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Why do industrial clusters have different innovation patterns? Hsinchu (Taiwan) and Beijing's High tech parks compared

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ABSTRACT

This paper uses the perspective of industrial cluster to investigate technological development in Hsinchu Science Industrial Park (HSIP) in Taiwan and Zongguancun (ZGC) in China respectively. It is found that HSIP's development in the semiconductor industry in general and IC design in particular has been closely linked to the prosperity of PC industry in the world market, as well as to the state's support and strong institutional networking. These factors synchronize together to push IC industry and the cluster to upgrade continuously in global production networks; whereas ZGC's picture in technological learning is not so clear as compared to HSIP, while some local firms learned knowledge from MNCs and local R&D institutes, they rarely have established dense learning networks. This mainly comes from its obvious de-linkages among actors in local settings that inherited from its socialist institutional arrangements which hampered local technological learning and upgrading.

1, Introduction

This purpose of this paper is to compare the innovation system in Hsinchu Science Industrial Park (HSIP) in Taiwan and Beijing's high-tech industrial park, or Zhongguancun (ZGC), and their respective technological development. HSIP was established by Taiwan's state in the late 1970s with the intention to upgrade its labor-intensive economy. After decades' development, together with its adjacent areas, HSIP currently has become a successful high-tech information technology (IT) cluster that has attracted many foreign and domestic firms to reside. On the other side, Beijng's ZGC is arguably the most innovative region in China, or called the Silicon Valley of China (Segal, 2003; Yu, 2008). It was originated in the initial stage of the Chinese economic reform and was formerly established as a high-tech science park by the Chinese state in 1988. Currently, ZGC has agglomerated many of the innovative Chinese IT and multinational firms to set up R&D centers. Together with the high concentration of R&D personnel and institutes in the Beijing area, ZGC has become the most important center for technology innovation in China.

The above two clusters however face enormous challenges ahead. For HSIP, the pressing issue is the threat of ZGC and other high-tech parks in China that have the advantages of low cost and massive domestic market. This therefore creates the pressure to HSIP as to whether it still has the innovative capability to sustain its competitiveness, especially in its dominant sector- the semiconductor industry. It is because even the design part of the semiconductor industry now can be decomposed into segments and outsourced to other parts of the world. The artisan-type of design activity now has been transformed into a highly standarized factory-type operation where most of the knowledge is codified (Ernst, 2005a: 2). Currently, designing an IC now can be organized on a 24 hours' basis, with teams relaying around the globe. While Taiwan has emerged as a power house in the semiconductor industry since the 1990s, it faces a new challenge arising from emerging global design networks through which global MNCs outsource their design functions to China and India to take advantage of the lower labor costs. The sustainability of the HSIP thus deserves to be investigated. For ZGC, the emerging issue is to catch up the technologies as fast as it can to become the innovation center that has its own technologies, or called 'self-reliant innovation' (*z-zhu-chuang-xin*). ZGC has been famous for its innovative activities in the development of software industries, due to its abundance of human resources and the industry's lower level of entry. Nevertheless, the opening of the Chinese market has pressured the domestic firms to meet the challenge of MNCs. The domestic firms thus have to upgrade as to compete with MNCs to survive even in its domestic market. Therefore, there is a common issue for both industrial clusters: that is, how to continue to upgrade technologically in order to sustain the region's competitiveness and development.

This above pressing issue for both HSIP and ZGC is the question that is often asked in the study of regional development: the sustainability of an economic region. Recently, studies of industrial clusters have emphasized the factors of knowledge learning (Bathelt et al, 2004; Malmberg and Maskell, 2002; Maskell, 2005; Morisini, 2002), and the global-local relational networks (Amin, 2002) that may enhance regional competitiveness and sustainability. This paper is intended to use the above theoretical tradition to investigate the development of both clusters and their learning capability. This paper will argue that HSIP's sustainability of innovation has been due to its full insertion into the global production networks of the ICT industries, together with its strong supports from local institutions in upgrading the ladder in GPNs; whereas ZGC's technological learning mainly comes from its obvious linkages within GPNs that support it to learn codified knowledge, however the local institutions in it lack of systemic supports for technological upgrading.

