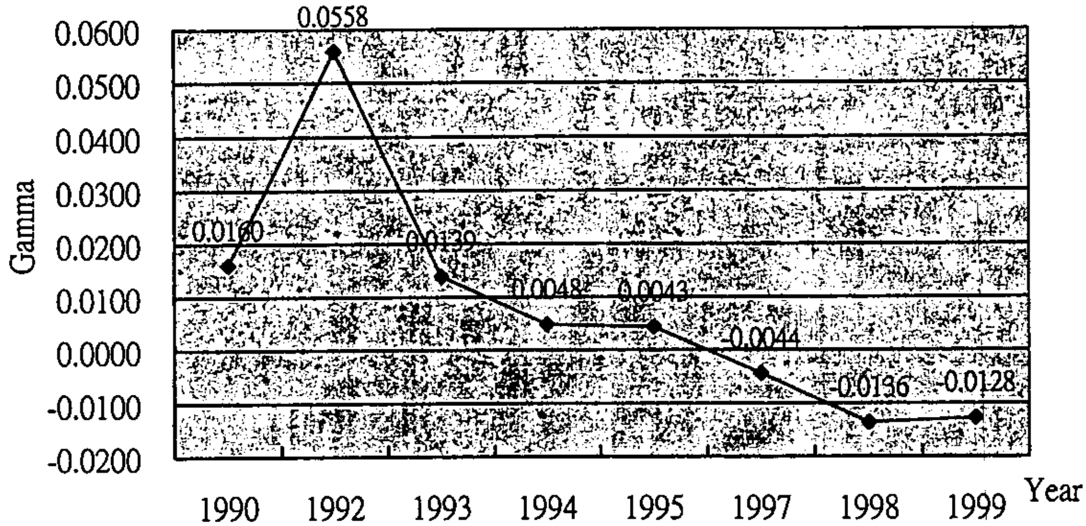


Figure 10.4 Ellison-Glaser Index: Audio Parts

There is no apparent systematic pattern between geographical concentration and new entry to the industry. Table 10.2 lists the Ellison-Glaeser index and the entry rate of the industry in 1990-1999. It can be seen that the most geographically concentrated industry, the semiconductor industry, is also the industry that experienced the highest entry rate: in 1990-1999, the number of semiconductor firms increased by more than 10 times. Other geographical concentrated industries such as optoelectronic devices and other audio/video parts only see modest entry rates. Meanwhile, wireless telecommunication equipment (code 3162) and data storage devices (code 3142) have a very high entry rate but the industries are either only modestly concentrated geographically or even quite dispersed. The relationship between geographical distribution and entry rate need to be investigated by using more detailed data.

Both data storage devices (code 3142) and wireless communication equipment (code 3162) are pretty high in terms of Herfindahl index and Gini coefficient. The reason that they are low in EG index is because they are concentrated in two single regions, Taipei and Taoyuan counties, where other industries are also concentrated. The other reason is that the industries are also dominated by a few sellers, hence industrial concentration ratios are high. With the entry of new firms, the industrial concentration of the data storage devices decreases and therefore the EG index increases from -0.0130 in 1990 to 0.0572 in 1999. For the wireless industry, new entry also raise the EG index up until 1995 and it started to decline afterwards. The wireless telecommunication industry encountered serious recessions since 1997 which may have interrupted the uptrend trend.

The emergence of wireless telecommunication industry (wireless far short) and the entry of new firms were affected by a few existing industries. The major sector of the wireless industry is cellular phones and related equipment. In 2003, the value of cellular phones-related production was worth about 200 billion NT, accounting for 80% of the entire wireless industry. This sector was mainly concentrated in Taipei County, a traditional stronghold of the electronic components industry. The second largest sector of the wireless industry was wireless local area network (WLAN) equipment, which was mainly attached to computers for accessing the Internet. WLAN products, particularly IC chips, were mainly produced in Hsinchu Science-based Industrial Park and adjacent regions. The industry is still in the stage of rapid development. New entry was vibrant and a cluster has not emerged.

10.2 Agglomeration and Location Choice

In this section, we will investigate how agglomeration may affect location choice of new firms. There are several reasons to expect that a new entrant may choose to locate in the region where most existing firms are located. One is the easiness to obtain the supply of materials needed for production, or the services offered to maintain machinery and equipment that is used in production. It is also easy to arrange outsourcing if potential cartractees are located nearby. Locating in the area where other firms are located also makes it easy to recruit skilled workers, a phenomenon known as "labor pooling" effect. Finally, there is an important benefit of information access or knowledge spillover by locating near the center of the industry. Locating near the center of the industry makes it easy to form strategic alliances or to learn from the other firms. The geographical center of the industry is also a "learning region" of the industry. Although Taiwan is a small island, we still expect geography to play some role in industry development.

A panel data consisting of newly established firms in the electronics industry in 1990-1999 are used as the sample. Two types of variables are used as explanatory variables. The first type is factor price variables representing local conditions such as wage rates, land prices, etc. The second type of variables are agglomeration variables such as the number of existing firms in the industry, total employment of the industry. A conditional logic model is used to model the location choice of new firms, taking 23 counties-cities as independent alternatives. The outcome of each year's choice, measured by frequency, is taken as the dependent variable to be explained. The explanatory variables are listed below and their expected effects on location choice are also discussed.

(1) FIRMi: Number of existing plants in the industry in location i. FIRM is intended to catch the agglomeration effect and we expect it to have a positive effect on new firms' choice of a particular location.

(2) EMPi: Total employment of the industry in location i. EMP is also intended to catch the agglomeration effect and its coefficient is expected to be positive.

(3) VADDi: Total value added of the industry in location i. VADD is also intended to catch the agglomeration effect and its coefficient is expected to be positive.

(4) LABORi: Total labor force of location i. LABOR represents the most important resource available in location i and we expect it to have a positive effect on new firms' choice of a particular location. LABOR is measured in thousand men.

(5) WAGEi: Average wage rate per man-year of the manufacturing industry in location i. WAGE represents labor cost, which is expected to have a

negative effect on the choice of a particular location. WAGE is measured thousand NT per man-year.

(6) INDi: The degree of industrialization in location i, measured by the total value added of the manufacturing industry. IND is measured in thousand NT.

(7) UNEMPi: Total number of unemployed persons. The more unemployed persons are in the location, the more attractive is the location to new entrants. UNEMP is measured in thousand persons.

(8) SKSi: Number of skilled workers in the region, measured by the number of college (including junior college) graduates with a major in science or engineering disciplines. SKS is intended to represent the "labor pooling" effect a-la Marshall and we expect it to have a positive effect on location choice by new entrants. SKS is measured by number of persons.

(9) RENTi: The price of industrial land in the region, measured by NT per squared meters. The higher the land price, the less attractive is the region to new entrants. We expect the coefficient to be negative.

We conducted regressions on separate industries at the three-digit industry level, using the location choice patterns of newly entered plants in 1990-1999 as the dependent variable. Before we discuss the regression results, let us look at the geographical distribution of new plants by industry, which is listed in Table 10.3.

Table 10.3 Geographical Distributions of New Entrants, 1990-1999

County-City	Computer products (314)	Consumer electronics (315)	Communications (316)	Semiconductors (317)
01. Taipei Hsien	977	314	326	943
02. Yilan	2	3	1	18
03. Taoyuan	196	62	132	556
04. Hsinchu Hsien	49	8	33	108
05. Miaoli	19	0	5	29
06. Taichung Hsien	15	28	27	96
07. Changhua	5	5	3	27
08. Nantou	0	1	2	6
09. Yunlin	0	2	0	7
10. Chiayi Hsien	0	3	1	5
11. Tainan Hsien	16	7	9	42
12. Kaohsiung Hsien	3	10	10	37
13. Pintung	0	3	0	1
14. Taitung	0	0	0	0
15. Hualien	0	0	0	0
16. Penghu	0	0	0	0
17. Keelung	1	0	0	4
18. Hsinchu City	52	17	28	94
19. Taichung City	17	28	6	28
20. Chiayi City	0	0	0	0
21. Tainan City	6	0	5	6
63. Taipei City	171	57	52	74
64. Kaohsiung City	23	21	20	67
Total	1552	569	660	2148

Source: Author's calculation.

It can be seen that the electronics plants were concentrated in a few counties and cities. In particular Taipei and Taoyuan counties account for more than a half of all electronics plants that entered the industry in 1990-1999. Taipei Hsien was particularly dominant and it alone accounted for more than a half of new entrants in the computer products and consumer electronics industries. Following Taipei Hsien and Taoyuan, Hsinchu Hsien, Hsinchu City and Taipei City accounted for the majority of the remaining new entrants. In other words, the belt area along the west coast of Taiwan extending from Taipei to Hsinchu is where electronics industry was concentrated. Take computer products as an example, 1,445 new entrants in 1990-1999 were located in Taipei Hsien, Taipei City, Taoyuan Hsien, Hsinchu Hsien and Hsinchu City, accounting for 93.1% of all new entrants during the period. The remaining new entrants were scattered around other regions, such as Taichung, Tainan and Kaohsiung. Counties in the east coast of Taiwan, including Taitung, Hualien and the offshore island of Penghu failed to attract any new plant entry. Chiayi City on the west coast was also ignored by all new entrants in the period. The establishment of Tainan Science-based Industrial Park may be useful to diversify some electronics plants to the South of the island, but its effect is yet to be felt.

The geographical concentration of the electronics industry in the northwest belt extending from Taipei to Hsinchu has its historical root. The origin of Taiwan's electronics industry was transplants of multinational firms in the 1960s (Chen, Chu and Chen 2000). When multinational firms first came to Taiwan, they concentrated in two major areas: Taipei and Kaohsiung. In Taipei, they concentrated in the outskirts of Taipei city; in Kaohsiung, they concentrated in two export processing zones near the Kaohsiung harbor. Both Kaohsiung and Taipei developed into Taiwan's major export bases of radios, television sets, and other electronic products. But Kaohsiung started to decline from Taiwan's electronics industry landscape, beginning in the early 1980s when Taiwan's indigenous firms become the mainstay of the island's electronics industry. The newly emerged computer, semiconductor, and optoelectronics industries were all concentrated in the northern part of Taiwan. This is probably because Taiwan's premier universities such as NTU, Tsinghua and Chiaotung were also located in the north. The cradle of Taiwan's industrial technology, Industrial Technology Research Institute (ITRI), was also located in the north (Hsinchu). In the high-tech era, skilled workers play a critical role in the industrial development. Universities provided the graduates, and ITRI provided trained engineers to feed the industry's needs for skilled labor. Kaohsiung, and the entire south, failed to play a more important role because of its inability to provide skilled labor.

10.3 Location Choice

If the profit to be expected by locating in location iI can be described by the following equation:

$$\pi_i = \alpha_i + \beta x_i + \varepsilon_i$$

where π_i is the expected profit for location i, β is a set of coefficients, xi is a vector describing the characteristics of location i, and ε_i is the disturbance term associated with location i. McFadden (1974) showed that with appropriate assumptions about ε_i, the probability of a firm to choose location i to locate its plant can be represented by the following probability

$$P_i = \frac{\exp(\alpha_i + \beta x_i)}{\sum_{i=1}^{n} \exp(\alpha_i + \beta x_i)}$$

where Pi is the probability of choosing location i among n alternative options from i=1 to i=n. The parameter α and β can then be estimated by a maximum likelihood method known as conditional logic model. In the actual regression, we model Pi as the following:

$$P_i = f(FIRM_i, EMP_i, VADD_i, WAGE_i, RENT_i, SKS_i)$$

where Pi is the probability of a new plant choosing to locate in region i; FIRMi is the number of existing firms in the industry located in region i; EMPi is the total employment of the industry in region i; VADDi is the total value added of the industry in region i; WAGEi is the manufacturing wage rate in region i; RENTi is the price of industrial land in region i; and SKSi is the supply of skilled labor in region i. The regression is conducted at the three-digit industry level and the results are listed in Table 10.4.

Table 10.4.1 Computer Parts (314)

Constants	(not shown)	(not shown)
FIRM(-1)	0.046 (0.0026)**	-
VADD(-1)	-	1.107×10^{-8} (3.84×10^{-9})**
EMP(-1)	-	0.00001 (3.26×10^{-6})**
WAGE	-0.0205 (0.0012)**	-0.0184 (0.0008)**
RENT	-0.00012 (8.03×10^{-6})**	-0.00008 (5.29×10^{-6})**
SKS	0.00013 (0.000049)**	0.00076 (0.0004)**

*Note: Numbers in parentheses are standard errors; ** indicates statistical significance at the 5% level; (-1) after the variables indicates lagged value by one period.*

Table 10.4.2 Consumer Electronics (315)

Constants	(not shown)	(not shown)
FIRM(-1)	0.022 (0.0020)**	0.0222 (0.0021)**
VADD(-1)	-	1.023×10^{-8} (3.61×10^{-8})
EMP(-1)	1.057×10^{-6} (9.56×10^{-6})	-
WAGE	-0.0194 (0.0015)**	-0.0195 (0.0015)**
RENT	-0.00009 (9.35×10^{-6})**	-0.00009 (9.27×10^{-6})**
SKS	0.00040 (0.000058)**	0.00039 (0.000067)**
UNEMP	0.0453 (0.0233)**	0.0471 (0.0227)**

*Note: Numbers in parentheses are standard errors; ** indicates statistical significance at the 5% level; (-1) after the variables indicates lagged value by one period.*

Table 10.4.3 Communication Equipment (316)

Constants	(not shown)	(not shown)
FIRM(-1)	0.0032 (0.00035)**	-
VADD(-1)	-	7.308×10^{-8} (1.002×10^{-8})**
WAGE	-0.0241 (0.0014)**	-0.0245 (0.0014)**
RENT	-0.00012 (8.65×10^{-6})**	-0.0001 (8.87×10^{-6})**
SKS	0.00071 (0.000053)**	0.00064 (0.00005)**
UNEMP	0.1772 (0.0196)**	0.2127 (0.0212)**

*Note: Numbers in parentheses are standard errors; ** indicates statistical significance at the 5% level; (-1) after the variables indicates lagged value by one period.*

Table 10.4.4 Semiconductors (317)

Constants	(not shown)	(not shown)
FIRM(-1)	0.0086 (0.00039)**	-
VADD(-1)	-	6.101×10^{-8} (3.105×10^{-9})**
WAGE	-0.0214 (0.00066)**	-0.0340 (0.0010)**
RENT	-0.00003 (5.31×10^{-6})**	-0.00003 (4.92×10^{-6})**
SKS	0.000105 (0.000033)**	0.00056 (0.000026)**
UNEMP	0.0215 (0.00783)**	0.1400 (0.0089)**

*Note: Numbers in parentheses are standard errors; ** indicates statistical significance at the 5% level; (-1) after the variables indicates lagged value by one period.*

It can be seen from Table 10.4.1~10.4.4 that the significance levels of explanatory variables differs by industry, but it largely confirms the importance of agglomeration. Two variables representing agglomeration, FIRM and VADD are significant in all regressions. They are also highly correlated, so only one of them should appear in the equation. The employment (EMP) is generally insignificant in the regressions, probably because the dependent variable is represented by the probability of new entry to occur in a particular location rather than the ratio of employment in a particular location. This suggests that agglomeration is at work, as the more concentrated regions are likely to attract more entries.

Two factor cost variables, WAGE and RENT, are also found to be a significant variable in affecting the location choice of new entrants. Both high wage and high land price tend to deter new firm entry. One resource variable, SKS, is found to be positively related to location choice. That is, the more skilled labor are available in the region, the more likely the region is to be the preferred location of new entrants. This seems to confirm the benefit of "labor pooling" in industrial agglomeration. Finally, the unemployment rate (UNEMP) is found to positively affect the location choice of new plants: the higher the unemployment rate, the more attractive is the region to new entrants. Combining with the positive effect of SKS, this suggests that although new firms care about the availability of skilled labor, they are also concerned about the availability of unskilled labor as most unemployed labor are unskilled in the sample period.

Because the same set of explanatory variables are used in regressions, we can also compare the coefficients across equations to see the differential effects across industries. For example, in terms of the number of firms (FIRM), it has a stronger effect on location choice of computer parts than the other industries. This is probably because the computer parts industry derivers its efficiency from a well-knit production network. Both horizontal division of labor and vertical integration are important elements for achieving efficiency. Note that computer parts also has the largest number of firms among four industries. In terms of value-added, then we see the effect is stronger for the communication equipment industry and semiconductor industry than for the computer and the consumer electronics industry. This seems to suggest that the newly emerged industries are more sensitive to where value added was concentrated more than the mature industries.

Two factor cost variables, on the other hand, have extremely similar effects on location choice across different industries. Both wage rate (WAGE) and land price (RENT) yield similar coefficients in different industries, indicating all industries are equally sensitive to factor costs of production.

The availability of skilled labor is most influential to the location choice of the communication equipment industry, followed by the consumer electronics industry, and then by computer and semiconductor industry. The reason that the communication equipment industry is most sensitive to the availability of skilled labor is probably because this newly emerged industry is badly in needed of skilled workers.

10.4 Conclusions

Geographic concentration of the electronic industry in Taiwan is modest. Only electronic tubes and data storage devices show a relative high degree of geographical concentration (with Herfindahl index and Gini coefficient above 0.2). But both industries are also characterized by a high degree of industrial (seller) concentration. When discount is made for industrial concentration, semiconductor industry is shown to be most localized among all electronics sectors. There is no apparent systemic pattern for the degree of geographical concentration, but the more matured industries such as computer terminals, computer peripherals, video/audio equipment, electronic components etc. tend to be more geographically dispersed than others. There is also a trend for the newly emerged industries to increase its geographical concentration and for the declining industry to decrease its geographical concentration. Apparent examples are semiconductors and optoelectronics which increased their degree of concentration in the 1990s while audio parts and computer terminals decreased their degree concentration in the same period.

The location choice model has shown agglomeration economies to be important determinants of location choice of new firms. Agglomeration measured in terms of the number of firms or value added all show a positive and significant impact on the location preference of new entrants. The availability of skilled workers are also shown to have a positive effect on attracting new firms. Factor costs such as labor and land prices show a negative effect on new firm location. The pattern seems to be pretty consistent across different subsectors of the electronics industry. However, the importance of agglomeration effects tends to differ across subsectors. Agglomeration measured in terms of the number of firms seems to be most influential on the semiconductor, and agglomeration measured in terms of value-added tends to be most influential on the semiconductor and communication equipment industries. Both are newly emerged industries compared to the other industries included in the study. The Taiwan experience seems to suggests that agglomeration economies are more important for the emerging industry than for the declining industry.

The results suggest that policies that facilitate agglomeration are useful for the newly emerged industries. When the industry is on the decline, then there is a tendency for it to disperse geographically. Newly entered firms in a declining industry have a tendency to choose new locations to explore new competitive advantage. This is evident in the case of the US industry, as Florida, Texas, California are apparent new havens for the industry. In the case of Taiwan, we may also experience the same phenomenon of regional inversion in the future. As the northwest coast is crowded with high-tech industries, it may be the time for more traditional, but yet competitive, industries to locate to the south. Although it is only fair to establish a new science-based park to attract high-tech companies in semiconductors, optoelectronics, biotechnology, it is probably more beneficial for the counties and cities in the south to attract the traditional strongholds of Taiwan's export industries such as textiles and machinery.

Despite being a small island, Taiwan's experience in the 1990s has indicated that geography still matters in industrial development. The electronics industry, which used to be polarized in the north and south, has increasingly concentrated in the north. The apparent reason is the concentration of good universities and research institutes in the north to the extent that the south suffered a brain drain. If the trend of brain drain is not reversed, the concentration of high-tech industry in the north can not be averted. It is therefore important to cultivate several premier universities in the south to breed a new generation of skilled workers in the south. Given that factor costs of labor and land remain important determinants of location choice, there are always opportunities for low cost regions to attract the attention of new firms, including those in the high-tech industry.

Chapter 11 Conclusions and Policy Recommendations

11.1 Conclusions

Industrial clustering occurs not only in high-tech industries, but also in traditional industries. It appears that innovation and growth are the two most important elements in the formation of an industrial cluster. Innovation provides the dynamics for competition and restructuring. Innovation also underlines the benefits of knowledge sharing, which is the basic reason for firms to congregate together. When innovation stops, the industrial cluster is likely to go into a decline and firms in the cluster start to dislocate, which is an inversion process of clustering. Meanwhile, growth is important both in terms of inducing new entry and facilitating a division of labor within the industry. Growth in most cases is demand-driven and therefore linking (or access) to the major market is the key to the formation of an industrial cluster. In short, an industrial cluster is characterized by innovation internally, and by growth externally.

