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## *Role of Science Park in the Formation of High Technology Industrial Cluster – Case of Southern Taiwan Science Park*

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*Entrepreneurship as a key value in knowledge economies - role of STPs*

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# Role of Science Park in the Formation of High Technology Industrial Cluster – Case of Southern Taiwan Science Park


## Executive Summary

Southern Taiwan Science Park (STSP) is the second science park in Taiwan, formally established in 1996. It is now the home of more than one hundred high technology firms which altogether provide 54,000 job opportunities by the end of 2007, with a total revenue of USD 17.5 billions. Originally targeted as an expansion site for IC industry in Hsinchu Science Park, STSP has emerged since the turn of the millennium as a major opto-electronic industrial cluster in Taiwan, within this, TFT-LCD industry cluster alone accounted for 70% of STSP's revenue and 63% of total employees. IC cluster comes as the second largest industry, biotechnology being the third. All these three industries had not been significant in Tainan area prior to the establishment of STSP, this implies that STSP may have played important role in the formation of these new industries in the region. This article briefly describes the development of STSP major industries, and services provided within the park; then, based on survey of STSP tenants, STSP administration (STSPA) and local HEI and research institutes, provide an explanation of the role and mechanism behind the formation of this regional high tech economy. Our study shows that STSPA, local entrepreneurship, major research universities and incubation services have all participated in the process, and STSPA has been instrumental in pulling all these forces together to produce the synergy effect.


**Keywords:** Science Park, industrial cluster, Southern Taiwan Science Park, TFT-LCD industry.

## 1. Introduction

Southern Taiwan Science Park (STSP) is consisted of two sites - Tainan Science Park (TSP)and Kaohsiung Science Park(KSP), and under one management body - Southern Taiwan Science Park Administration (STSPA). Since it is the second science park in Taiwan, the planning and development of STSP was highly influenced by its predecessor - Hsinchu Science Park (HSP, initially called Hsinchu Science-Based Industrial Park, HSIP). HSP was established in 1980 as Taiwan's first "experiment" to upgrade its economy from primarily labor-intensive one to knowledge-intensive, the so-called "high-technology", industries. After several years of struggle, the personal computer and peripheral (PC) industry and integrated circuits (IC) industry started burgeoning in mid-1980s, yet soon in 1989, at the height of a new waves of investment interest, HSP found it difficult to procure suitable land from nearby areas for further expansion. Tainan was chosen, through fierce competition among regions and complex political processes (Tseng, 1998; Kuo, 2001), as the site for new expansion, and to some extent, a spill-over park.

The designated site was a flat and low land of 638 hectares (2,565 acres), used to be Taiwan Sugar Corporation's immense sugarcane field, located across the border of three rural townships- Hsinshih, Shanhua, Anding- which altogether housed around 100,000 residents in mid-1990s. Just at a walking distance, there is a renowned international research institution – Asian Vegetable Research and Development Center. However, the nearest major city Tainan is 12 kilometers southwest from the site, and National Cheng Kung University (NCKU), the key higher education institution in Southern Taiwan. In terms of existing industry, there are two major industrial parks located at about 10 to 18 kilometers away, the nearer one hosts Taiwan's largest food and beverage enterprise – Uni-President Enterprise Corporation (UPEC), and the other was developed by and headquartered southern Taiwan's key petrochemical giant – Chimei Petrochemicals. Because of its relative isolation from major industrial districts, urban services and research sources at the time, based on HSIP and foreign experience of distance between science parks and their mother cities, there had been doubts concerning TSIP's opportunity to success. However, just two months after the beginning of construction works in January 1996, the first phase 240 hectares land was almost all leased out, mainly by investors from HSIP, all those worries were soon replaced by the issues of finding more land for further expansion. In September 1997 National Science Council announced Lujhu, Kaohsiung County as the first priority expansion site; and local politicians were also fighting for direct expansion into neighboring farmland. Later on, lead to the expansion of TSIP and Tree-valley Park.

In the beginning, the construction management and investment promotion of TSIP was charged by Science-Based Industrial Park Administration (SIPA) which is located at Hsinchu, more than 200 kilometers away from TSIP site. In July 1997, a relative independent TSIP Development Office was set up, but still under SIPA, and the first three directors had been

concurrently held by either the deputy director-general or the director-general of SIPA. It was not until in January 2000 when Dr. Chian Dai, a biotechnology professor of NCKU, became Director of the Office, TSIP began to be operated more independently from HSIP. In fact, the Development Office took over the responsibility of investment application in May 1999 may be regarded as an even earlier signal of independent operation and a more meaningful step in hatching new industries in local context. Arguably, it is from the beginning of the new Millennium that the management and service have better chance to be rooted in local networks.