2, From catching up to innovation cluster

A cluster can be very loosely defined as 'sectoral and spatial concentrations of firms' (Schmitz and Nadvi, 1999: 1503). Recent studies on industrial clusters in developing countries, though stressing the importance of cost advantage, highlight that learning is essential for a cluster to become competitive due to its crucial role in disseminating knowledge and generating possible innovation (Humphrey and Schmidt, 2002; Giuliani et al, 2005). There are two essential elements that have been stressed in the literature on a cluster to become innovative (Bathelt et al, 2004; Lundvall, 1990; Camagni, 1991; Stoper, 1995; Malmberg and Maskell, 2002; Maskell, 2005; Morisini, 2002). The first is a thick local institutional infrastructure that supports collective learning. This involves the intertwining of R&D institutes, networking among firms and a shared cultural tradition that facilitate information flow and knowledge diffusion. The second consists of the extra-local linkages that enable information and knowledge to flow in and out so that local firms not only can learn technologies form local settings but also from outside actors through social interactions, which can avoid lock-in effect and facilitate knowledge creation.

While most of the researches on innovative clusters are focused on localities of advanced countries, researches on the sustainability of industrial clusters in developing countries are increasingly brought to the concern from development studies (Humphrey and Schmitz, 1996; Schmitz and Nadvi, 1999; Humphrey and Schmidt, 2002; Giuliani, et al, 2005). It is because most of the industrial clusters in developing countries are state creation that upholds their competitiveness in attracting both local and foreign firms based on low cost. These clusters are in severe competition and in consequence they are vulnerable to similar low cost competition from other even lower cost countries. An urgent issue of sustainability of the industrial clusters in developing countries is thus on constant industrial upgrading – meaning 'to make better products, make them more efficiently, or move into more skilled activities (Humphrey and Schmidt, 2002:1017) - which may generate innovative capability of local firms and clusters' competitiveness.

Nevertheless, industrial upgrading for developing countries is not an easy task. Since the latecomer firms do not have the advanced knowledge in producing better products, they have to learn from firms in advanced countries. Latecomer firms learn, emulate and assimilate technologies from advanced countries through the channels such as reverse engineering, outsourcing, licensing, joint ventures, etc. Therefore, the states in developing countries tend to adopt policy on the one hand to build good environment in attracting foreign firms to invest in their industrial clusters, and on the other hand to construct local institutions that are favorable for technology learning. In the process, latecomer firms may be able to accumulate technological capability and build up their own innovative ability, if they made sufficient and efficient effort (Hobday, 1995; Amsden and Tschang, 2003; Amsden and Chu, 2003; Kim, 1997). Although the continuous outsourcing from leading firms offers a great opportunity for latecomer firms to learn newest technologies due to the global circulation of brain power and knowledge (Ernst, 2005a,b), it is the local effort that really make the difference. The ways in which the state reacts to the megatrend and whether local institutional arrangements are favorable for facilitating an innovation environment are the essential elements that determine a place's potentiality to transforming into an innovative region. As Humphrey and Schmidt (2002:1025) argue, 'the greater the leap in upgrading, the less likely it is that knowledge acquired in existing linkages suffices. Firms will have to rely to a greater extent on local and national sources of innovation.' That is, firms need greater institutional support to engage in technological upgrading as to engage into the GPNs for a higher position.

The building of local institutional structure however is not out of vacuum, it has its institutional roots that have inherited from historical legacy. It is because of the vested interests in the system has been established, people tend to choose paths that are more familiar with to adjust to the new environment. As institutionists argue, since institutions both enable and constrain individual behaviour by defining the incentive framework in which agents make decisions. Most of the time, this inhibits people from choosing more efficient arrangements than the current ones. Institutions therefore are generally not optimal (North, 1990), and continue to affect people's behaviour. North argues that this conventional act mainly results from the fixed cost of the institutional architecture and the increasing returns to adoption. As a result, it creates the path dependence or the lock-in effect, which explains the phenomenon in which existing institutions tend to persist and become growth trajectories that are followed by different countries.

Based on the above institutionist perspective, we propose that the existing industrial system of a late industrializing region in which institutional arrangements are the major components will continue to play a dominant role in its strategy selection in pursuing for innovation. The existing socially-embedded institutional arrangements which exist in a region's industrial system may create conditions either enabling or constraining local firms' ability to adjust and to transition toward innovation. In what follows, I will argue that HSIP's sustainability has been due to the institutional supports from the state and IT related industrial system through which a synergy effect has been created to uphold it to upgrade in the ladder in GPNs; whereas ZGC's technological learning mainly comes from its obvious linkages within GPNs that support it to learn codified knowledge, however the local institutions in it lack of systemic supports for technological upgrading.