Human resources are indispensable to the build-up of innovation capability. The case of Hsinchu Science-Based Industrial Park (HSIP) demonstrates the importance of brain circulation in the development of industrial cluster. A country that invests in human resources may not be able to utilize them fully because of the lack of opportunities and therefore it may suffer from a brain drain. But as the country develops, the human resources that have been deposited elsewhere found their way back, prompting a "reverse" brain drain. When the country develops more, it may even attract skilled labor from foreign countries, therefore benefiting from the human resources investments made by other countries. It is noticeable that human resources that are repatriated or borrowed from abroad are always insufficient to support the operations of an industrial cluster, as they have to be complemented by indigenous skills. In fact, indigenous skills are pivotal in leveraging foreign-based skills. Indigenous skills are the core of location advantage that underlines the formation of an industrial cluster. In the case of HSIP, foreign-based skills brought product innovations but they contributed little to management of production or marketing of products. Product innovations brought about from abroad are likely to be a one-shot event, and need to be appended by internal R&D to set off an innovation cycle. As time goes by, indigenous skills play an increasing role in innovations within the cluster.

The HSIP and the Hamamatsu case of Japan also demonstrate the possibility of industry restructuring within a cluster when the growth engine slows down. A cluster develops on the basis of a rapidly growing industry. As the growth rate slows down, there is a possibility for the cluster to switch to other industries to catch on a new growth engine. The ability to do so appears to hinge on the technological capability within the cluster and a reliable market linkage. In the case of HSIP, the cluster has switched from a computer-centered development path in the 1980s to an integrated circuit (IC)-centered development path in the 1990s. The market linkage can be easily struck because the two industries are vertically related. While the IC industry emerged, the computer industry was there to provide a consumption base for its products. The recent emergence of the liquid crystal display (LCD) industry followed the same pattern of industrial restructuring.

It is apparent that subcontracting is a prevalent practice within the cluster. Subcontracting allows firms in the cluster to realize economies of scale while maintaining the flexibility of production. Horizontal differentiation is an important characteristic of a cluster, as it allows for product competition and knowledge sharing. Subcontracting also allows for vertical disintegration within the cluster, which in turn, brews specialized suppliers. Marshall (1890) believes that specialized suppliers are the major benefit-generator of a cluster. In the case of HSIP, subcontracting is more attractive to export firms and more likely to be associated with larger firms. This suggests that linkages to a large, export market tend to facilitate vertical disintegration, which in turn, allows individual firms to grow larger. Subcontracting relationships may also be arranged with firms outside the cluster boundary, but in this case the contract tends to be long-term. The ability to subcontract appears to have reduced the entry barriers to potential firms, as more entries have been observed in industrial clusters than in other places. Easier entry means more competition, which sets off the dynamics of the industry.

Our study also shows that industrial clustering improves the productivity of individual firms. Both Porter externality and Marshall-Romer externality seem to be working for the benefits of the member firms in a cluster. Porter externality is based on local rivalry, which is characterized by horizontal differentiation of products. Marshall-Romer externality is based on the benefits of industry size and labor-pooling effects. Although the two externalities differ in nature, they probably exist simultaneously in a cluster. If firms in a cluster are more productive than those outside the cluster, it naturally follows that firms that locate too distant from the cluster will be driven out of the industry by competition. On the other hand, a potential firm should choose to locate in a cluster if it decides to enter the industry at all. This, of course, is the main driving force for agglomeration. Once the agglomeration force is at work, a cluster will be automatically formed.

11.2 Policy Recommendations

1. **Successful Formula**: Industrial clustering can be a useful policy for regional as well as national economic development. In an industrial cluster, the government, universities and firms form a complementary network to facilitate continuous industrial growth, upgrading and restructuring. As industrial cluster establishes a regional competitive advantage that allows itself to absorb technologies, create new technologies, diffuse knowledge, and retain skilled workers. National endowments create industrial districts, but it after takes some policy efforts to transform an industrial district into an industrial cluster. However, there is no fixed formula for successful industrial clustering and therefore a country should allow its comparative advantage to determine what industries to be put in a cluster. Benefits of industrial clustering apply to both high-tech and traditional industries and there is no reason that developing countries cannot benefit from industrial clustering even if they lack the ability to develop a high-tech industry.
2. **Investment Infrastructures**: Infrastructure such as electricity, water,

telecommunications, and living environment are important to pull potential firms and human skills together. For developing countries that lack the resources to embark on a full-blown infrastructure development, it may be useful to concentrate the effort in a small region. After a cluster emerges in the region, then the area can be gradually expanded to include adjacent regions.

3. **Human resources**: Human resources seem to be an indispensable ingredient in the formation of an industrial cluster. Although part of human resources can be obtained from abroad, the availability of local-sourced human resources is crucial to the operations of the cluster. Therefore, investment in human resources is an absolute necessity for any country that is interested in developing an industrial cluster. There is no evidence that training institutions such as universities have to be located near the cluster, but geographical proximity appears to be useful in terms of facilitating knowledge diffusion. Public institutions devoted to industry-specific training of human resources also prove to be useful in accelerating skill formation in preparation for cluster development.
4. **Building Innovation Capabilities**: Innovation is an important element in the operation of an industrial cluster. Without the capability to innovate, an industrial cluster will soon be on the decline and firms will begin to disperse and relocate to other regions. This capability has to be owned by firms themselves; public institutions can help but they cannot replace private efforts. This implies that a cluster may be developed initially by borrowing foreign technologies but eventually the sustainability of the cluster has to depend on indigenous technologies. Without the indigenous technologies, a cluster can only be an enclave at best. In other words, foreign investment is not enough to create a sustainable industrial cluster. The government has to make sure that indigenous technologies can be accumulated along with the formation of an industrial cluster.
5. **Sources of Growth**: Growth is also a very important element in an industrial cluster. Growth leads to an increase in the number of firms and it drives horizontal differentiation of products. Without significant growth in

market demand, a cluster will never emerge. Therefore linkage to a growing market is essential to the formation of a cluster. For most developing countries, the major growing markets are often in the developed countries, and therefore the ability to export to these markets is critical to the success of an industrial cluster. In this regard, foreign direct investment is useful in bringing about the linkage to the export market. But foreign investment is usually insufficient to set a cluster in motion for it lacks the dynamics of innovation. Domestic firms have to be a part of the export drive, making their own linkage to the major markets. Sometimes personal connections such as returned engineers from the major markets also help.

6. **Vertical Disintegration and Subcontracting**: Vertical disintegration is a norm in industrial clusters. Vertical disintegration allows specialized suppliers to reap the benefits of economies of scale, which is an important driving force for agglomeration. There is no apparently effective policy to prompt vertical disintegration in the industry. Vertical disintegration is a result of competition and the need to cut production costs through subcontracting and out-sourcing. The only meaningful policy in this regard is to ensure that competitive force is at work in the industry. Government should not attempt to protect the incumbent firms or to create a situation that brews monopoly. Even if the domestic firms have a dominant position in the world market, it is useful to make them contestable. The prevalence of subcontracting and out-sourcing arrangements in an industrial cluster not only allow specialized suppliers to emerge, but also reduce the cost of entry. As the entry barrier is lowered, more firms will compete in the industry, which drives the dynamic process of clustering. The empirical evidence has shown that entry barriers are lower in the industries that are more geographically concentrated. Therefore industrial clustering is also useful in promoting competition and incubating small and medium enterprise (SMEs). The government can adopt some proactive policies to attract specialized suppliers in the cluster if they are absent for the reason of location-specific entry barriers. Any missing links in the production chain tends to limit the development of an industrial cluster.

7. **Enhancing Productivity**: The fact that firms in an industrial cluster are more productive than their counterparts outside the cluster suggests that clustering is also a process in which inefficient firms are eliminated and the surviving firms are increasingly concentrated geographically over time. It suggests that a government policy aiming at relocating existing firms to economically disadvantageous region, such as low-income areas, is probably counter-productive. Only the declining industries in which agglomeration effects stop operating will the existing firms start to disperse and to seek lower-cost regions for relocation. A more sensitive policy for the disadvantageous regions is to find new ingredients such as human resources to attract location-specific industries that will eventually develop into a cluster. If this is infeasible then the alternative would be to develop the region into a satellite cluster for the existing clusters. As long as geography matters in industrial development, it is more important to link the regions to a manufacturing center or a market center rather than to lure existing firms away from a successful cluster.

References

In English

Adelman, M.A. (1955), 'Concept of Statistical Measurement of Vertical Integration,' *Business Concentration and Price Policy,' NJ: Princeton University Press*, 281-322.

Agesa, R.U. and S. Kim (1999), "The Determinants of Household Migration Patterns in Kenya," *Atlantic Economic Journal*, **27**(2): 239.

Anderson, G. (1994), "Industrial Clustering for Economic Development," *Economic Development Review*, **12**: 2.

Angel, D.P. (1991), "High-Technology Agglomeration and the Labor Market: The Case of Silicon Valley," *Environment and Planning A*, **23**: 1501-16.

Angel, D.P. and J. Engstrom (1995), "Manufacturing Systems and Technology Change: The US Personal Computer Industry," *Economic Geography*, **71**(1): 79-102.

Angelmar, R. (1984), "Market Structure and Research Intensity in High Technological Opportunity Industries," *Journal of Industrial Economics*, **34**: 69-79.

Armour, H.O. and D.J Teece (1980), "Vertical Integration and Technological Innovation," *Review of Economics and Statistics*, **62**: 420-74.

Audretsch, D.B. (1991), "New Firm Survival and the Technology Regime," *Review of Economics and Statistics*, **73**: 520-26.

Audretsch, D.B. and M. Feldman (1996), "R&D Spillovers and the Geography of Innovation and Production," *American Economic Review*, **86**: 630-40.

Baptista, R. and P. Swann (1998), "Do Firms in Clusters Innovate More," *Research Policy*, **27**(6): 525-40.

Baranson, J. (1966), "The Transfer of Technical Knowledge by International Corporations to Developing Economies," *American Economic Review*, **56**: 311.

Bartel, A.P. (1979), "Migration Decisions: What Role Does Job Mobility Play?" *American Economic Review*, **69**(5): 775-86.

Bernstein, J. (1997), "Inter-industry R&D Spillovers for Electrical and Electronic Products: the Canadian Case," *Economic Systems Research*, **9**(1): 111-25.

Bjorn, J. (1992), 'Institutional Learning,' *in Bengt-Ake Lundvall (ed.), National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, Pinter: London,* 23-44.

Borrus, M., Ernst, D. and S. Haggard (2000), 'International Production Networks in Asia: Rivalry or Riches?' *London; New York: Routledge.*

Borrus, M.D. and Z. Borrus (1997), "Globalisation with Borders: The Rise of Wintelism and Future of Global Competitions," *Industry and Innovation*, **4**(2): 141-66.

Bourdieu, P. (1985), 'The Forms of Capital,' *In Handbook of Theory and Research for the Sociology of Education, edited by J.G. Richardson. New York: Greenwood*, 241-258.

Braczyk, Hans-Joachim et al. (1998), *Regional Innovation Systems*, London: University College London Press.

Brehm, J. and W. Rahn (1997), "Individual-Level Evidence for the Causes and Consequences of Social Capital," *American Journal of Political Science*, **41**(3): 999-1023.

Breschi, S. and Malerba, F. (1997), "Sectoral Innovation Systems: Technological Regimes, Schumpeterian Dynamics, and Spatial Boundaries," in C. Edquist ed., *Systems of Innovation: Technologies, Organisations, and Institutions*, London: Pinter.

Bresnahan, T., Gambardella, A., and A. Saxenian (2001), "Old Economy Inputs for New Economy Outcomes: Clusters Formation in the New Silicon Valleys," *Industrial and Corporate Change*, **10**(4): 835-60.

Bygrave, W.D. and C.W. Hofer (1991), "Theorizing about entrepreneurship," *Entrepreneurship Theory and Practice*, (Winter), *16*(2): 13-22.

Carlsson, B. (1995), *Technological System and Economic Performance: A Case of Factory Automation*, Dordrecht/Boston/London: Kluwer.

Carlton, D.W. and J.M. Perloff (1994), *Modern Industrial Organization, 2nd edn.*, Harper Collins College Publishers.

Chang, M.C. and C.C. Chen (2001), "Competitiveness of SMEs: An Analysis of Vertical Disintegration," *Taiwan's Economic Development and the Role of SMEs.*

Chell, E. and S. Baines (2000), "Networking, Entrepreneurship and Microbusiness Behaviour," *Entrepreneurship & Regional Development*, **12**: 195-215.

Chen, D-S. (2003), *Making It Integrated: Organizational Networks in Taiwan's Integrated Circuits Industry*, Taipei: Socio Publishing. (*in Chinese*).

Chen, J., W. Chuang, and C. Yang (2002), "Symmetry and Relativity of Entry and Exit: Empirical Evidence from Taiwan's Manufacturing Industries," *Humanity and Social Science,* **3**: 33-54.

Chen, S.H. and D.N. Liu (1999), 'Strategic Alliances in the Context of Competition Policy (in Chinese),' *Final report to Industrial Development Bureau. Taipei: Chung-Hua Institution for Economic Research.*

Chen, T J and H. Y. Su (1995), "On-the-Job Training as a Cause of Brain Drain," *Review of World Economics,* **3**: 526-41.

Chiu, L.I. C, C.W. Chao and J.Y. Hou (2003), "Mobility of Highly-Skilled Workers in the US, Taiwan and Mainland China," APEC知識經濟之科技驅動力整合型計畫研討會， 台北：中華經濟研究院，2003年11月8日。

Clark, W.A.V. (1986), 'Human Migration,' *Beverly Hills, CA: Sage Publications.*

Coase, R. H. (1937), "The Nature of the Firm," *Economics,* **4**: 306-405.

Coase, R. H. (1972), "The Appointment of Pigou as Marshall's Successor," *Journal of Law and Economics,* **15**(2): 473-85.

Cohen, W. M. and Levinthal, D. (1989), "Innovation and Learning: The Two Faces of R&D," *Economic Journal*, **99**: 569-696.

Cohen, W. M. and Levinthal, D. (1990), "Absorptive Capabilities: A New Perspective on Learning and Innovation," *Administrative Science Quarterly*, **35**: 128-52.

Cohen, W.M. and S. Klepper (1996), "A Reprise of Size and R&D," *The Economic Journal*, **106**: 925-51.

Cohen, Wesley and D. Levinthal, (1989), "Innovation and Learning: The Two Faces of R&D," *Economic Journal*, **99**(397): 569-96.

Coleman, J. (1988), "Social Capital in the Creation of Human Capital," *American Journal of Sociology*, **94**: S95-121.

Cooke, P. (2000), "Introduction: Origins of the Concept," in Hans-Joachim Braczyk et al. eds., *Regional Innovation Systems, London: University College of London Press*, pp. 2-25.

Cooke, P. (2002), "Biotechnology Clusters as Regional, Sectoral Innovation Systems," *International Regional Science Review*, **25**(1): 8-37.

Cooke, P. (2003), "Biotechnology Clusters; Big Pharma' and the Knowledge-Driven Economy," *International Journal of Technology Management*, **25**(1/2): 65-80.

Coombs, R. and Metcalfe, J. S. (1998), 'Distributed Capabilities and the Governance of the Firm', *CRIC Discussion Paper No. 16, ESRC Centre in Innovation and Competition*, University of Manchester, UK.

Crevoisier, Olivier. (1990), 'Functional Logic and Territorial Logic and How They Inter-relate in the Region,' *In E. Ciciotti et al. (eds.), Technological Change in a Spatial Context. Berlin: Springer-Verla*, 17-55.

Czamanski, S. and L.A. Ablas (1979), "Identification of Industrial Clusters and Complexes: A Comparison of Methods and Findings," *Urban Studies*, **16**(1): 61-81.

Dahlman, C. J. (1979), "The Problem of Externality," *Journal of Law and Economics*, **22**, 14-162.

Dahmen, E. (1988), "'Developing blocks' in industrial economics," *Scandinavia Economic History Review*, **1**: 3-14.

Davis, D. and D. Weinstein (1998), "Market Access, Economic Geography, and Comparative Advantage: An Empirical Assessment," *NBER working paper* #6787.

Doz, Yves L. (1996) "The Evolution of Cooperation in Strategic Alliances: Initial Conditions or Learning Process?" *Strategic Management Journal*, **17**: 55-83.

Dumais, G., G. Ellison, and E. Glaeser (1997), "Geographic Concentration as a Dynamic Process," *NBER working paper* #6270.

Dunning, J. H. (1993), "Multinational Enterprises and the World Economy," *Wokingham: Addison-Wesley.*

Edquist, C. (1997), 'Systems of Innovation Approaches- Their Emergence and Characteristics,' *in Charles Edquist (ed.), Systems of Innovation: Technologies, Institutions, and Organizations, Pinter: London,* 1-29.

Edquist, C. and J. Bjorn (1997), "Institutions and Organizations in Systems of Innovation," in Charles Edquist ed., *Systems of Innovation: Technologies, Institutions, and Organizations, Pinter: London,* 41-63.

Ellison, E. and E. Glaeser (1997), "Geographic Concentration in US Manufacturing Industries: A Dartboard Approach," *Journal of Political Economy,* **105**: 889-927.

Ernst, D. (2003), "Global Production Networks and Upgrading Prospects in Asia's Electronics Industries," *Mimeo, Hawaii, East West Center.*

Eskelinen, H. and M. Kautonen (1997), "In the Shadow of the Dominant Cluster – The Case of Furniture Industry in Finland," in H. Eskelinen ed., *Regional Specialization and Local Environment – Learning and Competitiveness: Nord REFO Report,* **3**: 171-92.

Faulkner, W. and Senker, J. (1995), *Knowledge Frontiers: Public Sector Research and Industrial Innovation in Biotechnology,* Oxford: Clarendon Press.

Feenstra, R. C., J. A. Markusen, and A. K. Rose (2001), "Understanding the Home Market Effect and the Gravity Equation: The Role of Differentiated Goods," *Canadian Journal of Economics*, forthcoming.

Feser, E.J. and E.M. Bergman (2000), "National Industry Cluster Templates: A Framework for Applied Regional Cluster Analysis," *Regional Studies,* **34**: 1.

Fleisher, B.M. and T.J. Kniesner (1984) 'Labour Economics: Theory, Evidence and Policy,' *3rd edn., Englewood Cliffs, NJ: Prentice Hall.*

Foray, D. (1997), 'Generation and Distribution of Technological Knowledge: Incentives, Norms, and Institutions,' *in Charles Edquist (ed.), Systems of Innovation: Technologies, Institutions, and Organizations, Pinter: London,* 64-85.

Gadde, L.E. and H. Hakansson (1992), 'Analysing Change and Stability in Distribution Channels—A Network Approach,' *in Industrial Networks: A New View of Reality, London and New York: Routledge*, 166-79.

Glaeser E., H. Kallal, J. Scheinkman, and A. Shleifer (1992), "Growth in Cities," *Journal of Political Economy*, **100**: 1126-52.

Gordon, I.R. and P. McCann (2000), "Industrial Clusters: Complexes, Agglomeration and/or Social Networks?" *Urban Studies*, **37**(3): 513-32.

Gort, M. (1962), 'Diversification and Integration in American Industry,' *Princeton University Press.*

Grabher, G. (1993), 'The Weakness of Strong Ties: The Lock-in of Regional Development in the Ruhr Area,' *In the Embedded Firm: The Social-Economics of Industrial Network edited by Gernot Grabher, London: Rougledge*, 255-77.

Granovetter, M. (1973), "The Strength of Weak Tie," *American Journal of Sociology*, **78**: 1360-80.

Greenwood, M. (1975), "Research on Internal Migration in the US: A Survey," *Journal of Economic Literature*, **13**: 397-433.

Grossman, G.M. and E. Helpman (2002), "Interest Groups and Trade Policy," *Princeton and Oxford: Princeton University Press*, **VII**: 262.

Hall, P., M. Breheny, and R. McQuaid (1987), 'Western Sunrise: the Genesis and Growth of Britain's Major High Tech Corridor,' *London: Allen and Unwin.*

Hanson, G. (1996), "Localization Economies, Vertical Organization, and Trade," *American Economic Review*, **86**(5), 1266-78.

Hanson, G. (1997), "Increasing Returns, Trade, and the Regional Structure of Wages," *Economic Journal*, **107**, 113-33.

Herzog, H.W., A.M. Schlottmann, and D.L. Johnson (1986), "High-technology Jobs and Worker Mobility," *Journal of Regional Science*, **26**(3): 445-59.

Hirschman, A.O. (1958), "The Strategy of Economic Development," *New Haven: Yale University Press.*

Hobday, M. (1994), "The Limits of Silicon Valley: A Critique of Network Theory," *Technology Analysis and Strategic Management*, **6**: 231-44.

Hobday, M. (1995), "Innovation-Innovation in Services," *SI4S Synthesis Paper, Oslo: STEP Group.*

Holmes, T.J. (1999), "Location of Industry and Vertical Disintegration," *Review of Economics and Statistics*, **81**(2): 314-25.

Hoover, E.M. (1948), 'The Location of Economic Activity,' *New York: McGraw-Hill Press.*

Howells, J. (1999a), Regional Systems of Innovation?, in D. Archibugi et al. (eds.), *Innovation Policy in a Global Economy*, Cambridge: Cambridge University Press.

Howells, J. (1999b), Innovation and Technology Transfer within Multinational Firms, in J. Michie and J. G. Smith (eds.), *Globalisation, Growth, and Governance: Creating an Innovative Economy*, Oxford: Oxford University Press.