Global economic conditions have also played important roles. The East Asian financial crisis in 1997 did not hit Taiwan as heavily as most of her neighbors, but the semiconductor industrial downturn between 1996 and 1998 did have significant impact on TSIP. In late 1996, almost all investment proposals from HSIP firms deferred their construction dates due to the serious recession of IC industry; coupled with the concurrent found uncertain risks of high-speed rail vibration damages, some IC firms even cancelled their investment during the period. Nevertheless, a new investment wave from other industries emerged at the same time, though at a slower pace and smaller scale, some of these investments have been proved to be very important later; especially worth noting are those associated with local enterprises, for example, Chimei Petrochemicals invested a new business called Chimei Optoelectronics (CMO), local transportation equipment maker Ta Yih also selected optoelectronics industry and established Kenmos Technology; the food and beverage giant UPEC invested in biotechnology and established ScinoPharm. It seems that these local investments have been less influenced by the global economic conditions. CMO is especially important in this study, it is established in 1998 on a southwest corner 19 hectares site in TSIP, total employees exceeds 17,000 in Taiwan and 32,000 globally in February 2008, it is now the second largest TFT-LCD producer in Taiwan, and the leading firm of STSP TFT-LCD industrial cluster, total revenue in 2007 is approximately USD 10 billions.

In the beginning of 1999, global semiconductor market recovered and the remaining IC investors restarted and accelerated construction works, TSIP regained its growth momentum. By the end of March 1999, only 70 hectares of planned industrial area is left. In April, Regional Planning Committee of the Ministry of the Interior agreed to add another 400 ha (988 acres) adjacent land for the Phase II development of TSIP. In December, Ministry of the Interior approved the “Plan of the TSIP Special Zone” that would incorporate the Phase I, II of TSIP and their surrounding area as a science city of 3,299 ha (8,152 acres). In June 2001, Ministry of the Interior approved the planning of Lujhu (570 hectares or 1,409 acres)as the expansion site for TSIP. In January 2003, the Southern Taiwan Science Park Administration (STSPA) was officially formed to provide service and manage Tainan Science Park (TSP) and Lujhu Science Park (LSP). Lujhu site was renamed as Kaohsiung Science Park (KSP) in 2004.

## 2. Development of Major Industries in STSP

The original industrial target for TSIP was to develop three industries: microelectronics and precision machinery, semiconductor, and agricultural biotechnology industries; and they were expected to be geographically co-located in three specialized zones (National Science Council, 1996). For each target industrial cluster, a list of featured sub-industries was prepared, as shown in Table 1, at a further detailed level, several promising products or technologies within each of these industries were also pointed. Thus, "industrial cluster" was the underlining concept of TSIP industrial development planning. This is different from HSIP where no explicit expression concerning "industrial cluster" can be found in its early planning document.

**Table 1 Industrial Clusters Featured in TSIP 1996 Plan**

| Target industrial cluster | Target sub-industry |
|---|---|
| Microelectronics and precision machinery zone | wireless communication<br>precision machinery<br>medical instrument and materials<br>semiconductor equipment<br>computers and peripherals<br>micro-electro-mechanical systems (MEMS) industries |
| Semiconductor zone | microwave communication semiconductor<br>power electronics<br>special-purpose integrated circuit industries |
| Agricultural biotechnology zone | flowers and ornamental plants<br>biopesticide<br>livestock vaccine<br>aquaculture industries |

**Source:** National Science Council, 1996

The target production value and job opportunities of each industry for year 2005 and 2010 were also set in TSIP plans, as shown in Table 2. Altogether, total employment of TSIP was targeted at around 20,000 in 2005 and nearly 38,000 in 2010, and production value was targeted at USD 16 billion and USD 33 billion respectively. Obviously, semiconductor was expected to be the largest sector among them, and contributing more than 75% of employment and production value.

**Table 2 Industrial Development Target of Tainan Science-Based Industrial Park**

| Target year & value / Target industry | Production value (USD million) | | Number of employees (person) | |
|---|---|---|---|---|
| | 2005 | 2010 | 2005 | 2010 |
| Microelectronics and precision machinery | 2,600 | 4,600 | 5,000 | 7,000 |
| Semiconductor | 13,000 | 27,700 | 15,000 | 30,000 |
| Agricultural biotechnology | 370 | 685 | 380-860 | |
| Total | 15,970 | 32,985 | ca. 20,000 | ca. 37,000 |