3, The Hsinchu Science Industrial Park and its semiconductor industry

The successful story of HSIP and its learning capability has been documented by many studies (Saxenian and Hsu, 1999; Hu, et al., 2007; Mathews and Cho, 2000). The major findings of the above studies includes: the closer relationship between Silicon Valley and HSIP which facilitates the global-local linkages and knowledge diffusion; the closer network relationship between R&D institutes and local firms, including the Industrial Technology Research Institute (ITRI, founded in 1974) and adjacent universities, such as Tsinghua and Jiaotong, that provide valuable contribution to technological learning; the closer networking relationship among firms, especially the upstream and downstream firms in the production chains in PC-related and semiconductor industries in the areas; and most of all, the informal network relationships exist in HSIP that help to disseminate information and knowledge (including university alumni, peer in MNCs in the US, and friends in ITRI before working in HSIP). All these elements contribute HSIP as a learning region, despite the fact that many of the IT firms' manufacturing facilities already moved to China. Not to repeat the above research findings, this paper will use semiconductor in general and the IC design sector in particular to illustrate how HSIP sustain its development and innovation.

The significance of semiconductor industry in HSIP can be shown in the following figures. Although many of Taiwanese IT hardware firms already moved their production facilities to China (the last production line of notebook PC move to China in 2005), the related semiconductor industry in HSIP is still continued to grow over the years. The importance of semiconductor industry in HSIP can be shown in Table 1 in which the sale ratio of Integrated Circuits (IC or semiconductor) has been in increasing from 50% in 1997 to 71.6% in 2007. Whereas the computer and peripherals has been in decreasing from 35% to merely 8.3% in the same period. Clearly, the semiconductor industry has not followed the outward migration route of the computer and peripheral industries and has become a predominant sector in HSIP.

Table 1. Sales ratio of HSIP by industry, 2007 (source: MIC, 2008)

Year	Total	Integrated Circuits	Computers & Peripherals	Tele-Communi -cations	Opto-electronics	Precision Machinery	Bio-technology
1997	100.0	50.0	35.3	6.8	7.0	0.9	0.1
1998	100.0	50.7	35.1	5.8	6.5	1.6	0.1
1999	100.0	55.5	30.8	5.0	7.9	0.7	0.1
2000	100.0	61.9	22.3	5.4	9.5	0.8	0.1
2001	100.0	56.8	22.6	8.0	11.6	0.8	0.2
2002	100.0	62.5	15.4	7.1	13.9	0.9	0.2
2003	100.0	61.7	13.3	5.6	18.2	0.9	0.2
2004	100.0	61.5	10.4	4.6	22.3	1.0	0.3

2005	100.0	54.9	7.4	3.5	32.8	1.1	0.3
2006	100.0	53.6	5.9	2.7	36.0	1.6	0.3
2007	100.0	71.6	8.3	3.3	15.6	1.0	0.2

3.1, The emergence of semiconductor cluster

The emergence of the semiconductor industry in Taiwan was almost a state creation, which has been described in detail by Mathews and Cho (2000), Amsden and Chu (2003), Breznitz, (2005) in English and by Chen (2003) and many others in Chinese. In a nutshell, beginning in the late 1970s, the state decided to establish the semiconductor industry as a tool to deepen its industrialization and to upgrade its technological level. Rather than to depend on MNCs for transferring technology, the state established experimental factories through technology acquisition from abroad (mainly RCA), and then later spun off to the private sector (late became UMC). During the process, the ITRI was the main actor and later became a facilitator in accessing new technology and then transferred to local firms. The Taiwanese semiconductor firms therefore has been products of the state whose technologies were originally transferred from MNCs, ITRI and in due course were gradually assimilated accumulated into their own through in-house R&D.

The most significant contribution of Taiwan’s semiconductor industry in the world was the establishment of Taiwan Semiconductor Manufacturing Company (TSMC), which was the first pure play foundry in the world. Foundry companies in the semiconductor industry do not design chips, but only manufacture the chips designed by other companies. Before the emergence of TSMC, the standardized feature of the semiconductor companies was to keep all activities, including IC design, fabrication, and test and assembly, in-house. This is also referred to as the IDM (Integrated Device Manufacture) model, notable examples such as Intel, Motorola and Texas Instruments [1]. The launching of the foundry sector created a great transformation in the semiconductor industry, through which the design houses were able to concentrate their activities on innovative design and leave the fabrication aspects to foundries.