Howells, J. and Roberts, J. (2000), "From Innovation Systems to Knowledge Systems," *Prometheus*, **18**(1): 17-31.

Hsing, Y. T. (1999), "Trading companies in Taiwan's Fashion Shoe Networks," *Journal of International Economics*, **48**: 101-20.

Hsu, J.Y. (1997), "The Historical Study of Taiwan's Integrated Circuit Industry - High Technology, State Intervention, and Returnee Entrepreneurnism," *Journal of Geographical science*, **23**: 33-48, (in Chinese).

Hsu, J.Y. (1999), "Floating Embeddedness: the Labor Market and High Technology Development in the Hsinchu Science-Based Industrial Park," *Taiwan: A Radical Journal of Social Studies*, **35**(September): 75-118.

Hsu, J.Y. and A. Saxenian (2000), 'The Limits to Guanxi Capitalism: Transnational Collaboration between Taiwan and the US,' *Environment and Planning A*, **32**: 1991-2005.

Hummels, D. (1995), 'Global Income Patterns: Does Geography Play a Role?' *Chapter 2 of Phd Thesis, University of Michigan.*

Jarillo, J.C. (1988), "On Strategic Networks," *Strategic Management Journal*, **9**: 31-41.

Jarillo, J.C. (1990), "Research Notes and Communications: Comments on 'Transaction Costs and Networks," *Strategic Management Journal*, **11**: 497-549.

Johannisson, B. (1998), "Personal Networks in Emerging Knowledge-Based Firms: Spatial And Functional Patterns," *Entrepreneurship & Regional Development*, **10**(4): 297.

Johnson, Bjorn. (1992), "Institutional Learning," in Bengt-Ake Lundvall (ed.), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, pp. 23-44, Pinter: London.

Johnson, J. and L.G. Mattson (1987), "Inter-organizational Relations in Industrial Systems: A Network Approach Compared with the Transactional Cost Approach," *International Studies of Management and Organization*, **XVII**(1): 34-48.

Jou, S.C. (1998), "Another Version of the Science Park Development in Taiwan: The Tainan Science-based Industrial Park, Taiwan," *Radical Quarterly in Social Studies*, **32**(December): 125-63.

Jovanovic, B. and R. Rafael (1989), "The Growth and Diffusion of Knowledge," *Review of Economic Studies*, **56**(4): 569-82

Kawakami, M. (1996), 'Development of the Small- and Medium-sized Manufacturers in Taiwan's PC Industry,' *Chung-hua Institution for Economic Research, discussion paper series*, No. 9606.

Kim, S., and N. Tunzelmann (1998), "Aligning Internal and External Networks: Taiwan's Computer Industry," *The Information Society*, **12**:215-49.

Komoda, F. (1986), "Japanese Studies on Technology Transfer to Developing Countries: A survey," *The Developing Economies*, **24**: 405-11.

Krugman, P. (1991), 'Geography and Trade,' *Cambridge, Mass: MIT Press.*

Kumar, N. and N.S. Siddharthan (1994), "Technology, Firm Size and Export Behavior in Developing Countries: The Case of Indian Enterprises," *Journal of Development Studies*, **32**(2): 288-309.

Kuznets, S. (1996), 'Modern Economic Growth Rate, Structure and Speed,' *New Haven: Yale University Press.*

Kwok, V. and H. Leland (1982), "An Economic Model of the Brain Drain," *American Economic Review*, **72**: 91-100.

Lansing, J.B. and J.N. Morgan (1967), "The Effects of Geographical Mobility on Income," *Journal of Human Resources*, **2**(4): 449-60.

Lawson, C. (1997), 'Territorial Clustering and High-Technology Innovation: From Industrial Districts to Innovative Milieux,' *WP54, ESRC Center for Business Research, University of Cambridge, UK.*

Leamer, E. (1997), "Access to Western Markets and Eastern Effort," *in (ed) Zecchini, S, Lessons from the Economic Transition, Central and Eastern Europe in the 1990s, Dordrecht: Kluwer Academic Publishers*, 503-26.

Leana, C. R., J. Harry, and V. Buren III (1999), "Orgainzational Social Capital and Employment Practices," *Academy of Management Review*, **24**: 538-55.

Lechner, C. and M. Dowling (2000), "The Evolution of Industrial Districts and Regional Networks: the Case of the Biotechnology Region Munich/Martinsried," *Journal of Management and Governance (Special Issue)*, **99**(3): 309-38.

Lechner, C. and M. Dowling (2003), "Firm Networks: External Relationships as Sources for the Growth and Competitiveness of Entrepreneurial Firms," *Entrepreneurship & Regional Development*, **15**: 1-26.

Leonard-Barton, D. (1995), *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*, Boston, MA: Harvard Business School Press.

Levy, B. (1988), "Korean and Taiwanese Firms as International Competitors: The Challenge Ahead," *Columbia Journal of World Business*, 43-51.

Levy, B. and W.J. Kuo (1991), "The Strategic Orientations of Firms and the Performance of Korea and Taiwan in Frontier Industries: Lessons from Comparative Case Studies of Keyboard and Personal Computers," *World Development*, **19**(4): 367-74

Lichter, D.T. (1980), "Household Migration and the Labor Market Position of Married Women," *Social Science Research*, **9**(1): 83-97.

Lichter, D.T. (1982), "The Migration of Dual-worker Families: Does the Wife's Job Matter?" *Social Science Quarterly*, **63**(1): 48-57.

Lin, C.Y. (1997), "Technopolis Development: An Assessment of the Hsinchu Experience," *International Planning Studies*, **2**(2): 257-72.

Lin, Nan et al. (1981), "Social Resources and Strength of Strong ties: Structural Factors in Occupational Attainment," *American Sociological Review*, **46**: 393-405.

Liu, J. Q. (1991), "Taiwanese Small- and Medium-sized Enterprises and the International Division of Labor," *Taiwan Research Quarterly, Xiamen*, **1**: 25-40. (*Chinese Edition*)

Long, L.H. (1974), "Women's Labor Force Participation and the Residential Mobility of Families," *Social Forces*, **52**(3): 342-8.

Long, L.H. (1975) "Does Migration Interfere with Children's Progress in School?" *Sociology Education*, **48**: 369-81.

Long, W. (1983), "The Meaning of Entrepreneurship," *American Journal of Small Business*, **8**(2): 47-59.

Lundvall, B. A. (1992), 'User-Producer Relationships, National Systems of Innovation and Internationalization,' *in Bengt-Ake Lundvall (ed.), National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, Pinter: London, 45-67.*

Lundvall, B. A. (1992), *National Systems of Innovation: Towards a Theorem of Innovation and Interactive Learning*, London: Pinter Publications.

Lundvall, B. A., (1998), 'Innovation as an Interactive Process: From User-Producer Interaction to the National Systems of Innovation,' *in G. Dosi (ed.) Technological Change and Economic Theory, London: Printer Publisher.*

Lundvall, B.A. (2002), "National Systems of Production, Innovation and Competence Building," *Research Policy*, **31**(2): 213-31.

Luo, Y.L. and W.J. Wang (2002), "High-skill Migration and Chinese Taipei's Industrial Development," *in OECD, International Mobility of the High Skilled, Paris: OECD*, 253-69.

Mackun, P. and A.D. MacPherson (1997), "Externally Assisted Product Innovation in the Manufacturing Sector: The Role of Location, In-house R&D and Outside Technical Support," *Regional Studies*, **31**(7): 659-68.

Maddigan, R.J. (1981), "The Measurement if Vertical Integration," *Review of Economics and Statistics*, **63**(3): 328-35.

Malecki, E. J. (1989), "What about People in High Technology? Some Research and Policy Considerations," *Growth and Change*, **20**: 67-79.

Malecki, E. J. and S. L. Bradbury (1992) "R & D Facilities and Professional Labor: Labor Force Dynamics in High Technology," *Regional Studies*, **26**(2): 123-36.

Malecki, E.J. and P. Nijkamp (1988), "Technology and Regional Development: Some Thoughts on Policy," *Environment and Planning A*, **6**: 383-99.

Mansfield, E. (1975), "International Technology Transfer Forms, Resource Requirements and Polices," *American Economic Review*, **65**(2): 372-6.

Markham, W.T., P.O. Macken, C.M. Bonjean, and J. Corder (1983), "A Note on Sex, Geographic Mobility and Career Advancement," *Social Forces*, **61**(4): 1138-46.

Markusen, A., P. Hall, and A. Glasmerier (1986), "High Tech America: the What, How, Where and Why of the Sunrise Industries,' *Boston: George Allen Unwin.*

Marshall, A. (1890), 'Principles of Economics,' *London: Macmillan (for the Royal Economic Society).*

Martin, S. (1993), 'Advanced Industrial Economics,' *Oxford and Cambridge, Mass: Blackwell*, **XV**: 660.

Maskell, P. (2001), "Towards a Knowledge-based Theory of the Geographical Cluster," *Industrial and Corporate Change*, **10**(4), 921-43.

Maskell, P. et al. (1998), *Competitiveness, Localized Learning and regional development: Specialization and Propensity in Small Open Economies*, London: Routledge.

Masson R. and J. Shaanan (1987), "Optimal Oligopoly Pricing and the Threat of Entry: Canadian Evidence," *International Journal of Industrial Organization*, **5** (3): 323-39.

Mathews J. (1997), "A Silicon Valley of the East: Creating Taiwan's Semiconductor Industry," *California Management Review*, **39**(4): 26-54.

Maxwell, N.L. 1988, "Economic Returns to Migration: Marital Status and Gender Differences," *Social Science Quarterly*, **69**(1): 108-21.

McCombie, J.S.L. and J.R. de Ridder (1984), 'The Verdoorn Law Controversy: Some New Empirical Evidence Using US State Data,' *Oxford Economic Papers.*

McKelvey, M. (1997), Using Evolutionary Theory to Define Systems of Innovation, in C. Edquist ed., *Systems of Innovation: Technologies, Institutions and Organisations*, London: Pinter.

Meyer-Stamer, J. (1998), "Path Dependence in Regional Development: Persistence and Change in Three Industrial Clusters in Santa Catarina, Brazil," *World Development*, **26**(8): 1495-511.

Mincer, J. (1978), "Family Migration Decisions," *Journal of Political Economy*, **86**(5): 749-75.

Mowery D. C., J. E. Oxley; and B. S. Silverman (1996), "Strategic Alliances and Interfirm Knowledge Transfer," *Strategic Management Journal*, **17**: 77-91.

Mytelka, L. K. (2001), "Mergers, Acquisitions, and Inter-firm Technology Agreements in the Global Learning Economy," in Daniele Archibugi and Bengt-Ake Lundvall eds., *The Globalizing Learning Economy*, Oxford: Oxford University Press, 127-44.

Nahapiet, J and S. Ghoshal (1998), "Social Capital, Intellectual Capital, and the Organizational Advantage," *Academy of Management Review*, **23**: 242-66.

Narula, R. (2001), "Choosing between Internal and Non-internal R&D Activities: Some Technology and Economic Factors," *Technology Analysis and Strategic Management*, **13**(3): 365-87.

National science Council (2002), "Indicators of Science and technology," *Republic of China, Taipei: National Science Council.*

Nelson, J. (1959), "Migration, Real Income and Information," *Journal of Regional Science*, **1**(2): 43-74.

Nelson, R. (1993), *National Innovation Systems: A Comparative Analysis*, New York: Oxford University Press.

Niosi, J. and B. Bellon (1996), "The Globalization of National Innovation Systems," in John de la Mothe and Gilles Paquet eds., *Evolutionary Economics and the New International Political Economy. London: Pinter*, 138-159.

North, D. (1955), "Location Theory and Regional Economic Growth," *Journal of Political Economics*, **63**(3): 243-58.

Oakey, R. and S. Cooper (1989), "High Technology Industry, Agglomeration and the Potential for Peripherally Sited Small Firms," *Regional Studies*, **23**: 347-60.

Oakey, R.P. (1981), 'High Technology Industrial Location,' *Aldershot: Gower.*

Ogawa, E. (1979) 'Technology Transfer: An Examination,' *In K. Jojima, and T. Dams, (eds.), Economic Development and Aid Policy, Tokyo.*

Ohmae, K. (1995), 'The End of the Nation State,' *New York: Free Press.*

Oliver, C. (1990), "Determinants of Inter-organizational Relationships: Integration and Future Directions," *Academy of Management Review*, **15**(2): 241-65.

Olson, K. (1998), "Strategic Clustering," *Executive Excellence*, **15**: 12.

Orlando, M. (2000), 'On the Importance of Geographic and Technological Proximity for R&D Spillovers: An Empirical Investigation,' *Federal Reserve Bank of Kansas City, Research Division, working paper.*

Pack, H. (2001), "The Role of Acquisition of Foreign technology in Taiwanese Growth," *Industrial and Corporate Changes*, **10**(3): 713-34.

Paxton, P. (1999), "Is Social Capital Declining in the United States? A Multiple Indicator Assessment," *American Journal of Sociology*, **105**(1): 88-127.

Perroux, F. (1950), "Economic Space: Theory and Applications," *Quarterly of Journal of Economics*, **64**(1): 89-104.

Pfeffer, J. and. G.R. Salanick (1978), 'The External Control of Organizations: A Resource Dependence Perspective,' *New York: Harper & Row Publishers.*

Piore, M. and C. Sable 1(984), 'The Second Industrial Divide,' *New York: Basic Books.*

Polanyi, M. (1967), *The Tacit Dimension*, London: Routledge & Kegan Paul.

Porter, M. (1990), 'The Competitive Advantage of Nations,' *New York: Macmillan.*

Porter, M. (1998), 'Clusters and the New Economics of Competition,' *Harvard Business Review*, Nov.-Dec., 77-90.

Porter, M.E. (2001), 'Innovation: Location Matters,' *Sloan Management Review*, **42**: 28-36.

Portes, A. (1995), 'Economic Sociology and the Sociology of Immigration: An Overview,' *In the Economic Sociology of Immigration edited by Alejandro Portes, New York: Russell Sage Foundation*, 1-41.

Portes, A. (1998) "Social Capital: Its Origins and Applications in Modern Sociology," *Annual Review of Sociology*, **22**: 1-24.

Powell, W. and P. Brantley (1992), 'Competitive Cooperation in Biotechnology: Learning through Networks,' in Nitin Nohria and Robert G. Eccles eds, *Networks and Organizations: Structure, Form, and Action*, Boston: Harvard Business School Press, 366-394.

Powell, W., W. K. Kenneth, and S. D. Laurel (1996), "Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology," *Administrative Science Quarterly*, **41**: 116-45.

Prahalad, C. K. and Y Doz. (1987) *The Multinational Mission: Balancing Local Demands and Global Vision*, New York: Free Press.

Punnett, B.J., O. Crocker, and M.A. Stevens (1992) "The Challenge for Women Expatriates and Spouses: Some Empirical Evidence," *International Journal of Human Resource Management*, **3**: 585-92.

Putnam, R. (1993), *Making Democracy Work: Civic Traditions in Modern Italy. Princeton*, NJ: Princeton University Press.

Quinn, J.B. and F.G. Hilmer (1994), "Strategic Outsourcing," *Sloan Management Review*, **35**: 43-55.

Quinn, J.B., S. Finkelstein, and P. Anderson (1996), "Managing Professional Intellect - Making the Most of the Best," *Harvard Business Review*, **74**(2): 71-80.

Rantisi, N. (2002), "The Competitive Foundations of Localized Learning and Innovation: The Case of Women's Garment Production in New York City," *Economic Geography*, **78**(4): 441-62.

Rasiah, R. (2001), "Government-Business Coordination and Small Business Performance in the Machine Tools Sector in Malaysia," *World Bank*, **24**: 21-22.

Rasiah, R. (2002), "Systemic Coordination and Human Capital Development: Knowledge Flows in Malaysia's MNC-Driven Electronics Clusters," *INTEC Discussion Paper Series*, #2002-7, The United Nations University.

Reddy, M.N. and L. Zhao (1990), "International Technology Transfer: A Review," *Research Policy*, **19**: 285-307.

Rees, J. and H.A. Stafford (1981), *Industrial Location and Regional Systems*, New York: J.F. Bergin Publishers.

Rives, J.M. and J.M. West (1993), "Wife's Employment and Worker Relocation Behavior," *Journal of Socio-Economics*, **22**(1): 13-22.

Rogers, E.M. and J.K. Larsen (1984), *Silicon Valley Fever*, NY: Basic Books.

Romer, P. M. (1986), "Increasing Returns and Long-run Growth," *Journal of Political Economy*, **94**(5): 1002-37.

Romer, P. M. (1990), "Endogenous Technological Change," *Journal of Political Economy*, **98**(5): S71-102.

Romer, P.M. (1994), "The Origins of Endogenous Growth," *Journal of Economic Perspectives*, **8**(1): 3-22.

Rosenthal, S. and W. Strange (2001), "The Determinants of Agglomeration," *Journal of Urban Economics*, **50**, 191-229.

Rowen, H. and M. Toyoda (2002), "Japan Has Few High-Tech Startups: Does It Matter? Can It Be Changed?" *Working paper*, Hoover Institution, Stanford University.

San, G. (1987), "The Current Status of Vocational Training in the ROC and the Analysis of Factors Determining Why a Firm Conducts Vocational Training," *Proceeding of the 5th Social Science Conferênce, The Institute of the Three Principles of the People (currently Sun Yat-Sen Institute of Social Science)*, Taipei: Academia Sinica.

San, G. (1989), 'A Comparison between National Firms and Foreign Direct Investment Firms on Their R&D Efforts in the ROC – A Case Study of the Electronics Industry,' *Academic Economics Papers, Taipei: Institute of Economics, Academia Sinica.*

San, G. (1990), 'The Status and an Evaluation of the Electronics Industry in Taiwan,' *OECD Technical Paper Series*, No.29.

San, G. (2001), "Human Resources and Technological Advancement," in C-C. Mai and C-S. Shih (eds.), *Taiwan's Economic Success Since 1980, Cheltenham*, UK: Edward Elgar, pp.275-311.

San, G. and C.C. Su (2002), 'The Reverse Brain Drain Phenomena in Taiwan: Contributory Factors and the Impact on Industrial Technology,' *RCTED Working Paper Serious*, No. 2002-0032.

Sandell, S.H. (1977), "Women and the Economics of Family Migration," *Review of Economics and Statistics*, **59**(4): 406-14.

Santoro, M. and A. Chaknabarti (2002), "Firm Size and Technology Centrality in Industry – University Interactions," *Research Policy*, **31**(7): 1163-80.

Saxenian, A. (1994), *Regional Advantage: Culture and Competition in Silicon Valley and Route 128, Cambridge, Massachusetts, and London*, England: Harvard University Press.

Saxenian, A. (1997), 'Transactional Entrepreneurs and Regional Industrialization: The Silicon Valley-Hsinchu Connection,' *Paper presented at the Conference on "Social Structure and Social Change: International Perspective on Business Firms and Economic Life," Academia Sinica, Taipei, 9-10 May.*

Saxenian, A. and J.Y. Hsu (2001), "The Silicon Valley—Hsinchu Connection: Technical Communities and Industrial Upgrading," *Industrial and Corporate Changes*, **10** (4): 893-920.

Schive, C. (2000), "Global Logistics: A New Way of Doing Business in Taiwan," *Paper presented at the Global Entrepreneurship for the New Millennium Conference, Syracuse University, New York, 20-23 August.*

Schmenner, R.W. (1982), 'Making Business Location Decisions,' *Prentice-Hall: Englewood Cliffs.*

Schmitz, H. (2000), "Does Local Cooperation Matter? Evidence from Industrial Clusters in South Asia and Latin America," *Oxford Development Studies*, **28**(3): 323-36.

Schoenberger, E. (1997), *The Cultural Crisis of the Firm*, Cambridge: Blackwell.

Schumpeter, J.A. (1939), *Business Cycle*, New York: McGraw-Hill.

Schumpeter, J.A. (1942), *Capital, Socialism and Democracy, (2nd edn.)*, NY: Harper and Row.

Schumpeter, J.A. (1950), *Capitalism, Socialism and Democracy, (3rd edn)*, New York: Harper & Row.

Schwartz, A. (1973), "Interpreting the Effect of Distance on Migration," *Journal of Political Economy*, **81**(5): 1153-69.

Scott, A. (1993), *Technopolies: High-Technology Industry and Regional Development in South California*, Berkeley: UC Press.

Senchack, A.J. (1981), "Characteristics of Small Manufacturing Firms R&D Activities," *Journal of Small Business Management*, **19**: 48-55.

Shapiro, D. and R.S. Khemani (1987), "The Determinants of Entry and Exit Reconsidered," *International Journal of Industrial Organization* **5(1)**: 15-26.

Shepherd, W.G. (1997), *The Economics of Industrial Organization, (4th edn.)*, NJ: Prentice-Hall.

Siddharthan, N.S. (1992), "Transaction Costs, Technology Transfer and In-house R&D," *Journal of Economic Behavior and Organization*, **18**: 265-71.

Simonin, B. L. (1999), "Transfer of Marketing Know-How in International Strategic Alliances: An Empirical Investigation of the Role and Antecedents of Knowledge Ambiguity," *Journal of International Business Studies*, **30**: 463-90.