**Source:** adapted from National Science Council, 1996: 35, 47, 53.

Kung (1999) studied the industrial structure of Tainan area before the establishment of TSIP, and found that local industrial structure was quite different from the target described above. Based on Industry, Commerce and Service Census statistics 1986 and 1996, Table 3 shows the major manufacturing industries in Tainan before TSIP. It is clear that manufacturing was more important than commerce of service sector in terms of job provision before1996, but the relative importance of manufacturing was declining. Within manufacturing sector, none of the largest three industries in 1986 and 1996 can be regarded as having strong linkages with TSIP target industries. Although two of the major targeted industries - semiconductor, and microelectronics and precision machinery are commonly regarded as within the 2-digit electrical and electronic industry which ranked number five in 1986 and ascended to number four in 1996, nevertheless, the number of employees in the sector had slightly decreased during the period. Transport equipments is related to the precision machinery industry, it ranked as seventh in all manufacturing industries in 1986 and fifth in 1996, total employee increased by two thousands within the ten year period. When location quotient (LQ) is used, LQ for electrical and electronic industry in 1986 is 0.54, although slightly increased to 0.59, Tainan area had been relatively insignificant in the sector in Taiwan before TSIP; LQ of transport equipment industry is 1.43 in 1986 and 1.61 in 1996. Thus, it seems that the natural trend of local industrial growth would not strongly support TSIP industrial target, special measures must be taken to reach the goal.

**Table 3 Major Manufacturing Industries in Tainan Area 1986, 1996**

| | 1986 | | | 1996 | | |
|---|---|---|---|---|---|---|
| Rank | Industry | Employees (person) | Percent-age (%)* | Industry | Employees (person) | Percent-age (%)* |
| 1 | Textile Mill Products | 40974 | 10.39 | Fabricated Metal Products | 28885 | 6.36 |
| 2 | Plastic Products Manufacturing | 28602 | 7.25 | Plastic Products Manufacturing | 24710 | 5.44 |
| 3 | Fabricated Metal Products | 23546 | 5.97 | Textile Mill Products | 23276 | 5.12 |
| 4 | Wearing Apparel and Accessories | 22416 | 5.69 | Electrical and Electronic Machinery | 17195 | 3.78 |
| 5 | Electrical and Electronic Machinery | 19034 | 4.83 | Transport Equipments | 16896 | 3.71 |
| | All Manufacturing | 275015 | 69.77 | All Manufacturing | 256410 | 56.42 |

**Note:** *all figures are the percentages of total employment of secondary and tertiary industries.

**Source:** Kung, 1996: 58, 64.

As most of the science parks do, the planners have tried to solve the problem from supplying food facilities and quality services. Except for the general industrial inputs like flat land, road network, water and electricity supply, landscaped environment; or the HSIP model bi-lingual school, nearby residential quarters and recreation facilities; there are other more detailed considerations. For example, in order to meet the specific needs of different target industries, planners subdivided industrial blocks in three specialized zones differently, for example, it is obvious that most land parcels in semiconductor zone are much larger than the other two zones, this difference is clearly based on the experience of HSIP IC foundries, and the current trend of increasing wafer size from 6 inches to eight and twelve inches, hence, they are almost tailor-made to attract new generation IC establishments. In terms of electricity supply, based on HSIP lessons from 921 earthquake loss in 1999, electricity supply system in STSP is planned as two supplementary circuit routes to secure the stability of electricity supply. At a higher level, to avoid the negative image of park and city divide that HSIP had caused in its early years, Park administration has tried to enhance park and local relationships in both physical and political aspects. For example, an uncommon rain shower had caused floods in downstream area in June 1998, the park plan was soon adjusted to build better irrigation system and constructed five big scale detention ponds, there has been no flood in downstream area since then, and the detention ponds are now major amenity points to park employees and local people. STSPA has frequently holding activities or together with local governments or

community organizations to enhance neighborhood friendship.

This year STSP will celebrate the beginning of its second decade of operation. According to STSPA statistics, by the end of 2007, it has 107 tenant companies in operation with a total of 54,115 employees, total revenue of these firms reached USD 17.5 billion. In all there measures, STSP has been growing at a much faster speed than its Hsinchu predecessor. Comparing with planning figures in Table 2, the number of employee has already exceeded the employment target of 2010, and the 2007 revenue is ten percent higher than the 2005 target value. But the most significant difference is the structure of industry. As shown in Table 4, the largest industrial sectors in 2001 is optoelectronics, in terms of number of tenant and number of employees; while integrated circuits (IC) firms contribute the highest revenue. In 2007, the precision machinery sector take the lead in number of tenant; but, in terms of employment and revenue figures, optoelectronics industry is clearly the most important sector in STSP, and the three original target industrial sectors – semiconductor, microelectronics and precision machinery, and biotechnology follow. Within the optoelectronic sector, most of the tenants are TFT-LCD related firms, these fast expanding TFT-LCD firms have not only helped in pushing optoelectronics as the leading sector in STSP but also changed its possible fate as a spill-over site or satellite park of HSIP. Indeed, while most of the semiconductor leading tenants are the branch establishments of HSIP IC foundries, the leader in TFT-LCD sector is locally born. Thus, our following examination will focus on this industry.