The establishment of TSMC thus became a catalyst in Taiwan's semiconductor industry that enabled many domestic fabless IC design houses to emerge and take advantage of existing fabrication facilities. The emergence of a vast number of small IC design houses led Taiwan to become one of the major IC design countries in the world that eventually caused Taiwan's semiconductor industry to concentrate on the area of application-specific integrated circuits (ASIC) that could be used in various areas of the PC system. This in turn largely enhanced the competitiveness of Taiwan's PC industry. The success of TSMC triggered on the one hand the transformation of the first state-created and later spun-off to private own IDM firm, UMC, into another pure play foundry to take the advantage of the increasing demand of IC manufacturing. Currently, Taiwanese firms have taken over 70% of the world market share in the activity (Table 2). On the other hand, the concentration of pure play foundry also generated effect on the increasing of IC design houses in Taiwan. Now

[1] The 1980s saw the emergence of hundreds of fabless semiconductor firms, which designed and marketed semiconductor components and relied on contract IDM manufacturing for their designs. In addition, due to the rising cost of manufacturing facilities, IDMs were also seeking approaches that could control costs and risks. This resulted in the first pure-play foundry TSMC emerging in Taiwan in 1987 that specialized in semiconductor manufacturing (Brown & Linden, 2005).

Taiwan has 261 IC design firms whose sale value reaches over U.S. $10 billion and has about 23% of world market share, secondary only to the U.S. (MIC, 2007). These IC design firms are clustered in HSIP and nearby areas. The related semiconductor firms, from IC design to foundry and Mask are densely located in the area that takes less than 30 minutes by car or by motorbike.

Table 2. *World top four foundries in 2006*

Firm	Countries of origin	Revenue （billion）	Market share
TSMC	Taiwan	10.1	50%
UMC	Taiwan	3.8	19%
Charter	Singapore	1.6	8%
SMIC	China	1.5	7%

Source: MIC 2007.

3.2 local networking in HSIP

The booming of Taiwan's IC design houses in HSIP in a large degree has to do with the prosperity of two related industries: the first is the strong production capability of Taiwanese computer industry (Dedrick & Kraemer, 1998; Wang, 2007); and the second is the nearby pure play foundries. Taiwanese PC firms have played dominant role in the GPNs since the late 1990s. Although these firms do not have their own labels, they are able to play the turnkey suppliers role in the world market, due to their technological and organizational capabilities (Sturgeon and Lester, 2005; Ernst, 2004; Wang and Lee, 2007). Currently, Taiwanese PC firms produce over 90% of notebook PCs for the world market (MIC, 2007).

Since every computer needs enormous amount of IC to be integrated into its modularized components, such as motherboard, chip-sets, and many add-on cards, the

PC industry therefore generates massive demand on chip design in particular and semiconductor industry in general. Moreover, since the Taiwanese PC firms' adopted an original equipment manufacturing (OEM) and original design manufacturing (ODM) business model, whose competiveness lies on low cost, speed and flexibility, as to serve the branding buyers' time-to-market demands. Logically, these PC firms in turn transmitted the severe pressures upon the IC designer for good quality and low price products in a timely basis. In order to achieve massive and timely basis demand from buyers, the PC manufacturers have to work closely with IC designers in its initial stage of a new model when necessary in order to avoid mistakes and save time. Although all the major PC manufactures have moved their production bases to China (Wang and Lee, 2007), the headquarters are still located in Taiwan (mainly in HSIP or nearby area) whose design teams are working closely with Taiwanese IC designers that provide most of the chips to the formers' end products. The PC manufacturing firms thus have built a strong networking relationship that sustain the competitiveness of Taiwan's IT industry in the GPNs.

In addition to the PC firms, IC design firms in HSIP are also closely connected with nearby foundries. It is imperative for the IC designers to collaborate closely with engineers of the foundry in each stage of the chip design to avoid the possible low yield rate. Moreover, since the TSMC is the leading foundry in the semiconductor industry whose process technology is in the leading edge of the industry. Therefore, the spatial proximity of IC design houses and foundry not only largely reduces the transportation and transaction cost, but also benefits the IC design firms in learning new knowledge and technology. Although the utilization of the IT information and telecommunication technology has largely reduced the necessity of geographic proximity in connecting IC design and manufacturing, the demand for cheap and good quality chips from PC firms on Taiwanese IC design houses still constitute a very real concern. It is due to the technological and cost reasons that IC chip designers in HSIP have deeply networked with the nearby foundries such as TSMC and UMC. According to a survey (Deng, 2005), Taiwanese IC design firms use as high as 85% of local foundry service for their own products. This shows that spatial proximity matters for the IC design industry and this in turn creates a cluster effect.

3.3 Collective learning

The semiconductor cluster in HSIP has created an environment that facilitates collective learning and continuing upgrading. This in turn sustains HSIP's competitiveness in the semiconductor industry. There are at least three mechanisms that are favorable for HSIP to constitute an innovative environment.