Sjaastad, L.A. (1962), "The Costs and Returns of Human Immigration," *Journal of Political Economy, (Supplement)*, **70**(2): 80-93.

Solvell, O. and I. Zander (1998), "International Diffusion of Knowledge: Isolating Mechanisms and the Role of the MNE," in Chandler, A. Jr., P. Hagstrom and O. Solvell (eds.), *The Dynamic Firm: The Role of Technology, Strategy, Organization and Regions*, Oxford and New York: Oxford University Press, pp.402-16.

Staffan, G. and A. Larson (2000), 'Outsourcing and Location, presented at the conference on 'New Tracks on Swedish Economic Research in Europe,' *Working paper*.

Stalk, G. and T.M. Hout (1990), *Competing Against Time: How Time-based Competition is Reshaping Global Markets*, The Free Press.

Steinle, C. and H. Schiele (2002), "When Do Industries Cluster? A Proposal on How to Assess an Industry's Propensity to Concentrate at a Single Region or Nation," *Research Policy*, **31**: 849-58.

Stigler, G.J. (1951), "The Division of Labor is Limited by the Extent of the Market," *Journal of Political Economy*, **59**: 185-93.

Stoper, M. (1997), *The Regional World: Territorial Development in a Global Economy*, New York: The Guilford Press.

Stuckey, J. and D. White (1993), "When and When Not to Vertically Integrate," *Sloan Management Review*, **21**(3): 121-30.

Swann, P. (1993), "Clusters in High-technology Industries," *Business Economist*, **25**: 27-36.

Taiwan Shoe Manufacturers Association (1989), *Member List of Taiwanese Footwear Manufacturers*, Taipei (in *Chinese Edition*).

Taiwan Shoe Manufacturers Association (1989), *Thirty Years of Taiwan's Shoe Industry*, Taipei (in *Chinese Edition*).

Takeuchi, H. (2002), *Hamamatsu Kigyo Tsuyosa no Himitsu (The Secret Strength of Hamamatsu Enterprises)*, Tokyo: Toyo Keizai Shinpo Sha.

Todaro, M.J. (1969), "A Model of Labour Migration and Urban Unemployment in Less Developed Countries," *American Economic Review*, **59**(1): 138-48.

Tsia, C. L. and P. F. Tai (2001), 'The Trend and Effects of Reverse Brain Drain in Taiwan—the Case of High-Tech Industry,' *RCTED Working Paper Serious*, No. 2001-0006. (in Chinese)

Tushman, M. and Anderson, P. (1986), "Technological Discontinuities and Organisational Environments," *Administrative Science Quarterly*, **31**: 439-65.

Venables, A. J. (1999), "The International Division of Industries: Clustering and Comparative Advantage in a Multi-industry Model," *Scandanavian Journal of Economics*, 495-513.

Venables, A. J., (1996), "Equilibrium Locations of Vertically Linked Industries," *International Economic Review*, **37**: 341-59.

Wade, R. (1990), *Governing the Market: Economic Theory and the Role of Government in East Asian Industrialization*, Princeton: Princeton University Press.

Wakelin, K. (1998), "Innovation and Export Behavior at the Firm Level," *Research Policy*, **26**: 829-41.

Wallsten, S. (2001), "An Empirical Test of Geographic Knowledge Spillovers Using Geographic Information Systems and Firm-level Data," *Regional Science and Urban Economics*, **31**: 571-99.

Wang K. and C. W. Hsu et al., (2002), *The Post, Present and Future of Hsin-Chiu Technological Cluster*, Mimeo.

Waterson, M. (1984), *Economic Theory of the Industry*, Cambridge: Cambridge University Press.

Weber, A. (1929), *Theory of Location of Industries*, Chicago: University of Chicago.

Westwood, R.I. and S.M. Leung (1994), "The Female Expatriate Manager Experience: Coping with Gender and Culture," *International Studies of Management and Organizations*, **24**: 64-85.

Williamson, O.E. (1975), "Transaction Cost Economics: The Governance of Contractual Process," *Journal of Law and Economics*, **XXII**(2): 233-61.

Williamson, O.E. (1985), *The Limits of Firms: Incentive and Bureaucratic Features*, in O.E. Williamson, The Economic Institutions of Capitalism, NY: The Free Press, pp.131-62.

Windrum, P. (1999), 'The MERIT Report on Innovation Networks in E-commerce,' *Prepared for SEIN (Simulation Self-organising Innovative Network) Workpackage 4. EU TESR (Targeted Socio-economic Research) Programme.*

Winter, S. G. (1987), "Knowledge and competence as strategic resources," in D. J. Teece ed., *The Competitive Challenge: Strategies for Industrial Innovation and Renewal*, Cambridge, MA: Ballinger.

Wolfe, T. (1983), "The Tinkerings of Robert Noyce: How the Sun Rose on the Silicon Valley," *Esquire*, **100**: 346-74.

Wu, J. Y. (1989), *Strategic Development Report: Footwear Industry*, Taipei: Taiwan Institute of Economic Research, (in *Chinese Edition*).

Xue, L. (1997), "Promoting industrial R & D and high-tech development though science parks: the Taiwan experience and its implications for developing countries," *IJTM, Special Issue on R & D Management*, 744-61.

Yang, X. (2001), 'Economics: New Classical Versus Neoclassical Frameworks,' *Blackwell Publishers.*

Yuan, D. Y. and H. L., Chen, (1998), *Industrial Natural Selection*, Taipei: Commercial Times Poblishers.

Zhao, Y. and R.J. Calantone (2003), "The Trend Towards Outsourcing in New Product Development: Case Studies in Six Firms," *International Journal of Innovation Management*, 7(1): 51.

附錄　APEC會議記錄與考察報告

一、APEC ECONOMIC COMMITTEE-2003 First Plenary Meeting

會議地點：泰國清萊

會議時間：2003 年 2 月 16-17 日

在中華台北對有關「產業聚落」的研究計畫的簡報告一段落之後，主席表示，由於中華台北的計畫內容十分豐富，它須要較長時間作深入的討論，為此，主席宣佈休息 15 分鐘之後，再開始討論。在休息後，主席開放會場邀請各會員體代表表示意見，各會員體果然反應十分熱烈及踴躍，共有 7 個會員體表達八次意見。現將各會員體的意見及中華台北的回應扼要說明如下：

主席：在休息之前，中華台北提出了產業聚落的研究計畫，此一研究計畫十分重要，也很有吸引力，它讓我想起我在義大利時，觀察到北義大利那所形成的產業聚落，廠商在其中所形成的緊密關係，的確令人印象深刻，並且成效驚人，中華台北現在願意展開此一研究，著實重要，現在請各位表示意見。

加拿大：中華台北所提的研究十分重要也很有意義，加拿大願意支持。在此一研究中，中華台北的研究中，是否會考量諸如所得稅、工資差異等重要因素，以期更週全地探討「產業聚落」之形成。

中華台北：謝謝加拿大的支持，中華台北在研究中有關產業群落形成因素的探討中，將會特別考量此一重要因素，謝謝加拿大所提的寶貴意見。

智利：中華台北的提案十分重要，也很有意義。剛才主席提到的北義大利的產業聚落十分有意義，我個人的觀察是，當產業聚落形成之後，聚落內的廠商彼此建立了互信及聯繫網絡關係(network)。為此，產業內的交易成本大幅降低，產業的競爭力也大幅地提高，此點提供中華台北作參考。

中華台北：謝謝智利的支持及寶貴意見。中華台北完全同意智利的意見，在中華台北的研究中，有關產業聚落內廠商的互動，及其互動將如何降低其彼此間的交易成本的問題，將是主要的研究重點之一，中華台北將會對此作深入探討。

泰國：中華台北的提案十分重要，泰國十分支持。有關產業聚落之形成，我們認為關稅的因素十分重要，希望對此也能作探討。

中華台北：謝謝泰國的支持，有關泰國所提的意見十分重要。它使我想起中華台北及韓國在當時使用出口退稅的方式強化加工出口區的功能及運作。我想每個經濟體對於產業聚落的發展其定義及內容或許不盡相同，為此，中華台北特別歡迎及邀請

各會員體能參與此一研究，就各會員體內的產業聚落作研究，如此一來，我們將會有更豐富的內容，供作比較及相互參考。

中國：中國歡迎中華台北所提出的有意義及非常重要的計畫，中國支持此一提案，在此作兩點意見表達：第一，中華台北是否能進一步說明中華台北將如何衡量聚落內的廠商互動？第二點，中華台北若須對中國境內的產業聚落作研究，若有須要，我們願意提供必要協助。

中華台北：首先謝謝中國，中華台北的確須要中國的協助，在此再度表達誠摯的感謝之意。有關廠商在聚落內互動關係的衡量，這是一個非常重要而深入的問題，基本上中華台北將以問卷調查的方式，針對聚落內廠商他們的聯繫方式、對外採購的百分比率、主要的上流或下流廠商等等重要經濟變數作調查，藉以掌握此一重要變數。謝謝中國所提出的重要建議及支持。

日本：日本歡迎並支持中華台北所提出重要的研究計畫，在此是否請中華台北說明，在產業聚落的形成上主要的公共建設(infrastructure)為何？產業聚落之形成具體政策意涵為何？

中華台北：謝謝日本的支持並提出此重要問題，中華台北目前尚未完成此一研究，故未能對此提出完整的答案，但目前初步的研究顯示，在公共建設上，無論硬體及軟體的建設均十分重要，硬體方面如公共基本建設、標準廠房、穩定的水電供給、以及雙語學校等均扮演一定的角色；而在軟體建設方面，如行政程序簡化為單一窗口是典型的例證。在政策意涵上，如簡報所示，本研究希望能提供政府在產業政策及地方區域發展政策上重要的參考。

香港：與其他會員體所表示的意見一致，香港在此重申對中華台北所提的研究計畫表達支持及肯定。香港在此表達兩點意見：第一，是否請中華台北說明那些是推動產業聚落形成的重要因素？第二，中華台北在本研究上有關中國之區域研究似乎只考量長江三角洲，不知是否亦會考量珠江三角洲？

中華台北：謝謝香港的支持。有關第一個問題，本研究因為正準備開始故目前尚無法作具體的回答。但我認為這是一個重要問題，我個人初步的觀察與瞭解是，此一問題若從政策的角度來看，政府的支持是一個主要推動力量。由廠商的角度來看，歷史事件及地緣關係也是形成自然聚落的主要原因之一。另有關珠江流域產業聚落的研究，本計畫目前因資源及時間有限，對此暫不擬進行，但我們可以針對現有的研究成果，以文獻回顧的方式加以補強，對此當能在本研究上有較週詳的涵蓋。

中國：中華台北所提的研究是否可能較偏重技術的移轉？技術移轉對產業聚落形成是否有其重要性？若是，本計畫可能有再斟酌的必要？

中華台北：謝謝中國所提的重要意見，我想這點提醒是十分重要的，中華台北在此作二點補充：第一，以中華台北的新竹科學園區為例，其技術的形成主要有二類，一是由海外而來，在台外商投資及海外學人回流；另一則是由本地的大學如清華、交大、工研院及其他機構產生。為此，本地技術及外來的技術移轉均有其重要性。第二，目前中華台北的高科技廠商在中國主要的投資重點地區是在上海一帶，而非珠江三角洲區域，其主要的原因之一，是因為長江三角洲區域存在中國一流的大學，故經濟體內自身具有的技術能量以及外來技術的引進與移轉均是重要因素。謝謝中國所提的寶貴意見，中華台北在進行本研究之際，將會特別注意此一重要因素。

主席 (韓國) ：謝謝各會員體踴躍的發言並表示許多重要的意見，我個人對此計畫亦十分感興趣。在此，我也要請教中華台北一個問題，不知產業聚落相關政策如何與區域發展 (regional development) 產生關聯？

中華台北：謝謝主席，由中華台北目前的發展經驗可知，在中華台北的許多中南部縣市均紛紛爭取科學園區的設立，由此亦可清楚地指出產業聚落的形成對於地方經濟發展的重要性。主席所提的問題十分重要，在此研究中，我們也會把產業政策與區域發展政策兩者的互動關係作一探討。謝謝主席。

主席：謝謝各會員體對中華台北研究計畫所提出的意見，大家的討論均十分深入，也很熱烈，由此可見中華台北所提的計畫的確十分重要，也得到大家的肯定，若無其他意見，根據大家的發言，我在此確認中華台北所提的產業聚落研究計畫得到 EC 的正式授權 (endorse)。

The Development of Industrial Clusters Towards Knowledge-based Economy

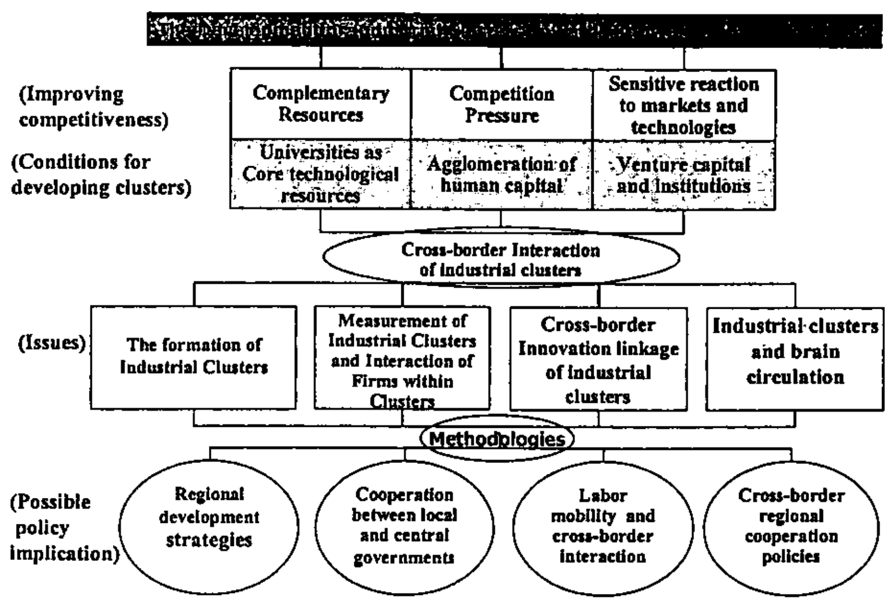
Chinese Taipei

February 2003

Contents

I. Research Background

1. Structure



2. Definition of Industrial Cluster

- Industrial Clusters may be defined as concentrations of interrelated industries that are located in a specific community or region.
- For example, Cambridge in the UK and Silicon Valley in the US are homes to some of the world's largest clusters of information firms.

3. Importance to Establish Industrial Clusters

- In today's global economy, continuous innovation is a core element to national competitiveness and economic development.
- Many developing countries regard establishing science and technology parks as an important vehicle to create industrial clusters in building innovative capabilities.

4. Conditions for Developing Industrial Clusters

- Well-established infrastructures, resources to innovation and the supporting institutions benefits the agglomeration process towards developing an industrial cluster.
- Due to increasing linkages between industrial clusters across national borders, international elements play an important role in the agglomeration of clusters.

II. Research Issues

1. The formation of Industrial Clusters
2. Measurement of Industrial Clusters and Interaction of Firms within Clusters
3. Cross-border Innovation Linkages of Industrial Clusters
4. Industrial Clusters and Brain Circulations

1. The formation of Industrial Clusters

- An indepth policy examination on the formation of the industrial clusters in Chinese Taipei, Silicon valley and in other APEC economies.
- Determines the conditions of industrial clusters through case studies and a comparative approach
- Examine the relationship between firms' location and their productivities.

2. Measurement of Industrial Clusters and Interaction of Firms within Clusters

- Compare the difference between firms within and outside the cluster in terms of vertical integration
- Looks at the model of firms' division of labor within a cluster and their coordination mechanism

3. Cross-border Innovation Linkages of Industrial Clusters

- Trend of cross-border innovation of industrial clusters
- With respect to cross-border interactions through trade, investment and labor mobility among clusters-- such as Hsinchu in Chinese Taipei, Silicon Valley in the U.S., and other APEC clusters

4. Industrial Clusters and Brain Circulations

- Driving forces of reverse-brain drain
- Technological contributions of reverse-brain drain to home countries
- Labor mobility and the formation of industrial clusters between Hsinchu and other APEC clusters

III. Methodologies

- Literature Review
- Government databanks
- Government policy review
- Questionnaire surveys
- Interview and field studies

IV. Policy Aspects

1. Possible Policy Implications

1. Regional development as one of core components of industrial policies,
2. Reformation cooperative relationships between local and central governments in terms of public policies,
3. Cross-border regional economic cooperation as a vehicle for economic development.

2. Policy Cooperation in APEC for Developing Industrial Clusters

- The exchange of international experience and cooperation among economies, which are inspired to develop such clusters, will benefit the developing economies in the APEC region.
- The improvement of linkages between industrial clusters among APEC regions should be an policy cooperation issue.

V. Research Schedule

Month/Year	Research Contents
August 2003	• Industrial clusters and brain circulation – Labor mobility and reverse brain • The formation of industrial clusters and the influence of clusters on firm productivity – The case study of Hsinchu Science Park – Total factor productivities of firms within and outside clusters
February 2004	– An investigation of a firm's locational choice – Development experience of Silicon valley, and other APEC clusters
August 2004	• Measurement of industrial clusters and interaction of firms within clusters – vertical disintegration and Division of labor • Cross-border Innovation linkage of industrial clusters • Submit project to EC

二、APEC ECONOMIC COMMITTEE

會議時間：2003 年 8 月 17–1 日

會議地點：泰國普吉島

(一) 考察報告

本次 APEC 經濟委員會 (Economic Committee) 的會議於 8 月 17–18 日在泰國普吉島舉行。第一天的議程主要是討論今年的經濟情勢展望報告 (Economic Outlook)，各會員對於細部內容有許多意見。接下來則為各個研究議題的報告，包括日本有關技術進步及企業家精神的報告、加拿大有關 ICT 運用的報告、韓國有關知識經濟網站的報告等。台灣的報告安排在 8 月 18 日上午，報告的內容詳見附錄。

我於 8 月 18 日下午搭泰國國內班機由普吉島抵達曼谷。駐泰代表處經濟組的高振民組長及馮海麗秘書前來接機。由經濟組的安排，8 月 18–19 日拜會一些泰國的台商，包括大同公司、亞法金屬公司、台達電子、興懋紡織、泰國金寶公司、宏碁電腦公司。除興懋紡織是由老一代的台僑 (來泰國超過 30 年) 所創立，屬於「個人創業」之外，其餘都是 1985 年以後由台灣企業投資的海外子公司。

泰國歷經亞洲金融風暴，許多台商企業在 10 年之內即遭到市場淘汰，例如凌亞電腦、誠洲電子等，能夠存活下來的，則有越做越大的趨勢。台達電、泰金寶和大同的營運狀況均相當良好，而且不斷在擴充當中。台達和金寶目前都是曼谷股市的上市公司。亞法金屬則是中小企業投資成功的案例。宏碁在泰國推展品牌但不做生產，也相當成功，目前是泰國市場的第一品牌。跨國營運還是需要相當的企業規模。

8 月 21 日應亞速 (Asoke) 和錫隆 (Silon) 兩個台商聯誼會的邀請，在曼谷的 Regent Hotel 發表專題演講，講題是「中國大陸經濟發展的前景」。演講由世界日報協辦，來賓多為在曼谷的台商，代表處的劉宜民副代表也出席。演講自中午 12 時開始至 2 時左右結束。8 月 22 日束裝返國。

(二) 會議記錄

中華台北：報告 (略)

日本：中華台北的報告和我方目前在著手進行的「技術進步」計畫有互補性存在，希望彼此能夠加強合作，互相討論與交換意見。而在人才流動方面，亦是我方正在進行的研究主題，其中差異之處在於，我方著重於總體面的探討，而中華台北則注重個體面的探討。

加拿大：中華台北的這份報告很有價值。創投資金對於各國產業聚落的重要性，雖然不盡相同，但仍存在部分資本市場的機制支持著產業聚落的發展；其次，不同產業聚落內的分工和專業化情形亦有所差異，希望報告中能夠針對這些議題作更深入之探討。還有對於 brain drain 的說法，我個人並不太贊同，是否可改為 brain exchange 更能夠描述實際之現象。

智利：對中華台北的研究內容深感興趣。報告中以亞太地區的產業聚落為分析的主軸，可否也加入歐洲的經驗共同討論，例如義大利的工業地區 (industrial district) 概念，尤其是社會網路 (social network) 及家庭所扮演的角色，可參考 Castell 的著作。此外，任何產業聚落的發展均先經過一段「機構建置」 (institution building) 的過程。對於矽谷形成的描述，我覺得 1950 至 1960 年代加州政府在當地所建立的教育體系是個十分重要的因素，且此一體系與民間部門有著密切地連結性。另外，對矽谷、新竹、上海的三個關係圖，表示的過於簡略，可否在詳加說明；例如「互補」指的是什麼，是生產性的互補，還是綜效 (synergy effect) 。

中國：對中華台北的報告表示肯定，但對有關中國的部分描述有些許意見，將再以書面詳細說明，此處只說幾項。第一，在 power-point 的圖表中顯示，上海的技術來源是來自於多方面的 (multi-source) ，而非只來自於 MNCs，中國本地企業和機構均有所貢獻。第二，在 local networking 方面，本地企業和研究機構的互動亦十分頻繁。第三，上海和新竹間的關係不是單項的互補，而是雙向的互補，如上海使新竹的生產成本下降，亦有互補的功能性存在。第四，第 19 頁最後一句提及，中華台北促成 (full) 中國 IT 產業的發展，有言過其實之誇。第五，希望中華台北的報告注意區域平衡，不要只談台北與上海的關係。

韓國：希望報告中可多談論到 MNCs 在產業聚落中所扮演的角色。此外，對於人才移動的內容中，除華人之外，可否加入分析非華人的人才移動情況，如此更能豐富報告內容。

主席 (安忠榮) ：主席也對中華台北的報告表示感謝。我對報告有個問題，就是新竹產業聚落的形成是由政府主導，還是由民間企業自然形成的？

The Development of Industrial Clusters towards a Knowledge-Based Economy

Chinese Taipei

17-18 August 2003, Phuket, Thailand

Contents

I. Industrial Clusters and Industry Competitiveness

1.1 Two Dimensions of a Cluster

1. A vertical dimension along which firms collaborate and perform complementary activities
2. A horizontal dimension along which firms compete and perform parallel activities.
   It is the combination of collaboration and competition that drives the dynamics of clusters.