**Table 4 Key Industrial Development Index of Southern Taiwan Science Park (2001, 2007)**

| Industry | Number of tenant | | Number of employee | | Revenue (NT$100mil.) | |
|---|---|---|---|---|---|---|
| | 2001 | 2007 | 2001 | 2007 | 2001 | 2007 |
| Integrated Circuits | 5 | 11 | 3498 | 11955 | 287.4 | 1302.1 |
| Opto-electronics | 10 | 31 | 4518 | 35098 | 199.6 | 4026.7 |
| Biotechnology | 2 | 18 | 326 | 950 | 1.5 | 30.9 |
| Telecommunications | 5 | 8 | 565 | 819 | 5.5 | 15.4 |
| Precision Machines | 1 | 32 | 427 | 3122 | 7.8 | 186.5 |
| Computer & Peripherals | 0 | 3 | 0 | 263 | 0 | 8.8 |
| Others | 0 | 4 | 155 | 1858 | 0 | 18.3 |
| Total | 23 | 107 | 9489 | 54115 | 501.8 | 5588.7 |

**Source:** adopted from www.stsipa.gov.tw/web/

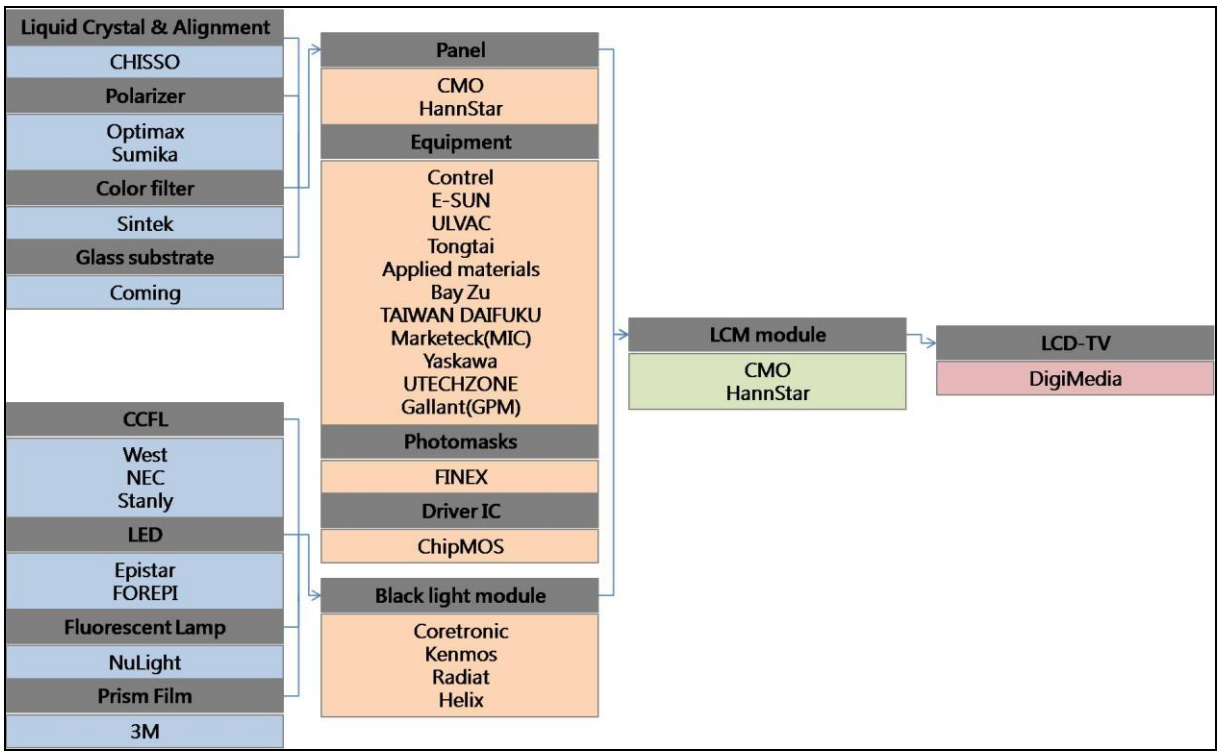
## 3. Role of STSP in the Formation of High Technology Industrial Cluster

To understand the development of the target industries, STSPA has been continuously tracing the growth of tenant by industry and relationships of firms, and constructing and

revising cluster diagrams from time to time, this information is a valuable service to both potential investors and serious investigators. The most recent upstream and downstream relationships of TFT-LCD industrial cluster from STSPA is shown in Figure 1. STSPA divides TFT-LCD firms into four tiers, according to the manufacturing process from materials and components to final product of LCD-TV, the upstream products and firms are placed on the left side of the diagram and the final product on the right. The rectangular brackets in the diagram describe the product and related tenant, in the upper part of each rectangular bracket denotes the material, component or product, and the lower part lists the respective tenants. The cluster includes some thirty firms, including 13 materials and component firms, 6 module firms, 11 equipment firms, 1 photo mask firm, 1 driver IC firm, 2 TFT-LCD panel firms. As most of the equipment firms are commonly classified into precision machinery industry, thus, the TFT-LCD industrial cluster in STSP is mainly composed of opto-electronics firms and precision machinery firms, supported by some key chemical material producers.