First of all, the state continues to play an important role in facilitating learning. The role of ITRI in learning and transmitting knowledge to local firms has been well documented (Wade, 1990; Mathews and Cho, 2000; Mathews, 2002; Amsden and Chu, 2003). Currently, ITRI has transformed from knowledge transmitter to platform builder that assisted smaller firms to learn and develop new products. For example, in the 1990s, ITRI developed IC design software and standards as well as set up 'Common Design Center' to assist the IC design industry to diffuse the knowledge and to develop sophisticated IC components (Chang and Tsai, 2002:109). The ITRI also set up a SoC development Center, collaborating with MIT and UCLA, in developing frontier technology for IC design. It also facilitates the formation of R&D

consortium in developing new 3D IC and memory chips for next generations. The members of these consortiums share the knowledge and new technologies being developed, which largely help the IC design firms to upgrade their technology capability.

Secondly, the networking and collaborations among the PC firms, IC design houses, and foundries, and most of all the dense linkages between HSIP and Silicon Valley (Saxenian and Hsu, 2001) are also mechanisms that facilitate collective learning. The IC designers are constantly engaged with PC system producers for design a new PC product even at the initial stage of the ODM. The IC designers also constantly consult with engineers from foundries due to the necessity of following the design rules of foundries' process technology. The engineers in HSIP are flying back and forth between HSIP and Silicon Valley for business and technological exchanges. All these are beneficial for HSIP's collective learning as a whole and link the local to the innovation center in the world.

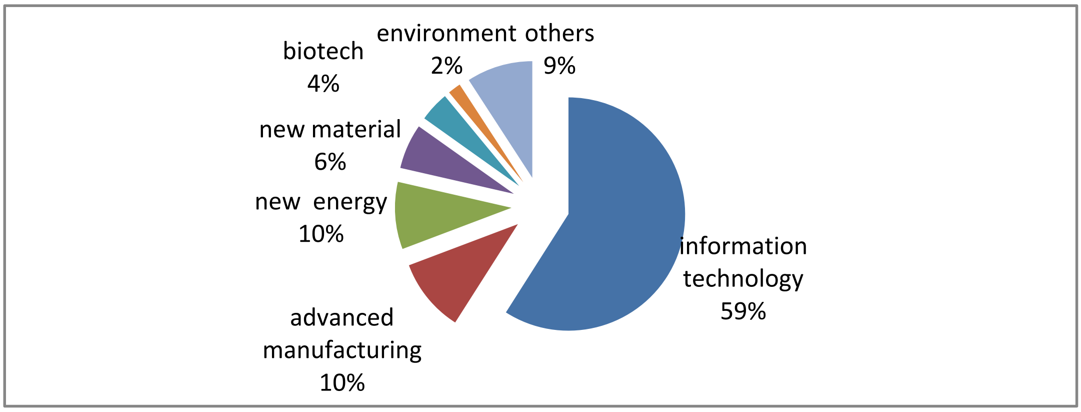
Thirdly, the adjacent elite universities, Tsinghua and ChiaoTong, also play the role of knowledge mediators that facilitate collective learning. As documented by Chen (2003) and Hsu (2000), because many of the founders of PC and IC design firms were graduates from the above universities, they constantly engage in formal and informal activities that disseminated market information and technological knowledge. Moreover, these universities not only supply necessary technological manpower for the firms, but also serve as the bridge that disseminating knowledge as well as forming alliance for co-developing new technologies. It is a normal tactics adopted by local firms to hire professors as consultants from these universities to assist their product development. Most of the time, informal networks among universities' graduates play an important role in formulating more formal networking and technological collaborations.

In sum, the above networking among firms, R&D institute and universities, together construct HSIP as a learning regional region of the semiconductor industry as a whole which is also beneficial for IC design sector in particular in upgrading its technological level. In the HSIP case, geographical proximity is still matter!

4, Zhongguancun's innovation pattern and weaknesses

Beijng's Zhongguancun (ZGC) has been regarded as the most innovative region in China. There are 68 universities (including China's most prestigious universities, Peking and Tsinghua), and 213 state-sponsored R&D institutes (including the Chinese Academic of Science, CAS) and over 300 thousand students in Beijing. Moreover, Beijing hosts over 36% of the honorary fellows of the CAS and Chinese Academic of Engineering. All these indicate that Beijing has more affluent S&T personnel as compared to other cities in China.