1.2 Formation of a Cluster

Bresnahan, Gambardella and Saxenian (2001) conclude that the economic factors that give rise to the start of a cluster can be very different from those that keep it going. Three key ingredients to the formation of a cluster

- Entrepreneurship
- Linkage to a major and growing market
- Availability of skilled labor

1.3 Mechanism Toward Building a Successful Industrial Cluster

- Although the ingredients to the start of a cluster have been identified, the mechanisms that put these ingredients together to work toward building a successful industry is not quite clear.
- The experience of Silicon Valley has pointed out the important role played by venture capital , but the experience in other countries is not as clear-cut.

1.4 Institutions and the Development of Clusters

1. Structures and institutions matter in the development of clusters. The institution that is discussed most often in the literature is the institutions for innovation. Regional or national innovation system is the focus of recent studies on cluster – based industrial policy .
2. We may also look into the problems that inhibit the establishment of a cluster. Inability to create a knowledge base may be the most obvious barrier that obstructs the development of an industrial cluster.

II. Case Studies of APEC Member Economies' Industrial Clusters:

Features of Industrial Clusters in the APEC Members

2.1 The Role of Government

Chinese Taipei: HSIP	USA: Silicon Valley	China: Shanghai	Malaysia: Penang and Kelang Valley	Japan: Hamamatsu
The government planned the park, and provided tax incentives, industrial land in the early stage. In the later stage, HSIP interacts with silicon valley and other clusters, fits in the internationalized environment and achieves self-sustained growth.	Private sector plays major roles in the growth and develop the cluster. The relocation of military contractor – Lockheed to California in mid-1980s, and defense agencies also fastened the booming of IC industry.	Government provides infrastructures and financial incentives.	Government provides infrastructures and financial incentives.	Most efforts from private sector , government plays a very limited role.

2.2 Source of Innovation

Chinese Taipei: HSIP	USA: Silicon Valley	China: Shanghai	Malaysia: Penang and Kelang Valley	Japan: Hamamatsu
Several sources: 1. Silicon Valley 2. Industrial Technology Research Institute (ITRI) 3. Suppliers 4. Interactions with firms inside the cluster	Private sector and nearby institutions, particularly, Stanford University.	MNCs and foreign firms transfer technologies by setting up research centers.	MNCs play a major role in giving ground for nurturing of entrepreneurs.	Continuous innovation is the key for the sustainability of the cluster, which continuously produce new industries to replace old ones. Innovation comes mainly from the in-house innovation of big enterprises such as Suzuki Motor, Yamaha, Honda and Kawai.

2.3 Selection of Geographical Location

Chinese Taipei: HSIP	USA: Silicon Valley	China: Shanghai	Malaysia: Penang and Kelang Valley	Japan: Hamamatsu
Planned by the government (based on the location of universities and research institutes).	The economic regions began in the northwest of the valley in Palo Alto, where Stanford university provides abundant research staff and technical personnel.	Planned by the government to attract the agglomeration of multinationals and local firms	Government policy to attract export-oriented MNCs and gradually formed the cluster.	Since 19th century, Hamamatsu has been an important manufacturing sector in Japan.

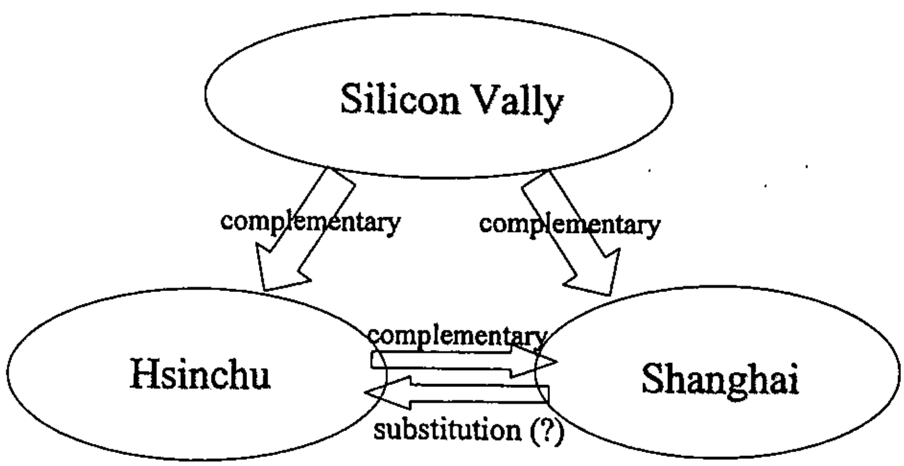
2.4 Local Networking

Chinese Taipei: HSIP	USA: Silicon Valley	China: Shanghai	Malaysia: Penang and Kelang Valley	Japan: Hamamatsu
Intensive interactions with universities and research institutes	Intensive interaction between firms, universities and research institutes.	Intensive interaction between MNCs	Penang: vertical division of labor between MNCs and local suppliers. Kelang Valley: inter-firm division of labor is less popular; linkage between MNC and local companies is limited.	Very intensive interactions.

III. The Movement of High-Tech Manpower between Industrial Clusters:

Hsinchu, Silicon Valley, and Shanghai as an Example

3.1 Interactions between Clusters in Hsinchu, Silicon Valley and Shanghai



3.2 Mobilizing Talents and Forming Industrial Clusters

The reverse brain drain in Chinese Taipei in the mid-1980s, and a new high-tech industrial cluster in Shanghai to attract high-tech talents from around the world.

1. Causes and effects of the reverse brain drain.
2. The factors driving high-tech talents to gather, and what the impacts may be on the management, R&D and innovation.
3. An in-depth analysis of the interactions between the three industrial clusters: HSIP, Silicon Valley and Shanghai.

IV. The Encouraging and Discouraging Factors of the Reverse Brain Drain

4.1 Causes and Effects of the Reverse Brain Drain

Through questionnaire survey, the top four main motivations for overseas high-tech talents to return to Chinese Taipei are found :

1. To spend more time with friends and relatives.
2. To help in the development of the home economy
3. To use what one has learned to help the home land.
4. Good job opportunities waiting at home.

4.2 Technology Formation and 'Reverse Brain Drain'

1. The higher the level of competition in a market, the more that firms will spend on R&D and the greater its subsequent need for hiring overseas scholars and specialists (OSSs) after their return.
2. OSSs make a significant contribution to technology formation for their employers after returning to Chinese Taipei; besides assisting in R&D work, OSSs also help firms to identify the experts they need from abroad.

4.3 The Migration of Skilled Workers

The family migration decisions of married expatriate workers of Chinese Taipei in Shanghai

1. China's economic future, the educational environment and the living conditions are critical.
2. School-age children and spouse's job security tend to discourage family migration.
3. As time passes, married migrants working in China tend to consider more seriously the possibility of family migration as they accumulate more social capital in China.

4.4 The Contribution of Expatriate Workers

To investigate the role of expatriate technical crew in the development of technology within these enterprises.

1. The Chinese Taipei parent companies were the major source of technology supply, with expatriate technical crew being the second source.
2. The contributions made by expatriate technical crew were wide-ranging, including providing know-how in manufacturing, management, R&D, human resource training.

4.5 R&D Expenditure amongst the Subsidiaries in China

1. Enterprises with greater human resources, larger scale or longer history are more likely to promote R&D activities, and their R&D expenditures will be larger.
2. The subsidiaries in China mainly obtain their technologies from expatriate technical crew and improve such technologies through R&D activities guided by these employees, in order to create new technologies.

V. Research Schedule

Month/Year	Research Contents
August 2003	• The case studies of APEC clusters ▪ Hsinchu Science Park, Silicon valley, Shanghai, Penang, Kelang Valley, and Hamamatsu. • Industrial clusters and brain circulation ▪ Labor mobility and reverse brain
February 2004	• The influence of industrial clusters on firm productivity ▪ An investigation of a firm's location choice ▪ Total factor productivity and clusters
August 2004	• Measurement of industrial clusters and interaction of firms within clusters ▪ Vertical disintegration and division of labor ▪ Cross-border innovation linkage of industrial clusters • Final report to EC

三、APEC ECONOMIC COMMITTEE-2004 First Plenary Meeting

會議地點：智利聖地牙哥

會議時間：2004 年 2 月 27-29 日

(一) 考察報告

這此去智利的聖地牙哥開 APEC 的 Economic Committee 的會議，一切都很順利，也很成功。

此次會議我們的報告是排在第一天下午的最後的個報告，我在完成 presentation 後原以為會跟著作 Q&A，沒想到主席在我的報告之後宣佈休息 15 分鐘，(這也是下午的第一次休息，也是僅有的一次)，在休息喝咖啡時，就有不少代表與我討論相關的內容，可以看出大家對此有興趣。其中也包括 EC 主席安院長及另一個 Committee 的主席，(我不知他的名字，但主席都會別上大會發的別針，我可以看的出來)，等到 coffee break 之後這才是大仗陣的開始，先由加拿大開問，再由智利，日本，韓國，印尼，香港等國代表發問，最後主席也發問，進行的方式是即問即答，這樣弄下來也花了半個小時，不過過程進行的很順利，結果也不錯。會後曾副座對會議的結果是滿意的— I think。

此次會議中，中方的代表沒有對我方的 presentation 有任何的意見，也沒有發言，所以沒有什麼困擾，而這也與曾副座與中方的代表作過溝通有關，此次中方的代表是位外交部的男士，我沒和他交談，所以不知他的名字，不是以前的那位小姐，曾副座告訴我說，她和中方的那位男士說，我們上次要你們提 case, 你們說要提，可是也沒有提，那人說，是的，那時他在場，他可以作證等等。因此，曾副座也出力不少，您有機會請謝謝她。

另外，在會議的第二天最後一個 session 時，曾副座也當場表示，支持主席再連任 2005-2006 的兩年，這也使安主席十分高興，在當時，雖然各國的代表沒有立及作任何表示 (也可能要回去請示)，但我們的人情是作到了。

會後，我離開會場前，安主席向我表示，他很感謝我們的貢獻，我想也是，綜觀此次會議，各國代表提的報告少有紮實的，加拿大的報告是委由美國的 IIE 作的，加拿大的代表一開始就表示有不少存疑之處，這讓大家很難有建設性地討論下去，而日本的兩個報告其中一篇沒有出來，日方作了一個 5 分鐘的說明，這一點也可學學，日方另一篇報告是沒有論文的綱要報告，此外韓方既為主席國，就要多出論文，多撐場面了，惟這些報告也不一定那麼好。為此，我們也不難體會韓方對我方的感謝應是真心的—若沒有我方的報告那麼 EC 的成果可要大打折扣的。

我當時和安主席說，你如果肯定我們，是否請你在 SOM 的會議報告中表達出來，若你不方便公開地為之，也至少要告訴我方出席 SOM 的代表（國貿局長及外交部的司長）如此經建會才有好的理由繼續支持 EC 相關的研究，如此才是善的循環。安他表示瞭解，我想安主席應可聽的進去。希望這個善的循環是能持續下去才好。以上就是我的會議報告。

(二) 會議記錄

在中華台北對有關「產業聚落」的研究計畫的簡報告一段落之後，主席表示，由於中華台北的計畫內容十分豐富，它須要較長時間作深入的討論，為此，主席宣佈休息 15 分鐘之後，再開始討論。在休息後，主席開放會場邀請各會員體代表表示意見，各會員體果然反應十分熱烈及踴躍，共有 7 個會員體表達八次意見。現將各會員體的意見及中華台北的回應扼要說明如下：

主席：在休息之前，中華台北提出了產業聚落的研究計畫，此一研究計畫十分重要，也很有吸引力，它讓我想起我在意大利時，觀察到北意大利那所形成的產業聚落，廠商在其中所形成的緊密關係，的確令人印象深刻，並且成效驚人，中華台北現在願意展開此一研究，著實重要，現在請各位表示意見。

加拿大：中華台北所提的研究十分重要也很有意義，加拿大願意支持。在此一研究中，中華台北的研究中，是否會考量諸如所得稅、工資差異等重要因素，以期更週全地探討「產業聚落」之形成。

中華台北：謝謝加拿大的支持，中華台北在研究中有關產業群落形成因素的探討中，將會特別考量此一重要因素，謝謝加拿大所提的寶貴意見。

智利：中華台北的提案十分重要，也很有意義。剛才主席提到的北意大利的產業聚落十分有意義，我個人的觀察是，當產業聚落形成之後，聚落內的廠商彼此建立了互信及聯繫網絡關係(network)。為此，產業內的交易成本大幅降低，產業的競爭力也大幅地提高，此點提供中華台北作參考。

中華台北：謝謝智利的支持及寶貴意見。中華台北完全同意智利的意見，在中華台北的研究中，有關產業聚落內廠商的互動，及其互動將如何降低其彼此間的交易成本的問題，將是主要的研究重點之一，中華台北將會對此作深入探討。

泰國：中華台北的提案十分重要，泰國十分支持。有關產業聚落之形成，我們認為關稅的因素十分重要，希望對此也能作探討。

中華台北：謝謝泰國的支持，有關泰國所提的意見十分重要。它使我想起中華台北及韓國在當時使用出口退稅的方式強化加工出口區的功能及運作。我想每個經濟體對

於產業聚落的發展其定義及內容或許不盡相同，為此，中華台北特別歡迎及邀請各會員體能參與此一研究，就各會員體內的產業聚落作研究，如此一來，我們將會有更豐富的內容，供作比較及相互參考。

中國：中國歡迎中華台北所提出的有意義及非常重要的計畫，中國支持此一提案，在此作兩點意見表達：第一，中華台北是否能進一步說明中華台北將如何衡量聚落內的廠商互動？第二點，中華台北若須對中國境內的產業聚落作研究，若有須要，我們願意提供必要協助。

中華台北：首先謝謝中國，中華台北的確須要中國的協助，在此再度表達誠摯的感謝之意。有關廠商在聚落內互動關係的衡量，這是一個非常重要而深入的問題，基本上中華台北將以問卷調查的方式，針對聚落內廠商他們的聯繫方式、對外採購的百分比率、主要的上流或下流廠商等等重要經濟變數作調查，藉以掌握此一重要變數。謝謝中國所提出的重要建議及支持。

日本：日本歡迎並支持中華台北所提出重要的研究計畫，在此是否請中華台北說明，在產業聚落的形成上主要的公共建設(infrastructure)為何？產業聚落之形成具體政策意涵為何？

中華台北：謝謝日本的支持並提出此重要問題，中華台北目前尚未完成此一研究，故未能對此提出完整的答案，但目前初步的研究顯示，在公共建設上，無論硬體及軟體的建設均十分重要，硬體方面如公共基本建設、標準廠房、穩定的水電供給、以及雙語學校等均扮演一定的角色；而在軟體建設方面，如行政程序簡化為單一窗口是典型的例證。在政策意涵上，如簡報所示，本研究希望能提供政府在產業政策及地方區域發展政策上重要的參考。

香港：與其他會員體所表示的意見一致，香港在此重申對中華台北所提的研究計畫表達支持及肯定。香港在此表達兩點意見：第一，是否請中華台北說明那些是推動產業聚落形成的重要因素？第二，中華台北在本研究上有關中國之區域研究似乎只考量長江三角洲，不知是否亦會考量珠江三角洲？

中華台北：謝謝香港的支持。有關第一個問題，本研究因為正準備開始故目前尚無法作具體的回答。但我認為這是一個重要問題，我個人初步的觀察與瞭解是，此一問題若從政策的角度來看，政府的支持是一個主要推動力量。由廠商的角度來看，歷史事件及地緣關係也是形成自然聚落的主要原因之一。另有關珠江流域產業聚落的研究，本計畫目前因資源及時間有限，對此暫不擬進行，但我們可以針對現有的研究成果，以文獻回顧的方式加以補強，對此當能在本研究上有較週詳的涵

蓋。

中國：中華台北所提的研究是否可能較偏重技術的移轉？技術移轉對產業聚落形成是否有其重要性？若是，本計畫可能有再斟酌的必要？

中華台北：謝謝中國所提的重要意見，我想這點提醒是十分重要的，中華台北在此作二點補充：第一，以中華台北的新竹科學園區為例，其技術的形成主要有二類，一是由海外而來，在台外商投資及海外學人回流；另一則是由本地的大學如清華、交大、工研院及其他機構產生。為此，本地技術及外來的技術移轉均有其重要性。第二，目前中華台北的高科技廠商在中國主要的投資重點地區是在上海一帶，而非珠江三角洲區域，其主要的原因之一，是因為長江三角洲區域存在中國一流的大學，故經濟體內自身具有的技術能量以及外來技術的引進與移轉均是重要因素。謝謝中國所提的寶貴意見，中華台北在進行本研究之際，將會特別注意此一重要因素。

主席（韓國）：謝謝各會員體踴躍的發言並表示許多重要的意見，我個人對此計畫亦十分感興趣。在此，我也要請教中華台北一個問題，不知產業聚落相關政策如何與區域發展(regional development)產生關聯？

中華台北：謝謝主席，由中華台北目前的發展經驗可知，在中華台北的許多中南部縣市均紛紛爭取科學園區的設立，由此亦可清楚地指出產業聚落的形成對於地方經濟發展的重要性。主席所提的問題十分重要，在此研究中，我們也會把產業政策與區域發展政策兩者的互動關係作一探討。謝謝主席。

主席：謝謝各會員體對中華台北研究計畫所提出的意見，大家的討論均十分深入，也很熱烈，由此可見中華台北所提的計畫的確十分重要，也得到大家的肯定，若無其他意見，根據大家的發言，我在此確認中華台北所提的產業聚落研究計畫得到EC 的正式授權(endorse)。

The Development of Industrial Clusters towards a Knowledge-Based Economy

Chinese Taipei

APEC EC Meeting

28-29 February 2004, Santiago, Chile

Presentation Outline

- Cluster and Labor Force Dynamics: Human Resource and Structural Change of Labor Force in the HSIP
- Entrepreneurship and Industrial Clusters: A Case Study of Chinese Taipei
- Subcontracting, Industrial Specialization and Industrial Clusters: the Case of High-tech firms in the Hsinchu Science-based Industrial Park in Chinese Taipei
- Research Schedule

1.Cluster and Labor Force Dynamics:

Human Resources and Structural Change in the Labor Force in the HSIP

1.1 Purposes

- To understand how the sources and composition of the labor force have changed through time and among different industries in the HSIP.
- To provide a historically dynamic picture of the internal development process of a high-tech cluster in a highly globally connected market.
- To uncovers the differential roles of the overseas returnees, foreign, and domestic high-tech workers in different industries and at different stages of cluster development.

1.2 High Quality of Labor Force in the HSIP

- Employees holding a Ph.D. or a master's degree accounted for around one fifth of the total labor force. Two thirds of the labor force were educated to at least college level.
- This high-tech cluster induces a concentration of relatively young skilled workers. Eighty-seven percent of the employees are in the age category of twenty to forty years old.

1.3 Effects of Overseas Returnees on Human Resources of the HSIP

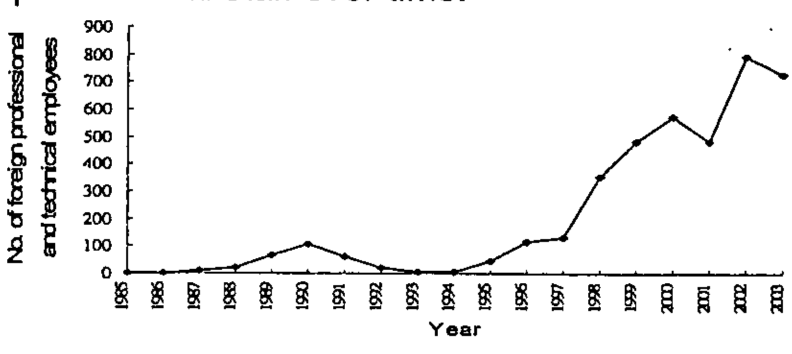
- Attracting overseas Chinese back to work in Chinese Taipei was one of the deliberative policies.
- The contribution of the overseas returnees to the success of the HSIP.
  - The technology transfer and diffusion , or more specifically in product development and modification.
  - Social capital, entrepreneurship and ethnic ties, intensify the spatial linkages.