According to Chiou (2005) and Wei (2006), in terms of production process, STSP has the most complete TFT-LCD industrial cluster in Taiwan. As shown in Table 5, there are four TFT-LCD industrial districts in Taiwan, altogether made Taiwan a major global player in the industry. To understand the structural difference among these districts, Chiou (2005) grouped TFT-LCD firms according to manufacturing process and industrial district, Tainan Science Park is the only place in Taiwan that all the materials, components and system products for TFT-LCD can be locally found. If we further compare Table 5 with Figure 1, two additional components - LED and fluorescent lamp - are added between 2005 and 2007 period in Figure 1. It is well-known that LED as back light source for LCD panels in order to increase the brightness and reduce the thickness of panel is the state of art technology, a new trend in the industry. Thus , there new produces also reflect the capacity of TFT-LCD industrial cluster in STSP to react to the technological changes and keep in market fronts.

**Figure 1 TFT-LCD Industrial Cluster in STSP**




**Source:** STSPA

With almost one-third of the total companies and more than two-thirds of the employment and sales, the TFT-LCD related tenants occupied a significant portion of land in STSP. As shown in Map1, the whole site of the Park is roughly 5 kilometers long (north-south) and 2 kilometers wide, a north-south boulevard and a shorter east-west boulevard divide the Park into four quarters; parallel to the north-south axis, Taiwan High-Speed Rail cut through the eastern quarters. The original plan allocated that semiconductor industrial zone to be developed in the northwestern quarter, microelectronics and precision machinery zone to be in the northeast quarter, and biotechnology zone in the tip eastern to the High -Speed Rail. Except for these three industries, there are land parcels totaled 274 hectares in northern and southern quarters reserved for second phase industrial expansion but not specified for any category of industry. Today, most of the precision machinery firms and upper stream materials and component producers are locating east of the north-south boulevard along the High-Speed Rail; the two giant LCD panel producers – Chimei and HannStar occupied the northwest and southwest corner, both are the land outside of the original park boundaries. Here the role of the park administration is vital. Through the application and negotiation process, investors may be introduced to the specialized zone as originally planned, many of the precision machinery tenants followed this rule, so were the biotechnology and IC tenants. Yet, for the unpredicted land-consuming TFT-LCD industrial investment, it is the coordination of the park administration, central and local government that have made the provision of the needed land and

environment speedy possible.

**Table 5 Distribution of TFT-LCD Producers in Taiwan, by Number of Firm**

| Product \ Place | Tainan SP | Taichung SP | Hsinchu SP | Taoyuan County |
|---|---|---|---|---|
| Black light module | 5 | 1 | 1 | 3 |
| Color filter | 2 | 1 | 3 | 1 |
| Driver IC | 1 | 1 | 4 | 0 |
| ITO glass | 1 | 0 | 2 | 0 |
| Liquid crystal | 1 | 0 | 0 | 1 |
| Panel polish | 1 | 1 | 0 | 0 |
| Polarizer | 3 | 1 | 1 | 3 |
| CCFL | 5 | 1 | 0 | 1 |
| Glass substrate | 2 | 2 | 1 | 1 |
| Photo mask | 1 | 0 | 2 | 0 |
| Prism film | 1 | 0 | 0 | 0 |
| LCD panel | 2 | 2 | 4 | 4 |
| LCD TV, monitor | 3 | 3 | 2 | 0 |
| Process equipment | 12 | 0 | 9 | - |