During the early stage of economic reform, some scholars had utilized their scientific research results to build their own enterprises and created many famous *mingying* (none-governmental owned) high-tech enterprises such as Legend (spun-off from the CAS) and Stone. In 1988 the central government decided to develop this area as the 'Silicon Valley of China". Over the years, the development of the ZGC has created an agglomeration effect for the high-tech, especially the IT industry. It gathered over 13000 firms in the area in 2006 (mainly in the Haidian area), including Legend (later renamed as Lenovo), Stone, Fangzheng, and MNCs such as Lucent, HP, Ericsson, Hitachi, Siemens, etc (2008, Annual report of ZGC). But different from other regions in the south, especially Shanghai and Shenzhen, where the IT hardware is the dominant sector, the ZGC has concentrated more on the industries of IT software development and production than on those of the hardware assembly. Many MNCs also established their R&D centers in this area. Until 2006, 95 among the top 500 largest firms in the world have set up branches in this area, among them, 65 were R&D centers (ZGC report, 2008). Together with the high concentration of R&D personnel and institutes in Beijing area, ZGC has become the most important center for technology learning and innovation in China. Even the biggest domestic firm, such as Leveno, has established it R&D center in this area and moved it hardware production and assembly into Suzhou and Shenzhen areas. Currently, many of China's most notable ICT companies can be found in this area. Besides Lenovo, they include Baidu (百度), China's leading Internet search engine company; UFIDA (用友), China's largest privately owned software company; Datang (大唐), one of China's largest telecommunication solution companies; Aigo (愛國者), China's leading portable storage and digital entertainment product maker, etc. The importance of IT industry in ZGC can be shown in fig. 1.



4.1 GPNs and IC design sector

As discussed above, the global transformation of the semiconductor industry has led to the emergence of global innovation networks in which the IC design can be disintegrated and reintegrated in a global scale. Now all parts of the IC design, including the whole procedure from specification to finished chips, can be outsourced to mainly either China and India where salaries of engineers are only 10% to 20% that of Silicon Valley (Ernst, 2005a). This saves large amount of cost for the firms. Thus, the IC design industry now can be organized in a 24 hours' based working team around the globe (Brown and Linden, 2005:16).

It is under this global transformation of IC design sector that ZGC has been integrated into the GPNs of the semiconductor industry. Therefore, many IC design firms have set up their R&D centers in ZGC to take the advantage of low cost and of the local state's favorable tax reduction. According to our interviews, most of the IC design works that the local engineers do are procedural and tedious parts rather than the architectural framework. The frameworks are decided in the center from abroad. What the local engineers do are the less sophisticated parts which need patient and longer working hours to finish. Since the MNCs pay good salary[2], therefore they can recruit the most talented engineers at the expense of local IC design firms. In general, the R&D centers of MNCs in ZGC rarely have local connection with local firms. The only connection that these R&D centers have established in the area is the elite universities where they have donated labs so as to find talented students for future recruitment.

On the other side, the local Chinese IC design firms are still very small and at their earlier stage that are still far lag behind the Taiwanese firms in terms of technological level (table4). They do not have the similar milieu that the Taiwanese counterparts have enjoyed in terms of networking with PC manufacturing firms and foundries. The biggest IC design firm, CEC Huada, is a state-owned firms whose major products are smart chips that do not contain very sophisticated technology. According to our interviews, the major difficulties that the IC design firms face are (1) lacking routine customers, because most of the PC system firms (mainly Taiwanese) will not use their chips, they can only design chips that are used by state sectors; (2) lacking of incentives to attract talented people such as stock option, therefore they are not able to compete with MNCs; (3) lacking of networked foundries nearby, they therefore have to send their chips to be manufactured in Shanghai which is not complimentary for chip designers to upgrade their knowledge level. All these factors stated above are not favorable for IC design firms in ZGC to survive in the market.

[2] The salary for the engineers work for MNCs is average RMB 7000 per month, higher than that of local firms, average from RMB 3000 to 4000 (interview data, 2008).

The only common resources which the IC design firms in ZGC has enjoyed and shared with the Taiwanese counterparts are the overseas returnees. Indeed, ZGC has attracted large amount of overseas returnees to start their own adventures which has increased rapidly over the years (ZGC annual report, 2008). The IC design firms which are setup by overseas returnees and are well connected with the GPNs are belonged to this type. For example, the rising star Vimicro (中星微) is founded by a returnee, whose specialties are on wireless communication chips and handheld equipments' panel drivers. The products of Vimicro now are used widely in PCs and handsets. This type of design firms is the national hero that is highly supported by the Chinese state for its 'independent innovation' (z-zhu-chuang-xin) effort. Therefore the Chinese state supports this emerging firm to link closely with local handheld and service providers as to largely expand their market share. In this sense, this type of firm can establish networks with the local firms and enjoy the fruit of the booming economy. Nevertheless, whether this type of firm can sustain its innovation momentum depends to large degree on the institutional milieu. On this, the current environment of ZGC is still far from satisfactory that can sustain an innovation cluster.