1.4 Foreign Professional and Technical Employees in the HSIP (I)

- Reliance on overseas returnee on technology transfer and diffusion may have its limitation due to competition in supply.
  - Foreign professional and technical employees have kept increasing steadily and significantly since 1995.
  - The high skilled human resources are not only from technology-advanced countries, but also from neighboring developing countries.

1.4 Foreign Professional and Technical Employees in the HSIP (II)

- Within the HSIP, in addition to the influx of overseas returnees, there has been a significant increase in the number of foreign technical and professional staff over time.



1.5 Nationality of Foreign Professional and Technical Employees in the HSIP, 2003/10

Nationality	US	Japan	Malaysia	Korea	Philippine	Singapore
Total	199	122	87	60	39	37

Nationality	India	UK	German	Canada	France	Russia	Others
Total	30	29	16	16	15	13	64

1.6 Contribution of Domestic Labor Force

- Overseas returnees' proportions in total labor force have begun stabilized and even dropped since 1995.
- For the composition of current labor force in the HSIP, there are nearly equal proportions of employees with foreign and domestic PhD degrees.
- Domestic masters are the most important high-skilled labor forces in the HSIP, no matter in terms of amount or proportion.

1.7 Conclusion

- Due to high skilled labor forces are highly mobile, the continue success of HSIP will be depended on its capability to keep attracting overseas returnees and foreign professionals. Currently they are accounted for around one fourths of the research staff in the HSIP.
- The HSIP cluster is the most important magnetic to attract the most intelligent young scientific brains in Chinese Taipei.

2. Entrepreneurship and Industrial Clusters:

A Case Study of Chinese Taipei

2.1 Main Purpose

- To investigate the role played by industrial clusters in the formation and development of entrepreneurship, with the empirical evidence for this study being obtained from a case study of the manufacturing industry in Chinese Taipei.

2.2 Industrial Clusters Reduce Market Entry Barriers

- Industrial clusters connects with suppliers of intermediate inputs, and are capable of creating knowledge spillover effects.
- Labor pooling reduces the risks for business ventures.
- As learning region which spawns innovation and sharing technological narratives, affluent mutual trust and a willingness to cooperate.
- Industrial clustering stimulates competition and emulation entrepreneurial achievements.

2.3 Determinants of Market Entry for Manufacturing Industries (I)

- This study uses a database on Chinese Taipei's manufacturing industry to examine the determinants of industrial market entry over two periods, 1992-95 and 1994-97.
- The empirical results are in line with earlier studies, and indicate that a successful industrial cluster is able to reduce market entry barriers, and further drive entrepreneurship.

2.3 Determinants of Market Entry for Manufacturing Industries (II)

- The most interesting result is that an industrial cluster can effectively reduce market entry barriers, indicating that industrial clusters not only enhance firms' productivity, but also promote entrepreneurship.

2.4 New Start-up Firms and Geographical Deployment

- We examine whether new start-up firms are significantly correlated with their incumbents, in terms of geographical deployment.
- A comparative approach is applied based upon the locational choices of new start-up firms.
- The comparison of these industries, in terms of their entry rates, underpins the argument that the spatial agglomeration effect of firms can effectively induce new firm formation.

2.5 Conclusion

- The spatial proximity of industrial clusters has become the essence of a firms' network relationship.
- The empirical results confirm that successful industrial cluster is able to reduce market entry barriers, and enhance entrepreneurship.
- Policy support for new ventures should focus on emerging networks, linking firms together, rather than on individual firms.
- The aggressive pursuit of proximity should be seen as a necessary means of promoting mutual learning and joint knowledge creation through business-social-network exchanges.

3. Subcontracting, Industrial Specialization and Industrial Clustering:

the Case of High-tech firms in the HSIP in Chinese Taipei

3.1 Purposes

- To explore what effect the prevalence of subcontracting practices has had on the overall industrial structure and on industrial clusters.
- To consider the key elements involved in the undertaking of subcontracting practices by high-tech firms within the HSIP
  - whether subcontracting is a common practice for these firms,
  - whether the practice of subcontracting provides a competitive edge for these firms,
  - whether the subcontracting operations of these firms enhances or enlarges the clustering effect of other firms.

3.2 Analysis Procedure

1.Hypotheses: Firms may lower their production costs by subcontracting part of their production activities.

- We intend to examine the primary reasons why firms rely upon subcontracting rather than endogenous production.

2.A survey was performed in early November 2002 and ended in mid-January 2003. The questionnaire , was mailed to all of the 334 high-tech firms in the HSIP.

3.3 Empirical Results

- Subcontracting is an effective means of reducing production costs especially when a firm faces strong competitive pressure to lower costs.
- Market competition increases the extent of its existing subcontracting work. The evidence confirms that high-exporting firms in the HSIP are more likely to have higher subcontracting ratios.
- The empirical study has also shown that an increase in the subcontracting practice will significantly encourage the potential entry of new firms, and a higher degree of subcontracting can effectively reduce entry barriers.

3.4 Conclusion

- 'Savings on capital investment' and 'effectively reducing production costs' are primary factors leading to a firm's decision to adopt subcontracting.
- Firm faces strong competitive pressure to lower costs, it may adopt subcontracting, or extend the degree of its existing subcontracting. Thus, high exporting firms in the HSIP are more likely to have higher subcontracting ratios.
- An increase in the prevalence of subcontracting will significantly encourage the potential entrance of new firms.

4. Research Schedule

Month/Year	Research Contents
August 2004	• The influence of industrial clusters on firm's productivity • Cross-border innovation linkage of industrial clusters • Final report to EC

四、APEC ECONOMIC COMMITTEE-2004 Second Plenary Meeting

會議地點：智利聖地牙哥

會議時間：2004 年 9 月 30 日-10 月 1 日

(一) 加拿大：

1.本研究是一篇很好的報告，感謝中華台北的貢獻。

2.在報告中，中華台北對於產業聚落對總要素生產力(TFP)的貢獻部分，以Porter externality, Marshall-Romer- externality等角度來探討其貢獻，這是一個很有趣的角度，很有參考價值。

3.在產業聚落集中度部分的探討，中華台北以三種不同的指標來衡量，而其結果有所不同，如此一來如何取捨呢？

4.在報告中對馬來西亞及日本的產業聚落亦有所探討，若能有這些聚落的類似研究將會很有參考價值。

5.在此提出兩個問題：

(1)在探討產業聚落對TFP的影響中，有關TFP的計算是否將勞動品質納入考慮？

答：有關勞動市場品質的部分是很重要的，我國政府對TFP的計算是以「有效工時」來計算，而不是單純地以「受雇員工數」計算，在本計畫中其TFP的計算方式將再確認。

(2)有關研發的部分，R&D的投入是一個創新投入的重要指標，惟R&D並不能確保創新，因此，在研究報告中是否就此有所說明？

答：我們會在此研究中將此納入考慮。

6.本研究報告與加拿大接下來要報告的高級人才的國際移動均可視為「經濟委員會」知識經濟研究的一環，因此或可請主席考慮將此兩個研究的結果稍做整合，以向SOM提出成果報告。

(二) 智利：

1.首先對中華台北表達感謝之意，這是一個很好(wonderful)的報告，如今智利正積極地提升國家創新，為此智利設立創新基金，並積極改善基礎環境，我想中華台北的經驗有許多值得參考的地方。在此要向中華台北請教：政府在政策上如何強化本土創新技術的能力？

答：要言之，在產業技術的發展上，政府除了支持相關研究機構發展技術，強化研發能量與能力外，政府也把符合資格的民間企業納入研發體系的一環，而其研發成

果也能更直接地轉化為企業之用，如此本土的創新技術能力就能強化。

(三) 印尼：

1.在中華台北的報告中對於委外代工有很深入的討論，我們想知道，對於天然資源的開發(如礦業)，這種委外代工是否能適用？

答：委外代工的出現最重要的是能經由垂直分工而能降低生產成本，這種情形是否能在各種相關產業(如礦業)出現，個人現在並不清楚。惟我認為，若其有存在的可能性，政府在政策上都需要加以重視，再者，委外代工的出現將有助於中小企業的發展。

(四) 香港：

1.感謝中華台北提出此一很具參考價值的報告，在此要提出一個問題：是否政府在政策上能輔助產業聚落的形成？或者，產業聚落之形成純係市場力量所致？

答：產業聚落之形成市場力量的重要性是不言而喻的，在義大利有許多傳統產業的聚落形成是市場力量所致，另就政府角色而言，由我國的新竹科學工業園區及中國的昆山之出現，他們皆是由政府政策結果所產生。其中，昆山的出現是由地方政府所主導。因此，我們的確可以找出政府政策成功的實例，惟在此要小心的是，政府的政策並不能保證產業聚落的成功，這也是政府在政策規劃上要小心的。

(五) 安忠榮主席：

1.為保持區域的平衡發展，韓國現在正積極地建立區域性的創新中心，不知中華台北對此有何建議？

答：如我國的報告所示，區域性的發展尤應重視各區域中既有的資源與特色，如此在發展上就比較容易成功。

(六) 美國：

1.這是一篇很好的報告，在此向中華台北致意。

2.產業聚落的發展是很重要，以矽谷為例，其人口占全美國的1%，而其專利權的取得卻占全美國的8%，故其成果十分亮麗。

3.在此要向中華台北提出一個問題，不知智慧財產權的保護對產業聚落的形成與成敗是否有關？

答：在回答這個問題之前，我們必須先確認智慧財產權的定義或範圍為何？產業聚落的形成，其主要的功能之一就是知識與經驗的分享，而若此一部分以智慧財產權的保護為由而過度介入，可能是不智的。美國表示，在此他們所關心的是智慧財

產權是專利權的保護，為此我國表示，對於專利權的保護他應是國家整體智慧財產權保護重要的一環，故應加以重視，而此，他也是進一步營造產業聚落形成的重要條件。

附記

(一)馬來西亞代表會後私下表示：在我國的報告中對於馬來西亞工業區的描述，特別是工作簽證相對較嚴的部分，此一情形目前已有一些改變，是否可以再做更新，為此，我國表示，此事回台北後將請相關研究同仁與她連絡。Mr. Yap Lay Hua (Principal Assistant Secretary, Ministry of Finance)

E-mail: lhyap@treasury.gov.my

(二)有關下二年度 (2005-2006) 的研究主題，我國發言如下：

主席提到下二個年度相關的研究主題，其中有關電子商務的課題，我國將在回國後作進一步的思考。如今電子商務的發展迅速，他已形成新的經濟發展趨勢，故十分值得重視。我們回國後再做相關確認，若真的確定進行此一研究計畫，誠致地希望相關的經濟體也能一齊努力合作，如此一來，我們能對此一課題有更深入、更周全的探討。

The Development of Industrial Clusters towards a Knowledge-Based Economy

Chinese Taipei
APEC EC Meeting
30 September – 1 October 2004,
Santiago, Chile

1. Outlines of Newly Completed Research

Month/Year	Research Contents
February 2003	Chapter 1 Introduction
August 2003	Chapter 2 The case studies of APEC clusters Chapter 3 Learning Network and Industrial Cluster Chapter 4 The Cross-Border Technological Linkages of Industrial Clusters Chapter 5 The Movement of High-Tech Manpower between Industrial Clusters
February 2004	Chapter 6 Cluster and Labor Force Dynamics: Human Resources and Structural Change of Labor Force in the HSIP Chapter 7. Entrepreneurship and Industrial Clusters: A Case Study of Chinese Taipei Chapter 8. Subcontracting, Industrial Specialization and Industrial Clusters: the Case of High-tech firms in the HSIP

Presentation Outline

- Outlines of Completed Research
- Chapter 9. Industrial Cluster and Firm's Productivity: A Case Study of Chinese Taipei's ICT Industry
- Chapter 10. Location Choice of New Firms: The Case of Chinese Taipei's Electronics Industry
- Chapter 11. Conclusion and Policy Recommendations

2. Industrial Cluster and Firm's Productivity:

A Case Study of Chinese Taipei's ICT Industry

2.1 Purposes

- Using the micro data on Chinese Taipei's ICT industry for 1999 to examine the effect of Industrial clusters upon the productivity at the plant level.
- This research explores the productivity differences of individual plants by taking into account their heterogeneity, including individual plants' attributes and the their external environments.

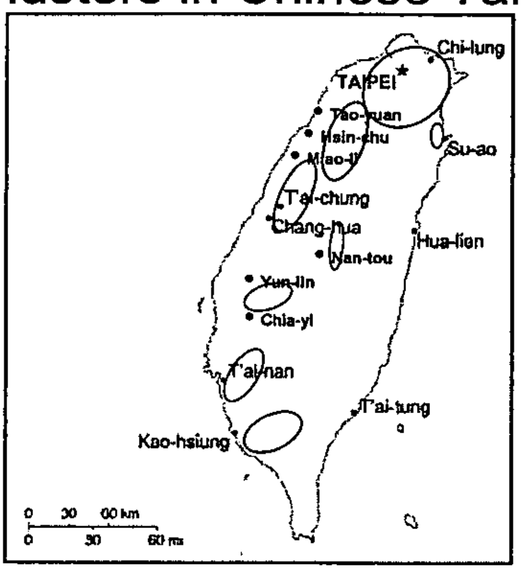
2.2 Data Source

- Data are drawn from "The Annual Manufacturing-Plant Survey of 1999" conducted by the Statistical Division of Ministry of Economic Affairs (MOEA), Chinese Taipei, in 2000.
- The classification of ICT industries includes computer, communication, and audio/video electronic productions.

2.2.1 Geographical Identification of ICT Industrial Clusters

- This study employs the cluster analysis, one of multivariate analyses, and the coordinate of each Chinese Taipei's ICT firms in terms of the T2-degree transverse Mercator to delineate the geographical boundaries of its ICT industrial clusters.
- Apart from the traditional approach based on administrative regions, we propose the cluster analysis.
  - The study refers to the optimal population of ICT clusters in Chinese Taipei to CCC, as well as the pseudo-F statistic and pseudo-t^2 statistic. As shown in the following Figure, the population of ICT clusters is 8.

2.2.2 Deployment of ICT Industrial Clusters in Chinese Taipei



2.3.1 Modeling Firm Productivity

$$TFP = \alpha_0 + \alpha_1 SIZE + \alpha_2 RDL + \alpha_3 LKL + \beta_1 ARDR + \beta_2 COM + \beta_3 JO + \varepsilon$$

$$F(SIZE, RDL, LKL, ARD, ARDR, COM, JO)$$

- Dependent variables : Firm's TFP indicator for 1999.
- Independent Variables :

  Firm-specific attributes : firm size (SIZE) 、capital intensity (LKL) 、R&D intensity (RDL) Regional advantages : regional R&D intensity (ARDR) 、Porter's externalities (COM) 、Marshall-Arrow-Romer externality (JO)

2.3.2 Definitions of Variables

Variables	Definitions
TFP	TFP for 1999
SIZE	Firm size in terms of number of employees, in natural logarithm
RDL	Firm's R&D intensity, per capita R&D expenditure, in terms of NT thousand
LKL	Capital-labor ratio for each firm, in natural logarithm
ARDR	Regional R&D intensity, per capita R&D expenditure, in terms of NT thousand
COM	Regional Porter's externalities, measured by the ratio of number of regional firms to the total number of employees in the region.
JO	Marshall-Arrow-Romer externality, measured by the ratio of number of regional ICT employees to the number of regional employees for the electrical components and equipment industries.

2.4.1 Estimation of ICT Firm's TFP, 1999

	(1)	(2)
Constant	0.613***	0.980***
	(4.71)	(16.66)
SIZE	0.113***	0.112***
	(11.44)	(11.76)
RDL	0.183***	0.173**
	(2.34)	(2.28)
LKL	-0.248***	-0.249***
	(-25.58)	(-25.66)
ARDR	2.236***	-
	(2.45)	
COM	0.137***	-
	(2.63)	
JO	0.223***	-
	(3.72)	
R^2	0.381	0.376
F test	83.20***	205.13***
Log-Likelihood	-1401.348	-1410.586
Breusch-Pagan $\chi^2(1)$	283.03	278.21***

2.4.2 Empirical Results

- Firm-specific attributes:
  - LKL is negative and significant. Firms with greater capital-intensity have lower productivity.
  - RDL is positive and significant. Firms undertaking R&D investment will reap subsequent rewards in terms of their own TFP.
- Regional attributes:
  - ARDR upon firms' productivity is statistically significant and positive, suggesting that productivity can be improved through regional innovative activities.
  - COM is significant and positive. Regions with more competitive pressure force regional firms to boost productivity more aggressively.
  - JO is significant and positive, indicating that regions with more specialized labor increase productivity.

2.5 Conclusions

- Two results significantly feature this study:
  - We propose a new approach to classifying industrial clusters based on the Euclid distance between any two firms within a relevant industrial sector.
  - Apart from firms' own heterogeneity, this study highlights the roles played by regional business environments.
- With respect to public policies, governments' investment in regional innovation (R&D) systems seems to be increasingly important for promoting firms' TFP in a knowledge-based economy.

3. Location Choice of New Firms:

The Case of Chinese Taipei's Electronics Industry

3.1 Purposes

- To study the agglomeration effects in the development process of Chinese Taipei's electronics industry.
- By examining the firm-level data obtained from the census of manufacturers from 1990 to 1999, we hope to detect the existence of agglomeration effects, and to estimate the magnitudes if they do exist.
- We will investigate how location choice of newly established firms is affected by geographical concentration of the industry.

3.2 Measures of Geographical Concentration

- Herfindahl Index:

$$H = \sum_i S_i^2$$

- Gini coefficient

- Ellison-Glaser Index :

$$EG = \frac{\sum_i (S_i - X_i) - (1 - \sum_i X_i^2) z}{(1 - \sum_i X_i^2)(1 - z)}$$

3.2.1 Herfindahl Index and Gini Coefficient 1990-99 Average (I)

- Herfindahl index
  - The electronic tubes industry is most concentrated geographically.
  - This is followed by the data storage devices (such as CD-R and CD-ROM), semiconductor industry, and audio/video parts, in that order.
  - The least geographically concentrated industries are passive electronic components and other electronic parts.
- Gini coefficients produce a similar ranking.

3.2.2 Ellison-Glaeser index (I)

1. EG produce a different result, with the semiconductor industry ranked as the most geographically concentrated industry, followed by other audio/video parts, optoelectronic devices and other computer parts, in that order.
2. Electronic tubes and data storage devices are ranked very low because both industries are also very high in terms of seller concentration.