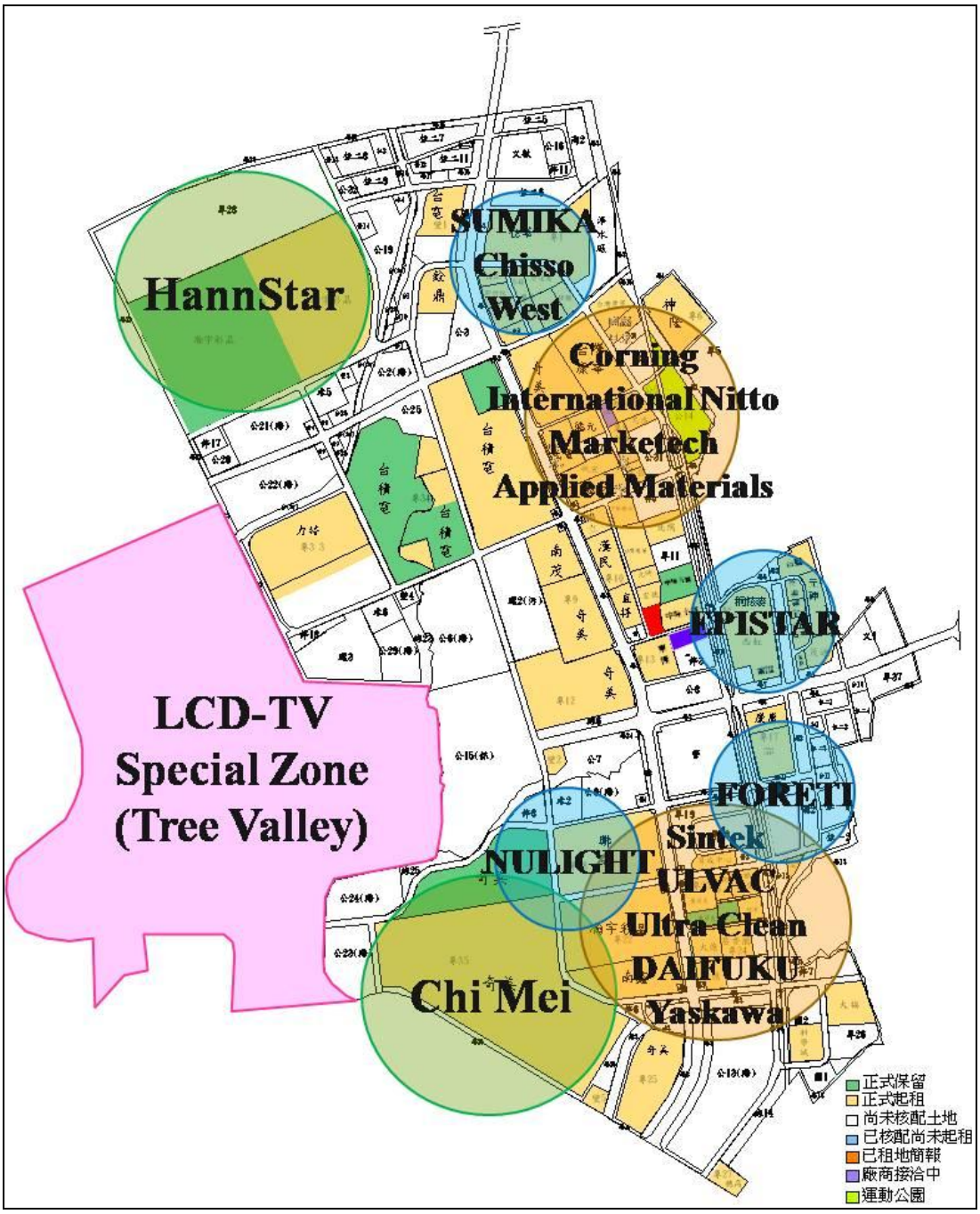
**Source:** adapted from Chiou (2005)

Nevertheless, there are conflicts in attracting high technology investment and the completeness of industrial cluster within the park, especially, in terms of environmental suitability and the integrity of keeping the proposed investment compatible with the target industrial goal. With the help of building close relationships with local governments and other industrial parks, STSPA has been quite often redirecting unsuitable investment to other industrial parks, especially the Tainan Technology Park; in this way, the related industries can still be established within short distance to enhance the strength of the target industrial cluster. An interesting case is the development of LCD-TV Special Zone (Tree Valley Park). When the market potential of LCD-TV had gradually gained attention, the then newly established LCD panel maker Chimei envisaged the necessity of building up a further downstream production site near its existing investment in STSP, because of the need to reduce the risk of transporting large size LCD panels. However, LCD-TV is considered as a new type of consumer electronic product and its R&D ratio would be low to be qualified as high technology product, STSPA has no reason to approve the application, in addition, the required land area would surely exceed the final land reserve of STSP. The entrepreneur and the central and local politicians eventually agreed to set up a special zone adjacent to STSP to accommodate LCD-TV related firms. While Tree Valley Park is not part of STSP, STSPA does agree with local government to support this neighbor park with the necessary planning and service expertise. It is expected that this 247-hectare zone will eventually provide 30,000 job opportunities, and the complete industrial

chain will increase the competitiveness of TFT-LCD industry in Tainan.