4.2 The IT software industry

In contrast to the IT hardware industry, the IT software industry currently is the most innovative sector in ZGC. As in the IC design sector, this sector can also be divided into 3 types: MNCs, state-owned and private-owned, in which the private-owned is the most innovative type.

MNCs' strategy in software industry in ZGC has mainly focused on office application and middleware software. Due to the widespread and extensive piracy rate in China's software market, the MNCs have almost lost their competitiveness in the consumer software market field. Therefore, in this sector of the software industry, MNCs are the major system and application suppliers, including office application, enterprise management software such as enterprise resource planning (ERP), data base, etc. It is also in this sector that MNCs have interest to collaborate with Chinese firms in the expectation of high market growth.

Different from IT hardware, whose production procedures can be universalized, the IT software has to consider and adjust to the language, needs and customs of local users. That is, the utilization of office and middleware software has to be indigenized. To fulfill this demand, the MNCs can only depends on local people and local firms to expand the market share. Therefore, all the major software MNCs, such as Oracle, Sun, Cisco, collaborate with local firms to sell their products. It is also through this collaboration, the MNCs have trained local engineer related knowledge and through which knowledge diffusion has occurred. Zhou and Tong (2003) observe that there are various types of relationship between MNCs and local firms. The first is that some local firms become agents for MNCs in delivering technology to customers and organizations. The local firms' works are to distribute and install software products as well as to deliver continual services to the users. Secondly, in some cases, the local firms may develop their own products but target at lower end market in order to avoid directly confronting the interests of the MNCs. The lower end market is neither the place where MNCs have the interest to step in nor have the capability to enter. Thirdly, there are also cases that MNCs outsource software development to local firms. This may involve translation or develop new applications for MNCs. In the end, MNCs have to train qualified local engineers to certify good service. In sum, as Zhou and Tong (2003) argue, 'overall, the relationships between Chinese local firms and MNCs have largely been mutually beneficial thus far. MNCs use Chinese local firms to open their markets and to deal with the more tedious and costly application work in the form of system integration or network solution (2003:143) '.

Our interviews in ZGC confirm what Zhou and Tong (2003) observed. The high end office software market is dominated by MNCs. The lower end however is dominated by local firms whose technological capability has largely learned from MNCs. For instance, the most innovative local ERP firm UFIDA (用友) learned extensively from Oracle in its early stage and then began to develop its own office software that targeted at enterprises of smaller cities or smaller enterprises in big cities. Since UFIDA was able to enter the market where MNCs was not able to enter, it then began to take off and recently has become the biggest ERP software firm in China. In the process, UFIDA has collaborated with university professors to develop and improve new products and begun in recent year to enter into the higher end market that intend to confront with MNCs head by head in big cities.

4.3 Institutional weakness in supporting networking

The transformation of ZGC has largely reflected the historical transition of China' innovation system since the early reform ear. In general, the tendencies of the reform were changing from centrally planned to local and market-oriented; from stressing SOEs' role in innovation to emphasizing the importance of non-state high-technology enterprises; from mutual isolation of R&D and industrial production to the increase of the integration of them (Segal, 2003; Liu and White, 2001; Gu and Lundvall, 2006). The transformation of high-tech and R&D policies have been in an unsmooth and evolutionary fashion, because it has changed from the pre-reform institutions that were based on centrally controlled and funded system to one that were more opened to market orientation, foreign investment, and individualist incentive. Nevertheless, as Liu and White (2001:1103) stressed, the Chinese' tapping of foreign sources have focused more on embodied and codified technology rather than intangible assets. The Chinese firms have neglected other exchanges and interactions — such as collaborative development and problem-solving — which would otherwise provide greater opportunity for the transfer of tacit knowledge.

The above description on the transformation of China's innovation system has imprinted in ZGC's development. ZGC indeed has agglomerated large amount of enterprises and R&D institutes in it since the late 1980s, which was naturally favorable for learning activities to take place. Nevertheless, as compare to Silicon Valley and HSIP, GZC lacks a friendly institutional environment that is favorable for networking and deep technological learning to occur. This relates to the following institutional arrangements that generate the fragmentation of R&D system and de-linkage of R&D institutes and firms.