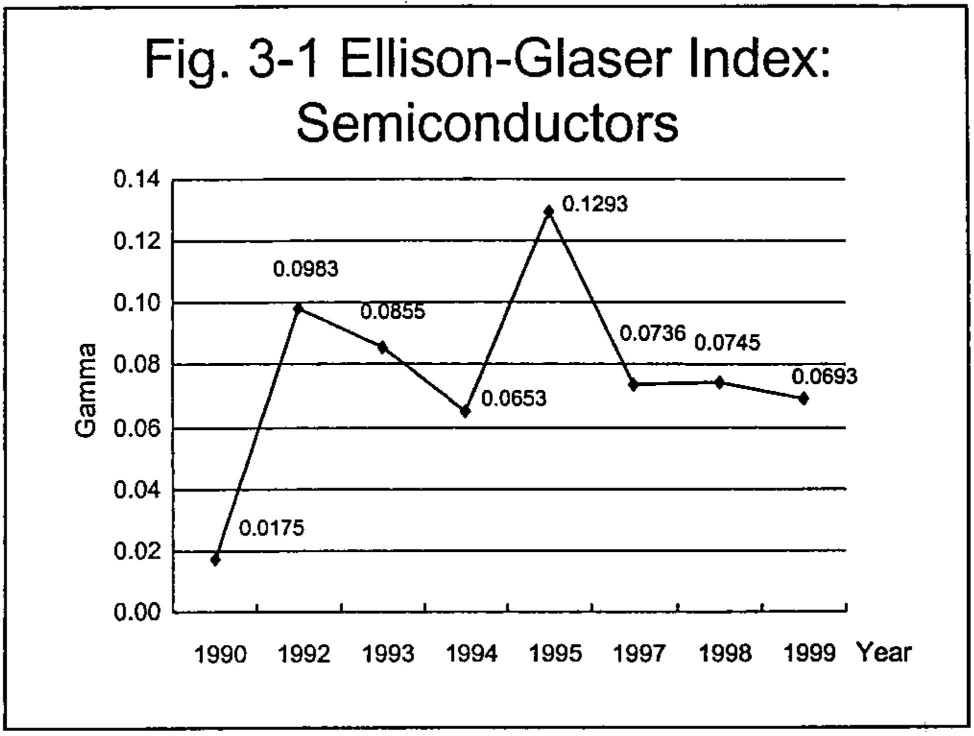


Fig. 3-1 Ellison-Glaser Index: Semiconductors
Gamma
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0.0175
0.0983
0.0855
0.0653
0.1293
0.0736
0.0745
0.0693
1990
1992
1993
1994
1995
1997
1998
1999
Year

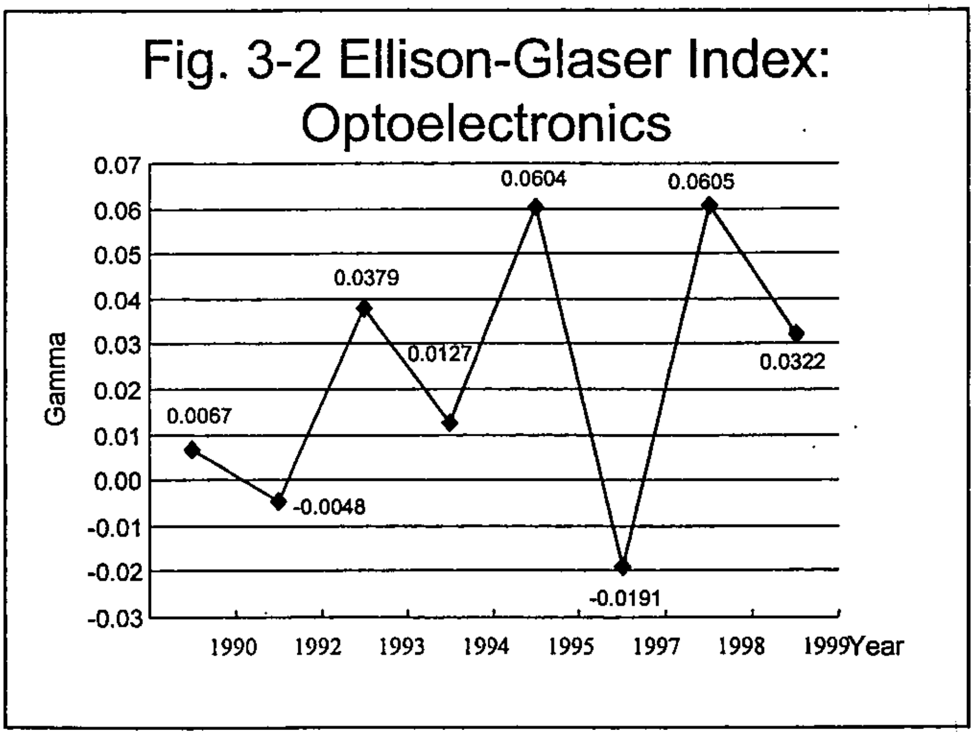


Fig. 3-2 Ellison-Glaser Index: Optoelectronics
Gamma
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
0.0067
-0.0048
0.0379
0.0127
0.0604
-0.0191
0.0605
0.0322
1990
1992
1993
1994
1995
1997
1998
1999
Year

3.2.2 Ellison-Glaeser index (II)

- The optoelectronics industry started with a lower EG index than the semiconductor industry, but both moved to the range of EG=0.060 in 1999.
- In 1990-99, the number of semiconductor producers increased by 10.548 times while that of the optoelectronics industry increased by 3.962 times.

Fig. 3-3 Ellison-Glaser Index: Computer Terminals

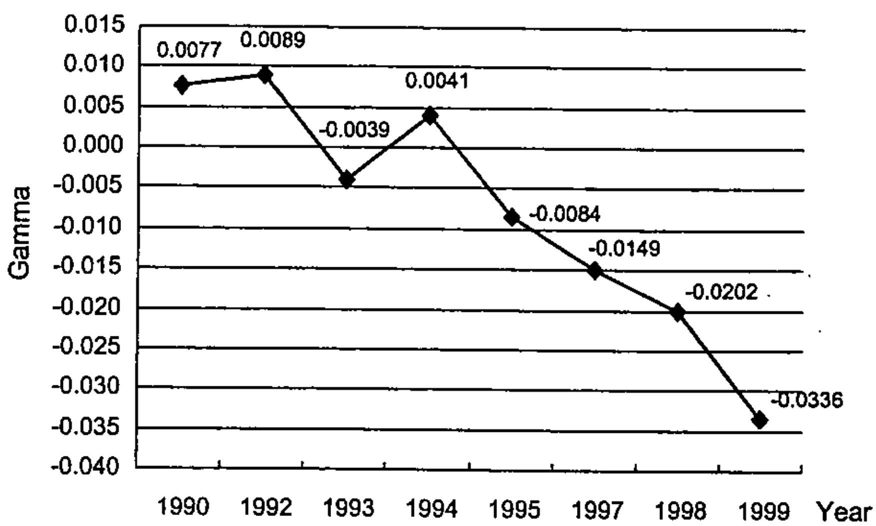
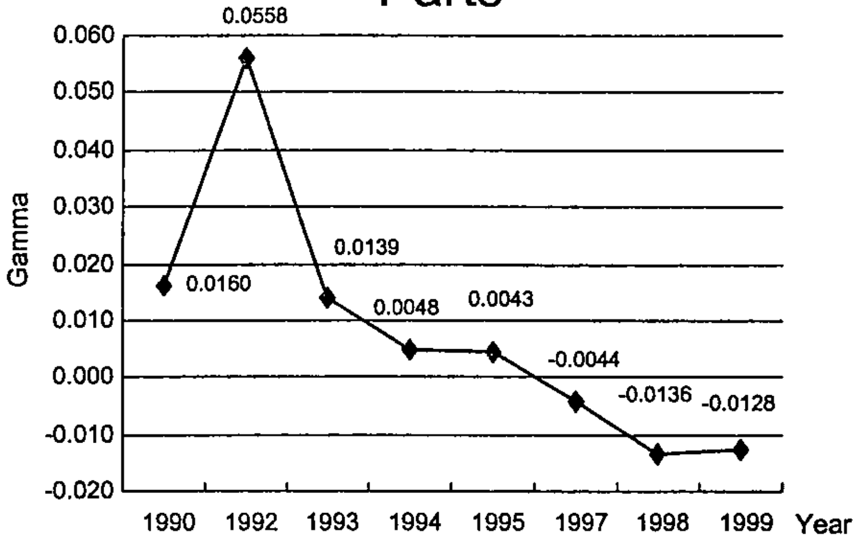


Fig. 3-4 Ellison-Glaser Index: Audio Parts



3.2.2 Ellison-Glaser Index (III)

- Both computer terminals and audio parts are apparently declining industries, although new plants never stopped from entering the industry.
- In th e computer terminal industry, new entrants in 1990-1999 amounted to 2.576 times of existing firms in 1990, and in the audio equipment industry, the entry rate was 1.342.

3.3 Agglomeration and Location Choice

- A panel data consisting of newly established firms in the electronics industry in 1990-1999 are used as the sample.
- explanatory variables.
  - price variables representing local conditions such as wage rates, land prices, etc.
  - agglomeration variables such as the number of existing firms in the industry, total employment of the industry.
- A conditional logic model is used to model the location choice of new firms, taking 23 counties-cities as independent alternatives.

3.3.1 Explanatory Variables

Variables	Definitions
$FIRM_i$	Number of existing plants in the industry in location *i*
EMP_i	Total employment of the industry in location *i*
$VADD_i$	Total value added of the industry in location *i*
$LABOR_i$	Total labor force of location *i*
$WAGE_i$	Average wage rate per man-year of the manufacturing industry in location *i*
IND_i	The degree of industrialization in location *i*, measured by the total value added of the industry
$UNEMP_i$	Total number of unemployed persons
SKS_i	Number of skilled workers in the region, measured by the number of college graduates with a major in science or engineering disciplines
$RENT_i$	The price of industrial land in the region, measured by NT per squared meters

3.3.2 Geographical Distributions of New Entrants, 1990-1999

County-City	Computer products (314)	Consumer electronics (315)	Communications (316)	Semiconductors (317)
01. Taipei Hsien	977	314	328	943
02. Yilan	2	3	1	18
03. Taoyuan	198	62	132	556
04. Hsinchu Hsien	49	8	33	108
05. Miaoli	19	0	5	29
06. Taichung Hsien	15	28	27	96
07. Changhua	5	5	3	27
08. Nantou	0	1	2	6
09. Yunlin	0	2	0	7
10. Chiayi Hsien	0	3	1	5
11. Tainan Hsien	16	7	9	42
12. Kaohsiung Hsien	3	10	10	37
13. Pintung	0	3	0	1
14. Taitung	0	0	0	0
15. Hualien	0	0	0	0
16. Penghu	0	0	0	0
17. Keelung	1	0	0	4
18. Hsinchu City	52	17	28	94
19. Taichung City	17	28	6	28
20. Chiayi City	0	0	0	0
21. Tainan City	6	0	5	6
63. Taipei City	171	57	52	74
64. Kaohsiung City	23	21	20	67
Total	1552	569	660	2148

3.4 Empirical Results for Location Choice

- agglomeration variables : FIRM and VADD are significant in all regressions.
- cost variables : WAGE and RENT, are also found to be significant variables in affecting the location choice of new entrants. Both high wage and high land price tend to deter new firm entry.
- resource variable : SKS, is found to be positively related to location choice.
- unemployment rate (UNEMP) is found to positively affect the location choice of new plants.

3.5 Conclusions

- Agglomeration economies are the important determinants of location choice of new firms.
- Agglomeration measured shows a positive and significant impact on the location preference of new entrants. The availability of skilled workers are also shown to have a positive effect on attracting new firms.
- When the industry is on the decline, there is a tendency for it to disperse geographically. Newly entered firms in a declining industry have a tendency to choose new locations to explore new competitive advantage.

4. Conclusion and Policy Recommendations

4.1 Conclusions for the Whole Report(I)

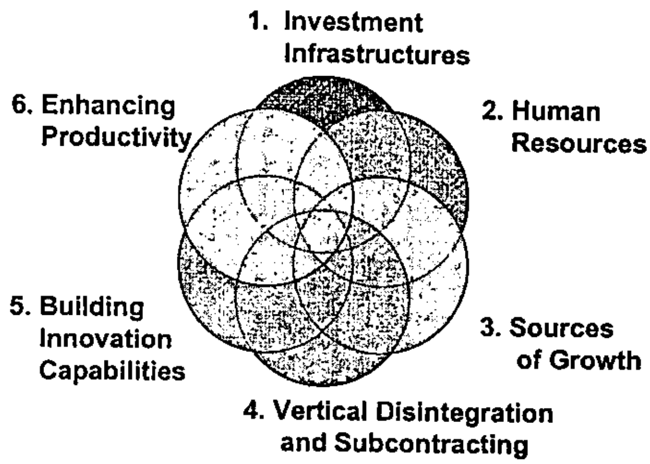
- Innovation and growth are the two most important elements in the formation of an industrial cluster.
  - Innovation provides the dynamics for competition and restructuring, and underlines the benefits of knowledge sharing, which motive firms to congregate together.
  - Growth is important to induce new entry and to facilitate a division of labor within the industry. Linking to the major market is the key to the formation of an industrial cluster.
- Abundant skills are the core of location advantage for forming an industrial cluster. Indigenous skills are critical to leverage the inflow of foreign-based skills when human resources are insufficient

4.1 Conclusions for the Whole Report(II)

- Both horizontal and vertical subcontracting are a prevalent practice within the cluster. Subcontracting allows firms in the cluster to realize economies of scale while maintaining the flexibility of production.
- Industrial clustering improves the productivity of individual firms. Both Porter externality and Marshall-Romer externality seem to be working for the benefits of the member firms in a cluster. Although the two externalities differ in nature, they probably exist simultaneously in a cluster.

4.2 Policy Recommendations:

Six Elements even No Fixed Successful Formula



4.2.1 Investment Infrastructures

- Infrastructure such as electricity, water, telecommunications, and living environment are important to pull potential firms and human skills together.
- For developing countries that lack the resources to embark on a full-blown infrastructure development, it may be useful to concentrate the effort in a small region. After a cluster emerges in the region, then the area can be gradually expanded to include adjacent regions.

4.2.2 Human Resources

- Even though part of human resources can be obtained from abroad, the availability of local-sourced human resources is crucial to the operations of the cluster.
- Investment in human resources is an absolute necessity for any country to develop an industrial cluster. Geographical proximity of training institutions, such as universities, appears to be useful in facilitating knowledge diffusion. Public institutions devoted to industry-specific training of human resources prove to be useful in accelerating skill formation for cluster development.

4.2.3 Building Innovation Capabilities

- Innovation is an important element in the operation of an industrial cluster. Innovation capability has to be owned by firms themselves; public institutions can help but they cannot replace private efforts.
- A cluster may be developed initially by borrowing foreign technologies but eventually the sustainability of the cluster has to depend on indigenous technologies. The government has to ensure that indigenous technologies can be accumulated along with the formation of an industrial cluster.

4.2.4 Sources of Growth

- Growth leads to an increase in the number of firms and differentiation of products. For most developing countries, the major growing markets are often in the developed countries. The ability to export to these markets is critical to the success of an industrial cluster.
- In this regard, FDI is useful in bringing about the linkage to the export market. Domestic firms also have to be a part of the export drive, making their own linkage to the major markets. Sometimes personal connections such as returned engineers from the major markets also help.

4.2.5 Vertical Disintegration and Subcontracting

- Vertical disintegration is a result of competition and the need to cut production costs through subcontracting and out-sourcing. To ensure that competitive force is at work in the industry. Government should not attempt to protect the incumbent firms or to create a situation that brews monopoly.
- The prevalence of subcontracting and out-sourcing arrangements in an industrial cluster allow specialized suppliers to emerge, and reduce the cost of entry. This will drive the dynamic process of clustering.

4.2.6 Enhancing Productivity

- Clustering is a process in which inefficient firms are eliminated and the surviving firms are increasingly concentrated geographically over time. A government policy aiming at relocating existing firms to economically disadvantageous region is probably counter-productive.
- An available policy for the disadvantageous regions is to find new ingredients such as human resources to attract location-specific industries, or to develop the region into a satellite cluster for the existing clusters. It is more important to link the regions to a manufacturing center or a market center.

五、考察報告

地點：中國（昆山、吳江、上海）

時間：2003 年 8 月 31 日-9 月 6 日

此次的考察除了要進一步瞭解中國華東地區資訊電子產業聚落的發展現況外，也希望透過面訪的方式瞭解台商企業與台商組織在中國大陸的運作狀況，相較於過去的經驗，這個部分並無太多突破性的發現，而且國內相關的研究重複度度亦較高，因此，相關訪談主要是持續地蒐集和累積個案資料，及追蹤過去訪談過的台商企業。在這此次的考察行程中，比較新的課題是要進一步地瞭解這些台商聚集的電子業聚落，它們的招商引資策略，及其間的競爭性，由此來深化對於台商聚集的大上海地區（主要集中於昆山、吳江、松江、張江等地）之區域差異的瞭解，所以，相當多的時間是以訪談中國的地方官員為主，並以開發區及其基礎設施的投融資作為訪談的重點。因此，考報告的重點有二：一為簡述中國華東地區整體資訊電子產業的發展概況，二則說明中國基礎設施投融資的渠道，以作為日後進一步討論開發區間競爭的基礎素材。

一、中國華東地區整體資訊電子產業的發展概況

（此部分感謝滬鍊光電張永南總經理、張江高科技園區領導小組辦公室紀龍主任所提供的書面說明及資料）

由上海、蘇南、浙北所構成的長江三角洲，是當前中國電子製造業發展最為熱絡的區域，其新形成的產業聚集優勢，已有凌駕珠江三角洲地區的趨勢，而這個地區也是資訊電子業台商投資的熱點與高度聚集的地方。

上海主要是以大尺寸、高工藝晶片製造來確立高階產品的製造與研發為定位，目前已形成包括設計、製造、封裝、測試、服務在內的完整晶片產業鍊。以此次參訪的張江高科技園區來看，根據 2002 年 6 月的統計資料顯示， IC 產業在張江共有產業項目 171 家， 孵化項目 216 家， 研發 26 家，教育項目 11 家， 中介機構 33 家， 共計 457 家， 2001 年工業產值已達 88 億人民幣，目前進駐的廠商，粗略統計如下：

<u>製造 3 家</u>：中芯、宏力、上海貝岭

<u>研發 9 家</u>：華虹研發、復旦微電子研究院、復旦微分析中心、西安交大研究院、復旦訊息學院、復旦國家軟體示範學院、中興通訊研發中心、聯想研發中心、中國科技大學研發中心

設計 22 家：華宏、復旦微電子、華龍信息、宏盛集成電路、Avanti、Synopsys、SST、邁世、英聯、岭豐、中星、華騰、大翰

封裝 6 家：阿法泰克、威宇、泰隆、華岭、還有其他（也不是我負責）

配套及設備供應 17 家：PraxAir、SAES、Lam Research、Novellus、Applied Materials、TOWA、TIC、迪艾。

而蘇州和無錫則是江蘇省兩大電子製造基地，從行政隸屬關係來說，蘇州電子製造基地又包括蘇州工業園區、蘇州國家高新技術產業開發區、昆山經濟技術開發區和吳江經濟技術開發區。就投資來源言，無錫新區是日資青睞之地，蘇州工業園區是歐美跨國公司聚集之地，蘇州新區、昆山市和吳江是台灣中大型電子企業最為聚集的地區。就蘇州已有的 1000 多家電子企業來看，其中台資就佔了 500 多家，由此可見電子業台商聚集蘇州的密度。

另杭州灣（包括杭州、寧波、紹興、嘉興與湖洲）則聚集了將近 6000 餘家的電子產品製造企業，這浙江現有的 12 個產業園區中，11 個聚集在杭州灣地區，目前浙江省正積極打造杭州灣微電子產業帶，全力發展其為繼上海、北京、蘇南之後的另一個中國重量級的微電子產基地。移動通信產品、中小尺寸的晶片及新行的元件器，是該地目前最具競爭力的產業。寧波保稅區電子資訊產業園和半導體光電科技工業園是目前中國大陸唯一在保稅區設立的電子產業園區，也是浙江省最大的電子產業聚集地，凸顯了電子資訊、半導體光電等兩大產業重點。

二、開發區競爭與基礎設施投融資

（此部分主要由倫敦政經學院地理與環境資源系博士生簡旭伸負責整理歸納）

近十年來長三角地區對於外資的新引力道相當強勁，各開發區區之間也頗具競爭關係，最明顯的就是在招商引資時對台商所提供的親切性、效率與彈性度，以及反映在地價成本上的優勢。從研究的角度來看，前者可以從各開發區的管理體制來檢視，而後者則可以從開發區基礎設施的投融資渠道分析之，事實上，對各開發區來說，兩者其實也是一體的兩面，也就是說，開發區基礎設施資金來源的問題，其實也反映出各開發區管理體制不同的現況。因為，各類開發區雖然在中國改革開放的過程中扮演關鍵角色，但是卻至今尚未有其全國性開發區的統一法律體系。

據大陸學者的研究指出，目前中國開發區管理體制，主要可大致分為三種模

式：一是行政主導型， 以成立管理委員會直接管理；二是公司型，在沒有管理委員會的架構下，建立經濟發展總公司作爲經濟法人來推動園區建設；三則是混合型，即又有管委會又有總公司的交叉運作 (朱永新， 劉伯高等 2001)。換言之，在實際操作上，各開發區往往會運作一套符合各自當時政經環境的管理體制，當然也就相對應的連動到各種不同類型的基礎設施投融資渠道。同時，這也意味著面對激烈的開發區競爭，各開發區也就必須彈性機動調整相關的管理體制，以可方便創新推出便捷操作的基礎設施投融資渠道。

在中國改革開放過程中的基礎設施投資渠道經驗，若是按照預算口徑來分可以分成預算收入，預算外資金以及制度外資金三種。然而就實際的開發區財政資料以及其基礎設施投資金額相對照，就可以發現在絕大多數的開發區發展歷程的早期階段，就算全部預算收入以及預算外資金總合投入仍無法滿足基礎設施開發所需的資金，更何況這預算收入的支出分配不只是獨厚基礎設施開發，還有一大部分是支援農村生產與各項事業費用，挖潛改造費用，文化科學衛生事業費用，以及行政管理費費用等. 所以等於就形式上來說，從事基礎設施的資金來源已經越來越難單純仰賴現有的財政架構 (Kumar, Gray et al. 1997)，絕大多數的各級政府是在制度外資金上獲取基礎設施的資金。

（一）政府財政融資—包括預算收入以及預算外資金

在有關對中國財政議題的討論，所謂預算收入 (budgetary revenue) 與預算外資金 (extra-budgetary revenue) 已經引起廣泛的注意 (Wong, Heady et al. 1995; Brean 1998; Wang and Hu 1999)。在 1994 年的稅制改革中，中央與地方的預算收入包括關稅，消費稅，增值稅，企業所得稅，營業稅，個人所得稅，土地使用稅，城市維護建設稅，房屋稅，印花稅，車船使用稅，資源稅，集中繳納的收入等 (Bahl 1999)。在泰虹的調查中顯示，這項資金來源在九零年代以前是建設的主要來源，但因爲各地基礎建設的需求越來越大，這項資金對於占整體城市地方基礎建設的已經從 1991 的超過 50% 變成 2001 年的 29% (泰虹 2003)。