To further investigate the role of STSP in the formation of industrial clusters, the author and colleagues conducted structural interviews to TFT-LCD industrial cluster firms from September to November in 2007. Our major inquiries include: the importance of facilities provided by the park, inter-tenant buy and sale linkages, source area of technology and human capital, and competition and cooperation among tenant firms. The selection of respondents is based on two considerations: the production chain tiers and the importance of the tenant in the tier. Altogether, high rank managers of eight key enterprises accepted our interview and completed the major questions, roughly represent a quarter of all tenants within the cluster. The tenants interviewed include: the component producers Sumika Tech, Sintech and West; the backlight unit producer Core-tronic; equipment makers Contrel and Taiwan Daifuku; and the two giant TFT-LCD panel enterprises Chimei Optoelectronics (CMO) and Hann Star. These interviews contribute greatly to our understanding of the TFT-LCD industrial cluster in STSP.

**Map 1 Distribution of Optoelectronic Firms in STSP**




In terms of park facilities, all the respondents agree that one-stop window service and transportation cost reduction due to co-location are very important. But almost no respondents is satisfied with the quality of life in STSP, mainly due to its isolation and the lack of urban amenities, many higher rank managers and engineers prefer to live in Tainan City. Although STSPA boasts of having a much better electricity supply then HSIP, electricity stability is not quite satisfactory by the tenants, at least two respondents mentioned that the sudden short circuits caused significant damage to business income last year; nevertheless, water supply is

generally regarded as good. Location is generally regarded as good, with convenient highway system, but the public transportation is not convenient; and since most of the park land is already occupied, two of the respondents mentioned that large scale expansion in STSP will be very difficult.

Concerning the source area of upstream material, over half of the respondents get their upstream material mainly from Japan, three of them dependent on Japanese direct shipping supply for even more than ninety percent. In contrast, one tenant claims that almost hundred percent of its material can be purchased from southern Taiwan; and the leading tenant get forty percent material from within STSP, twenty percent from Japan, and other forty percent from rest of Taiwan. It seems that certain degree of self-sufficiency of materials in the region is achieved, but there is still a strong dependency upon Japanese producers.

Concerning the source area of components, one major tenant claims that almost all components can be found from STSP; most of the other tenants can find more than sixty percent of components from Southern Taiwan; only two tenants depend on imported components for more than forty percent. In terms of machine, imported machine are still the most important, only one tenant can get seventy percent of the needed machinery equipment from domestic producers, Japan account for more than sixty percent of the machines needed for other tenants, one tenant rely on Korea and another rely on United States machin4es for twenty percent, rest of the machine can be found from Southern Taiwan, roughly twenty percent.

In terms of source of technology, most of the respondents reckon that attraction of the technological leading firm-Chimei is an important factor for locating in STSP. Yet most of them consider that there are only very limited interactions and exchanges of production and technological information among tenants, one of the main reasons is that division of labor is very fine within the cluster, thus each tenant is interested in quite specialized and somewhat differentiated information. Nevertheless, most tenants are supportive to the benefit of such detailed division of labor, and even when there are competition between tenants of similar products, they still consider that competition has contributed to the continuous upgrade of the industry as a whole.

In terms of human resource, most respondents agree that locating in STSP has advantages in recruit employees. However, because of the speed and scale of optoelectronic industry development in STSP, the industry is highly dependent upon optical and chemistry technical labor force, existing labor pool in southern Taiwan cannot fully support employment demand, there is already a shortage of such technical workers. And within STSP, because of CMO's strong competitiveness, it has a special advantage in attracting all kinds of labor, especially in R&D staff, therefore, half of the respondents expressed their worries of disadvantage in higher qualified labor force competition with CMO. Most of the respondents consider that the labor

force turnover in STSP is high, but this high turn-over is generally regarded as a kind of regional advantage, because it is seen as a way to accelerate technological transfer and thus contribute to the accumulation of regional technical capacity.

In general, based on the interviews, the science park and Chimei Group have both played key role in the formation of STSP TFT-LCD industrial cluster. It is well-known that the founder of Chimei Group is a son of Tainan and that when facing the tide of industrial restructuring, his first choice of locating new business is still in Tainan, therefore, the decision of government to establish a new science park in Tainan has a fundamental importance in facilitating his new vision. And based on his former experience of establishing a petrochemical industrial cluster, his idea was not only to build a plant but a vertically integrated industrial system within Tainan area, this fit NSC's original idea of "specialized industrial zone", although the TFT-LCD had not been included in original target. In fact, coordination among STSPA and local government and Chimei in the land planning and development process is the key in the making of this new industrial investment from a traditional enterprise into the flagship of a new industrial cluster. And through CMO's aggressive actions in finding and persuading potential upstream supplier to co-locate in STSP or in Tainan, the TFT-LCD industrial cluster can eventually be established in a less advantageous place, comparing with Hsinchu or northern Taiwan, within very short time, and even accomplished the most complete industrial chain in Taiwan.