First of all, the Chinese national innovation system induces competition than collaboration between R&D institutes and industrial firms. The competition between R&D institutes and firms is because most of the R&D funding until recently has been mainly supplied by state agencies, this turns out to the situation in which they are competing the same funding. Although there is a tendency for the state to encourage in-house R&D at the firm level, the major funding of R&D still mainly comes from the government's budget. In this case, state-sponsored R&D institutes, universities and firms are applying for funding that are overlapped, which in consequence resulted in the competitive rather than collaborative relationship between R&D institutes and firms.

Moreover, secondly, the R&D institutes tend to do researches that are not directly related to the needs of the industry. The state-sponsored R&D institutes are targeting frontier technologies or basic researches, however what the local firms need are not the frontier technologies but the middle level technologies which can support them to catch up rapidly. As a consequence, as our interviews show, managers of local firms indicate that the local R&D institutes can only provide them information and consulting functions rather than R&D collaboration. What the local universities function to them is mainly providing them future engineers than product development.

Thirdly, as compared to HSIP, ZGC is a low trust cluster; enterprises show little interests in building local networks. The interest of MNCs in setting up R&D centers in this area is to recruit most talented people without the interest to networking with local firms. The universities and research institutes are interested in applying state's science budget with little interest in building local industrial networks and transferring knowledge to local firms, as shown above. Moreover, the local firms are more interested in seeking opportunity to expand their market share in this booming economy rather than to cooperate with other firms to deepen their technological capability. As Zhou (2005: 1127) shows in her field research, 'When we asked the manager of a Chinese hardware company about the company's partnership with other

Chinese firms, the immediate response was blunt: ZGC firms do not cooperate with one another.' Our field research in ZGC shows similar result. Zhou (2005:1128) attributes this lacking of networking among local firms to the institutional root of *Danwei* (單位) mentality, or so-called `big and complete' or `small and complete' systems. We suggest instead that it is also due to the legacy of socialist system that generate distrust among people on the one hand, and the high competition among firms due to their similar level of technologies which engenders horizontal competition than collaboration on the other.

Finally, there is also downside of the rapid development of ZGC. Similar to other rapidly developing regions in China, the leaders of the local state in ZGC put economic growth in the area as their major political mission so as to bet for their future promotion. In the urban area such as the Haidian district in Beijing where ZGC is located, the real estate sector naturally becomes the major target for promoting economic development. The urban restructuring of the area and the emergence of blocks of high-rise signify the booming of the economy, which in turn become the basis for local leaders to persuade MNCs to locate R&D centers in the area. The strategy has been indeed very successful. However, the downside of this rapid development of real estate sector in recent years is that it has pushed up the prices of rent to a level that was not favorable for the start-ups or smaller firms to survive in this area[3]. Many smaller star-ups already moved out of this expensive area and sought cheaper places at the outskirt of the city to survive. The local state's GDP-ism has

[3] The rent reached as high as RMB 7 dollars a day per square meter in ZGC. The outskirt areas of Beijing city is about RMB 4 dollars.

greatly improved the image of this area which however is a strategy that pursues for short term growth at the expense of long term innovation investment (see also Wang, 2007).

5, Conclusion

This paper uses the perspective of industrial cluster to investigate technological development in HSIP in Taiwan and ZGC in China respectively. It is found that HSIP's development in the semiconductor industry in general and IC design in particular has been closely linked to the prosperity of PC industry in the world market, as well as to the state's support and strong institutional networking. These factors synchronize together to push IC industry and the cluster to upgrade continuously in GPNs; whereas ZGC's picture in technological learning is not so clear as compared to HSIP, which mainly comes from its obvious de-linkages among actors in local settings that inherited from its socialist institutional arrangements and hampered technological learning and upgrading.

However, firms in ZGC have the strength which firms in HSIP do not have. That is, firms in ZGC can directly access the enormous Chinese domestic market that support them to grow through strategies such as entering the low end and second tier markets. These firms are able to accumulate knowledge in the process and in the end can compete directly with MNCs in major markets. Indeed, as Zhou (2008) shows, many ZGC firms currently synchronize technologies of foreign firms (mainly Taiwanese) with accessibility of market channels to become major players in domestic market. The emergence of domestic market provides Chinese firms a possibility to access technologies from foreign firms and to accumulate technologies

(Harwit, 2007; Thun, 2004). The ‘exchange market access for technologies’ (以市場換技術) policy may have become a possibility that Chinese firms can learn technology from MNCs, especially for the domestic oriented sector. Nevertheless, even this situation occurs, the competitiveness of a cluster still lies in its domestic firms’ learning and innovation capability that depends in a large degree on local institutional arrangement, to which ZGC has to face in its transition toward ‘z-zhu-chuang-xin’.

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