在改革開放後，中國北京中央政府曾經多次做出界定預算外資金，如 1983 年財政部公佈的第一份全國性預算外資金管理辦法，1993 年公告將多達 80 項行政性收費納入預算收入管理，以及 1996 年 7 月國務院公告的「國務院關於加強預算外資金管理的決定」，明定說預算外收入是指，「國家機關，事業單位以及社會團體未履行或代行政府職能，依據國家法律，法規和具體法律效力的規章而收取，提

取或安排使用的未納入國家預算管理的各種財政性資金」，然而歷年預算外資金往往相當於預算內收入的 50-100%不等 (Gore 1999)。至於用預算外資金來進行各種基礎設施，則是指城市建設配套費和增容費、過路過橋費、市政設施有償使用費以及其他各種收費等。這類收費曾經在 1994 年曾經占全中國整體基礎設施投入的 47%，但最近也已經又下降到 2000 年的 25%，以及 2001 年的 10% (秦虹 2003)。

（二）制度外資金 (off-institutional revenue)

然而就中國的地方政府而言，由於從事基礎建設是勢在必行的工程，在預算法規定各級地方政府不得舉債以及財政赤字的規定下，只好變形衍伸出各式樣包括銀行貸款，股票市場，國外或國外債券，企業債券或外國政府貸款等，成爲中國各級政府除預算收入以及預算外資金之外的另一種資金來源，用以從事各項基礎設施公益專案或私利活動 (Woo 1998)。這被稱爲制度外資金，用以區隔依法律課征的預算收入，以及國務院或財政部同意的管理規則收取的預算外資金。制度外資金則是被巧妙募集自沒有合法授權各級政府或部們的權宜性，變通性與應急性安排 (Ma 2000)。根據賈康與閻坤的研究，制度外資金就籌措方式來說，包括有償與無償兩項。後者是指各級政府和部門與依託於政府的社會團體，憑藉自己特定權威而向社會募集的資金;而前者則是指以政府或部門或是採取直接運作或是採取委託企業運作等不同管理方式，來運用向社會各界收取的貸款資金 (賈康與閻坤 2000)。也就是說，在預算收入以及預算外資金不敷使用之際，各級政府實務上自行設計具有可操作性的管理架構，來具體運作制度外資金。整個以制度外資金從事基礎設施投融資的渠道，又可以分成下列幾項:

1. 政府出面貸款

"九五"期間，中國實行積極財政政策，加大了對城市基礎設施的資金投入。1998 年至 2001 年，由中央政府出面共安排 766 億元國債資金用於 967 個城市基礎設施專案的建設。這些專案大部分是城市急需建設而以前無力投資的專案，涉及到全國 95%的地級以上城市及中西部地區部分縣城的供水、道路、供氣、供熱、垃圾和汙水處理等領域 (秦虹 2003)。

另一種形式的政府舉債則是外國政府或機構的貸款。例如世界銀行就已經從 1991 到 1996 年對中國，進行高達 163 億美金的貸款從事基礎建設，或是以亞洲開發銀行在 1995 年也對中國，有高達 52 億美金從事交通，能源，農業等各種建設專案，另外還有日本政府海外援助計畫 (Japanese Overseas Development Assistance)

與澳洲海外援助計畫 (Australian Overseas Development Assistance) (Spear， Nailer et al. 1997)。這類外國機構或政府的貸款，原則上是由地方政府或部門出面提出申請，之後送到中央國務院計畫委員會進行優先順序排列，並且提出可行性評估報告，再由財政部出面與貸款國或機構進行協商，協商內容包括貸款金額，所需償還金額，貸款利率，還款周期，以及技術轉移內容等。但在實際操作上，涉及地方政府與中央政府，以及中央與外國政府的彼此談判籌碼與能力。上海爲例，最近幾年就有日本政府於 1997 年貸款興建浦東機場，1999 年法國政府貸款興建輕軌明珠線，以及德國政府 2000 年貸款興建浦東機場高速鐵路線等。而在大蘇州地區也有 1996 年間由世界銀行協助蘇州新區興建汙水處理廠。

以上兩種政府貸款主要都是由中央政府出面處理，這是因爲在中國預算法中有明定地方政府財政不得列赤字的規定。唯獨 1999 年以後，國家開發銀行嘗試建立一套變通的信用結構，以方便貸款給地方政府進行基礎設施建設。這主要是要地方政府將規劃建設的基礎設施專案整批次處理，由地方政府的代理人 (通常是地方政府下轄的全資公司) 提出申請，但要件是：若是該建設專案日後可以收費，則國家開發銀行具體要求地方政府要將收費權授與該代理公司，若是該專案以土地批租使用權轉讓，則要求地方政府明定轉讓收益授與該代理公司，若是仍不足額部分則要求地方政府承諾以本級財政進行補貼，並且該項補貼計畫需提交同級人大批准並出示正式文件。只是這項計畫剛剛實施，而且因爲法律規定不明確，各地方政府以及地方人大對開發銀行的信用仍只是一種君子協定，萬一違約，國家開發銀行等債權銀行也無法透過司法途徑進行追討 (王大用 2003)。

2. 企業積累融資模式

上述國家開發銀行企圖推動地方政府貸款信用的最原始形式，其實就是早已存在多年。許多開發區以及地方政府以全資公司 XX 經濟發展總公司的形式，來進行基礎設施融資，其中包括地方政府用道德勸說的方式要求同級行政轄區內的各類銀行對該公司進行放款，或是利用行政優勢推動該公司或旗下一兩家子公司股票上市，或是由這公司出面投資國內外債券獲取匯率差價，或是以該公司名義發行國內外債券以吸引資金等。

3. 經營資源融資模式

這一部分又可以細分成土地，無形資產以及有形資產三部分。就土地部分，主要就是推動「土地有償使用收入」制度以爲彌補城市建設資金不足，近幾年由

於工業用地開發過多而導致競爭激烈價格下滑，部分地方也試著通過土地開發和市政基礎設施配套建設帶動土地升值，升值後的土地 (主要是以商業用地) 招標或拍賣出讓，出讓收入再用於城市建設，甚至成立土地批租拍賣中心專責進行商業用地拍賣工作，形成基礎建設與土地經營良性互動的新模式。

無形資產經營，例如出讓計程車經營權，公車路線經營權，道路廣場命名權，廣告權等 例如北京「紫玉山莊路」，就是由紫玉山莊房地產開發公司爲其開發的地產爲取得命名而出資建設。這部分可以當成是城市建設資金的少量補充 (劉慧勇，梁維和等 2001)。

有形資產 (例如收費路橋，自來水廠，污水廠) 的部分，則是指各級政府將過去成壟斷經營的有形城市建設資產，通過對經營權轉讓，股權轉讓以及資產轉讓等方式實現對有形資產進行盤活經營，例如經營權轉讓收入，或是股權轉讓或是資產轉讓等方式而產生的收入 (泰虹 2003)。例如南京在 2003 年通過出讓其下的液化汽公司部分資產給華潤液化氣集團 (薛樂群 2003)；蘇州新區將現有一家煤氣廠轉以香港中華煤氣集團經營，將一家學校轉給上海中瑞集團經營。

4. 外商或民營企業直接投資基礎設施，指以 BOT (Built-Operation-Transfer) 爲主或變形的基礎設施興建

這是指各地將有盈利的基礎設施以專案委託給民間興建營運，利用以及 BOT 建設，發行企業債券，股票等方式盤活存量資產、吸引民間投資。1998 年湖南長大建設集團股份有限公司投資建設長沙第八水廠，成爲中國第一家國內 BOT 專案例 (泰虹 2003)。如 2000 年上海成功的江滬青平高速，莘奉金高速，外環線越江隧道，盧浦大橋等社會招商，由中國造船總公司，愛建信託投資公司等五家公司承建。

5. 其他金融工具

此外，在操作過程中也出現銀行主動出擊的變形案例。例如深圳機場 (集團) 公司與建設銀行深圳分行於 2003 年 6 月，簽署「集合委託貸款」協定當成基礎設施投資管道，以用於機場候機室的改建工程。集合委託貸款是一種介於儲蓄，國債以及股票之間的中間產品，銀行將以一般銀行或國債利率還要高的利率，來吸引民衆參與儲蓄「集合委託貸款」專案；又因爲是集中委託貸款，乃是以企業經營績效爲吸引民衆參與投資，所以銀行也將對參與「集合委託貸款」專案的企業，進行貸款利率的調降，以低於同期的銀行貸款或是企業債券利率。

六、考察報告

地點：中國（北京）

時間：2004 年 9 月 20 日-9 月 24 日

1. 北京在發展高科技產業過程，已開始重視中介機構的發展問題，初期以行業協會當作推動的重點之一，由行業協會替代政府承擔協調企業之間、行業之間及行業與政府之間的關係。根據光華管理學院的調查，中關村園區有各類協會 17 家，覆蓋資訊技術、生物工程等多領域，各類會員累計達 8,000 多人。其中，行業協會 10 家，占協會總數約 60%，多數為近年成立的純民間性行業協會。現階段，園區協會發展仍然處於調整和提高階段，有兩個主要特點：第一，在規範運作條件下保持較強活力，特別是民間行業協會發展定位比較清楚，治理結構和運作相對規範，在一定範圍內有較強的影響力與凝聚力。第二，協會自主發展過程中政府積極引導和支持。包括：政府搭建平臺促成民間協會成立；管委會設立"服務體系建設處"，以正式組織結構保證政府與協會的溝通與協調渠道通暢；管委會通過政府向協會購買服務、與協會進行專案合作等方式，給予協會資金支援，在緩解協會資金短缺壓力的同時，引導協會提升職能層次和規範化運作。

   園區協會目前以初級職能（內部培訓、組織沙龍、專案仲介等）為主，高級職能較少。主要原因是：第一，民間協會大多面臨經費壓力，不得不以組織培訓、沙龍等創造收入的服務性專案為主要工作重點。第二，協會缺乏推動協會行使高級職能的高素質專業人才。多數協會僅有少量專職工作人員，且職業前景不確定、報酬較低、社會地位不受認可，致使這部分職能發展緩慢。第三，協會運行模式存在缺陷，未建立確認、整合及實現行業共同利益的機制。第四，目前的政策、體制環境尚不能給協會組織行使高級職能創造足夠的空間。整體而言，園區協會組織的職能層次還不高，但已經出現了職能層次提升的趨勢，如發佈行業價格資訊、制定行業自律規範、影響行業稅收政策等。園區行業協會發展中存在的問題包括：(1)協會設立和解散都存在明顯障礙；(2)

經費不足是普遍現象；(3)職能層次提升困難；(4)發展定位模糊；(5)協會運行模式有缺陷；(6)協會的代表性、權威性和影響力不足。

表一　中關村企業合作研發之型態

	2003	2002	2001
外部研發合作支出	178.72	117.61	113.98
其中員工人數少於100人企業所佔比重	89.61 (50.14)	50.04 (42.55)	35.29 (30.95)
與學術機構合作研發經費支出	66.79	28.78	21.19
其中員工人數少於100人企業所佔比重	22.74 (34.04)	11.05 (38.41)	12.02 (56.74)
與產業合作研發經費支出	66.36	31.36	28.23
其中員工人數少於100人企業所佔比重	45.79 (69.00)	16.21 (51.67)	10.90 (38.60)

表二　中關村企業之知識生產效率的產業間比較

產業	專利申請/100人	專利申請/百萬元	授權專利/100人	授權專利/百萬元	科技論文/人	科技論文/百萬元
電子與信息	2.228	0.164	1.108	0.082	0.017	0.122
其他配套	2.069	0.226	1.108	0.121	3.392	37.082
先進製造技術	2.215	0.229	2.279	0.235	0.064	0.664
新材料及應用技術	2.144	0.307	1.525	0.218	0.062	0.899
生物工程和新醫藥	6.91	0.512	1.849	0.137	0.047	0.353
新能源與高效節能	7.103	0.638	3.090	0.277	0.06	0.54
環境保護技術	4.102	0.417	1.723	0.175	0.034	0.35
現代农業技術	1.942	0.244	0.324	0.041	0.106	1.343
核應用技術	5.76	0.588	2.535	0.259	0.011	0.117
航空航天技術	0.126	0.007	0.063	0.004	88.216	493.001
海洋工程技術	0	0.000	0.000	0.000	0.055	1.215

2. 根據光華管理學院的高新園區企業研究，中關村園區企業，在

2002-2003 年間，用於研發合作的投入顯著增加，但是中小企業增幅更大。與科研機構和與工業企業合作研發費用大體相當；但中小企業卻表現出對與工業企業合作的顯著傾斜（詳見表一）。另外，中關村企業之知識生產效率的產業間比較詳見表二，中關村企業之知識的商業轉化效率的產業間比較詳見表三。

表三　中關村企業之知識的商業轉化效率的產業間比較

產業	E1 技術收入 百萬元/篇論文	E2 技術收入 百萬元/專利申請	E3 技術收入 百萬元/專利授權	E4 技術收入 百萬元/人	E5 技術收入 /研發投入
電子與信息	21991.967	16349.291	32.891	2.745	2.680
其他配套	122.136	20025.163	37.380	2.414	4.529
先進製造技術	5116.257	14870.273	14.454	3.036	3.402
新材料及應用技術	3051.183	8933.360	12.558	5.221	2.743
新能源與高效節能技術	7900.589	5452.519	20.375	2.654	2.790
生物工程和新醫藥	7243.937	6138.930	14.112	2.293	3.915
環境保護技術	8590.250	7215.810	17.181	3.379	3.012
航空航天技術	1723.122	9477.172	56.863	5.434	2.315
核應用技術	13933.410	2786.682	6.333	6.230	1.638
現代衣業技術	2.239	156755.895	313.512	5.062	1.104
海洋工程技術	6889.505	137790.100	137.790	2.613	8.371

整體而言，中國企業的演化呈現四個時代的型態，包括生產時代、銷售時代、營銷時代、戰略時代；而後者方興未艾。對照這四個階段，關注可持續的核心競爭能力的策略分別為：生產換知識、市場換知識、知識換知識、知識創造知識；知識換知識已略有進展，但知識創造知識則是未來的發展方向。因此，中國大陸高新產業發展固然已有相當不錯的基礎，但仍然有很長的路要走；然而，其企圖心不容忽略。尤其，根據新華通訊社所出版的《參考消息》（2004 年 9 月 23 日），目前外商在中國大陸所設的研發實驗室總數已約有 600 家。這些發展將可能在未來深遠地影響國際的研發創新版圖與兩岸的競合。

3. 根據中國國家知識產權局的統計資料，2003 年中國大陸專利申請總量為 30.9 萬件，核准量 18.2 萬件，分別較上年成長了 22%和 38%。從三種專利占總核准量比重的歷年變化看，中國大陸發明

專利核准在數量上雖然一直處於最低水平，但近年來所占比重持續大幅提升。發明專利（3.7 萬件）占專利總量（18.2 萬件）的比重從 1986 年的 2%（歷史最低）上升到 2003 年的 20%，年均成長率達 15%。而實用新型專利的比重從 1988 年的 85%（歷史最高）降低到 2003 年的 38%。因此，在中國大陸核准的專利中，技術含量較高的發明專利的地位在不斷提高。不過，2002 年在中國大陸的核准專利中，本國人擁有的專利為 11.2 萬件，外國人擁有的專利為 2.0 萬件。其中，本國人擁有的核准專利以實用新型為主體，所占比重達到一半以上，而發明專利的比重僅為核准專利總數量的 5%。相反地，在外國人擁有的核准專利中，發明專利所占比重達 77%，而實用新型專利僅有 2%。可見，在總量上本國人擁有的專利雖然佔有絕對優勢，但從擁有的專利類型來看，本國人與外國人擁有的專利在質量上的差距十分明顯。因此，大陸面臨低成本優勢被高額權利金削弱，60%企業遭遇外國技術壁壘，帶來高達 450 億美元影響，佔年出口總額 25%以上。大陸有鑑於國內企業遭遇國外企業技術障礙，因此致力研發自有技術標準如 Linux、WAPI 等，提昇自身競爭力。

4. 中關村的發展已由一園五區擴大為一園七區，包括海淀園、豐台園、昌平園、電子城科技園、亦莊科技園、德勝科技園、健翔科技園；後兩者為新設園區。到 2000 年止，從產值上看，北京 90%的高新技術產業都集中在中關村科技園區，其中 70%集中在海澱，其空間集聚特徵已十分明顯。

   另外，北京附近還有中關村軟件園區，為國家軟件產業基地。中關村軟件園位於海淀區上地信息產業基地兩側，規劃總佔地面積 139 公頃，總建築面積 610,000m2，，容積率 0.44，平均層數 3 層。週邊中科院、清華大學、北京大學等眾多高校及科研院所為入園企業形成強大的科技區位支撐和人才依托。中關村軟件園區設有北京市軟件出口服務的中樞，並將致力於發展軟件的國際外包業務。園區內將設電子商務平台合作為業務和管理平台，連接全市軟件出品企業、海外商口、客戶和相關政府部門，對外輻射

全球市場，對內服務中關村科技園區的"一區七園"。目前包括 Oracle、Siemens、IONA（愛爾蘭）等外商進駐，其中 Oracle、Siemens 為研發中心。進駐的本國廠商則包括信威通信、方舟、國永融通、中國銀聯、中國普天、中關村華夏、東軟、港灣網絡、中關村科技軟件、漢王科技。進駐的廠商同時適用下列優惠政策：國務院鼓勵軟件產業和集成電路產業發展的若干政策（18 號文件，即將因美國壓力廢除）、北京市關於進一步促進高新技術產業發展的若干政策、北京市促進軟件產業發展的相關政策、中關村科技園區有關優惠政策。

5. 整體而言，北京高科技產業聚落特色，可歸納如下：

- 大部分皆為政府主導
- 依賴大量國家資源成立
- 與東南沿海外商直接投資驅動下的外向型加工工業區，以及浙江溫州靠當地小型企業家創業投資和傳統企業發展起來的特色產業形成產業聚落不同
- 電信產業聚落是以 Nokia 所帶動興建的星網國際工業園區為主，因此電子產業聚落的發展亦可說是中關村的發展

北京工業園區的優勢：

- 人才優勢：擁有北大、清大等學術單位，研發能力較強。
- 研發資源較多：北京承擔國家三大計畫（863 計畫、基礎研究計畫、攻關計畫）；北京研究開發的投入水準較高。
- 市場需求優勢：北京擁有信息、市場、品牌的優勢；市場需求相較大陸其他地區為高；北京比較容易獲得相關的公共關係資源；且北京跟國際市場接軌較深，營銷的品種齊全且方式靈活，庫存量小。

北京工業園區的劣勢：

<u>中關村的劣勢</u>

- 缺乏有力的區域支撐-包含支持性活動以及產業聚落本身的活動，沒有形成完整的上下游產業鏈，使得北京許多研發成果在外地實現產業化。
- 水、電等生產要素缺乏。
- 清華大學學生真正創業的很少入園的項目是否屬於高科技，而非商業

性。

– 缺乏創業環境。

– 中小企業仍然面臨資金缺乏、管理不善、市場秩序不健全等困難；地價上漲、勞動力成本居高不下、交通條件欠佳。

– 與上海相比，北京作為大陸金融中心的功能稍遜色。

– 海外歸國學子相較北京，大多比較想要到上海工作。

– 政府主導型的園區，缺乏自主發展能力：過度依賴土地經營和優惠措施。

– 主要的專業化集群中並沒有設立相應的機構，科技仲介機構與產業的脫節，工業園區內企業之間缺乏必然的產業聯繫。

中國公司的困境

– 中國公司除靠技術及資源，還面對外商強烈競爭。

– 中國官員為保險起見，較喜歡跨國企業的產品。

北京工業園區的機會：

藉由吸引跨國公司進入中關村之際，改變中關村的產業定位和外部形象，提升中關村在全球 IT 生產網絡中的位置；中關村與北京市商業銀行推出共同支持中小高新技術企業便利融資的措施，支持留學人員創業的融資。

北京工業園區的威脅：

面臨大陸產業聚落發展的困難、其他開發中興新國家的崛起（如印度）、制度上較先進國家缺乏效率、制度面對經濟快速發展的制約、缺乏公益性產品開發服務和資訊服務以及其他配套服務、仿製現象突出、誠信水平不高、與金融擔保體系尚未建立。

6. 北京大學的創業育成中心（孵化器）仍然是以外來企業進駐為主，只有少部分進駐企業為由北京大學內教職員出來創業的。不過，有一些進駐企業是由北京市內研究機構或企業以承接政府科研計畫之研究成果做為基礎所衍生出來的新創企業。例如北京科宇聯合幹細胞生物技術有限公司是由北京大學醫學部、北大資源集團、北京和眾華信科技發展有限公司和科學家團隊共同組成，獲得“863”、“973”、“211”工程、北京市重大科研專項等六千萬人民幣科研經費的支持。台灣的創業育成中心未來也應著重於催生政府科研計畫成果的衍生公司，而非只是一味吸引外來企業進駐。

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