## 4. Conclusion

From the general development of STSP and, more specifically, its TFT-LCD industrial cluster, it is clear that STSPA, local entrepreneurship, local government, major research universities and incubation services have all participated. STSPA has been instrumental in pulling all these forces together to produce the synergy effect. Firstly, the layout of the science park development plan and setting up of target industries, especially, with the "special zone" concept that combined traditional land development planning and industrial planning together, and eventually helped the formation of sectoral clusters. Secondly, the ability to attract the flagship companies in target industries, and the ability to help materialize local entrepreneurship and assist them to invest in the new frontier industries, especially Chimei in TFT-LCD industry, this is the key investment that ahs changed STSP from a satellite park of HSIP into a science park with its own industrial identity. Thirdly, a local flagship is important, almost all the interviewee consider that the existence of science park and Chimei are both important to their decision to choose Tainan, without them, especially without Chimei, there won't be a TFT-LCD industrial cluster in Tainan. Fourthly, tenants formed an industrial cluster, they "coopete" (cooperate and compete) with each other. Fifth, "flexibility" in planning and "integrity" in management of STSPA, and coordination with local communities are important, for example, adapt to the industrial change, from a more general "microelectronics" to LCD, changing the threat of high speed railway vibration to encourage biotechnology, using

archaeological site to establish museum and add more cultural ingredient to the science park, water flooding to retention ponds and entertainment function, wildlife preservation.

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## APPENDIX

**Appendix table 1 Number of Firms in Tainan Science Park (1998-2007)**

**Unit: number of establishment**

| Industry | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|
| Integrated Circuits | 1 | 1 | 3 | 5 | 8 | 7 | 8 | 10 | 11 | 11 |
| Opto-electronics | 0 | 1 | 4 | 10 | 12 | 17 | 23 | 28 | 30 | 31 |
| Biotechnology | 0 | 0 | 2 | 2 | 6 | 11 | 11 | 17 | 17 | 18 |
| Telecommunications | 1 | 2 | 3 | 5 | 5 | 7 | 8 | 9 | 9 | 8 |
| Precision Machines | 0 | 1 | 1 | 1 | 2 | 6 | 13 | 23 | 29 | 32 |
| Computer & Peripherals | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 2 | 3 |
| Others | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 4 |
| Total | 2 | 5 | 13 | 23 | 33 | 50 | 65 | 91 | 101 | 107 |

**Source:** www.stsipa.gov.tw/web/

**Appendix Table 2 Number of Employees in Tainan Science Park (2001-2007)**

**Unit: person**

| Industry | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Integrated Circuits | 3498 | 4930 | 6011 | 7859 | 8745 | 10569 | 11955 |
| Opto-electronics | 4518 | 7352 | 11877 | 21306 | 27880 | 29810 | 35098 |
| Biotechnology | 326 | 619 | 584 | 635 | 790 | 917 | 950 |
| Telecommunications | 565 | 710 | 753 | 595 | 724 | 1476 | 819 |
| Precision Machines | 427 | 403 | 261 | 1098 | 1745 | 2872 | 3122 |
| Computer & Peripherals | 0 | 0 | 0 | 108 | 176 | 216 | 263 |
| Others | 155 | 611 | 927 | 1300 | 1210 | 1511 | 1858 |
| Total | 9489 | 14625 | 20413 | 32793 | 41270 | 47371 | 54115 |

**Source:** www.stsipa.gov.tw/web/

**Appendix Table 3 Total Revenue of Firms in Tainan Science Park (1998-2007)**

**Unit: NT$ 100millions**

| Industry | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|
| Integrated Circuits | 0.7 | 11.4 | 139.1 | 287.4 | 485.4 | 609.0 | 831.5 | 831.7 | 1102.2 | 1302.1 |
| Opto-electronics | 0 | 0.5 | 98.4 | 199.6 | 523.4 | 897.3 | 1685.8 | 2604.6 | 3224.0 | 4026.7 |
| Biotechnology | 0 | 0.1 | 0.6 | 1.5 | 2.4 | 5.3 | 11.6 | 15.4 | 20.0 | 30.9 |
| Telecommunications | 0.4 | 3.1 | 6.7 | 5.5 | 3.7 | 6.6 | 8.7 | 10.6 | 14.2 | 15.4 |
| Precision Machines | 0 | 0.8 | 2.5 | 7.8 | 16.1 | 32.7 | 46.0 | 50.7 | 137.1 | 186.5 |
| Computer & Peripherals | 0 | 0 | 0 | 0 | 0 | 1.1 | 9.0 | 11.3 | 9.2 | 8.8 |
| Others | 0 | 0 | 0 | 0 | 0 | 0 | 1.7 | 3.5 | 9.4 | 18.3 |
| Total | 1.1 | 15.9 | 247.3 | 501.8 | 1031 | 1553.2 | 2594.3 | 3527.8 | 4516.1 | 5588.7 |

**Source:** www.stsipa.gov.tw/web/