行政院所屬各機關因公出國人員出國報告書
（出國類別：出席國際會議）

參加 2008 世界科學園區協會(IASP)
南非年會出國報告

出國人服務機關：科學工業園區管理局
職　　稱：研究員
姓　　名：馬維揚

機　　關：中部科學工業園區管理局
職　　稱：局長
姓　　名：楊文科

機　　關：中部科學工業園區管理局
職　　稱：組長
姓　　名：王宏元

機　　關：南部科學工業園區管理局
職　　稱：局長
姓　　名：陳俊偉

機　　關：南部科學工業園區管理局
職　　稱：助理研究員
姓　　名：咼乃之

出國地點：南非
出國期間：97.9.13 – 97.9.19
報告日期：97.11.20

前言

南部科學工業園區管理局陳俊偉局長、中部科學園區管理局楊文科局長、投資組王宏元組長、科學工業園區管理局馬維揚研究員、國立成功大學孔憲法教授及金屬工業研究發展中心黃博偉博士等一行 8 人於 9 月 13 日赴南非約翰尼斯堡出席 2008 世界科學園區協會(International Association of Science Parks; IASP)年會。本年度 IASP 年會主題爲「科學園區在加速知識經濟成長中扮演之角色-新興與已開發國家的比較」(The role of science parks in accelerating knowledge economy growth – contrasts between emerging and more developed economies)。

本次會議期間除聆聽世界各國園區相關組織之園區發展經驗外，竹科馬維揚研究員、金屬工業研究發展中心黃博偉博士、成功大學孔憲法教授及都市計畫系閻永祺同學亦代表台灣科學園區，分別就「竹科創新群聚指標研究」(Research on Innovation Cluster Indicators of the Hsinchu Science Park)、「以台灣中小企業爲例，探討在地研發量能於新興醫療器材產業聚落中所扮演之角色」(The role of local innovation capacity in the emergence of a SME-based medical device industry cluster in STP: An experience in Taiwan)、「科學園區在高科技產業聚落形塑過程中的角色-以南部科學工業園區爲例」(Role of Science Park in the Formation of High Technology Industrial Cluster – Case of Southern Taiwan Science Park)及「南部科學工業園區 TFT-LCD 產業聚落規劃經驗分享」(The Planning Experience of TFT-LCD Industrial Cluster in Southern Taiwan Science Park)等題目發表演說，中科楊文科局長亦由獲頒 IASP 會員證，正式成爲國際組織會員之一，展開中科園區國際化的第一步。

經過此次的交流與互動，期能建立良好溝通平台及友誼，進而提昇台灣園區在國際的能見度，藉由推動科技外交之軟性的策略，開創台灣外交新局面。

目錄

世界科學園區協會(IASP)簡介

世界科學園區協會（International Association of Science Parks, 以下簡稱 IASP）成立於 1984 年，為一獨立、非營利、非政府的國際組織，亦係全球唯一世界級的科學園區協會。IASP 總部設在西班牙，在亞太地區、歐洲、北美和拉丁美洲皆設有分會，會員分為 4 種等級：包括有正式營運的科學園區「正式會員」；成立中的科學園區為「附屬會員」，與 IASP 目標相同的育成中心，大學，研究機構，財團法人，或個人可加入成為「相關會員」；對 IASP 有重大貢獻之團體或個人則可成為「榮譽會員」。截至 2007 年底，全世界共有 71 個國家、356 個會員加入。

IASP 主要工作宗旨為協助各國開發科學園區、管理與協助提供科學園區專業人才、協助科學園區和其廠商吸引新興投資機會、增加會員國和贊助者的國際可見度等。從工作內容、目前規模、相關國際活動等項目評估，可看出該會為各國科學園區研究專家長期關注的對象，又台灣在全球園區發展的歷史上扮演著舉足輕重的腳色，是發展中國家開發科學園區與高科技產業成功的學習對象，因此，台灣積極出席該會舉辦的活動，期能更加強化台灣園區優質形象及重要地位。

IASP 年會簡介

IASP 每年均在世界各國召開年會， 內容除會員國行政事務外，還包括學術性質之研討會、新科技展覽、人脈建立、當地科學園區參訪等。由於該學術研討會每年皆會提出新的主題與想法，具有指標性意義，因此世界各國研究科學園區之學者、園區管理公司或政府官員等，皆會親自投稿，希望藉由研討會之發表與交流，擴大研究視野、增加科學園區的曝光度及吸引廠商與高科技產業投資。台灣三各科學園區管理局皆為 IASP 會員，透過積極參與該協會每年例行性年會，達到人脈建立、形象塑造及國際行銷等目標，此活動可謂園區管理局與世界園區相關組織互動聯繫之重

要溝通平台。

今年第 25 屆世界科學園區年會在南非約翰尼斯堡舉行，由南非創新中心(The Innovation Hub)主辦，統計共有 486 位來自 60 個國家代表出席，創下了三項「第一」，分別是歷年來首次於非洲國家舉辦、投稿篇數最多及首創 IASP 非洲分會。2009 年第 26 屆年會則計畫於 2009 年 6 月 1 日至 4 日假美國北卡羅來納州之三角研究園區舉行。北卡三角研究園區係北卡工商學界領袖於 1959 年推動成立，屬民營性質，佔地 7 千英畝，現有 IBM、Cisco、Sony Ericsson、台灣之台達電、美國聯邦環保署實驗室等公、民營機構之科技研發部門及支援 R&D 之諮詢、財務、法律等公司企業共 157 家機構及廠商。位於園區附近的杜克大學、北卡大學教堂山分校及北卡州立大學（NCSU）提供其高科技人才及人力資源，又加以其他優越因素，如物價較其他高科技地區低，預期未來發展相當可觀。

年會議程

2008.09.14

14:00-17:00　註冊

17:30-20:00　歡迎晚宴

2008.09.15

10:00-11:30　開幕式

11:00-11:30　專題演講 – Dr. Ramesh Mashelkar, 印度全球研究聯盟主席 (President of Global Research Alliance, India)

11:30-12:00　休息

12:00- 13:30　主題討論 1：企業家精神在知識經濟中重要的價值：科學園區的角色 (Entrepreneurship as a key value in knowledge economies – role of STPs)

12:40-12:55 科學園區在高科技產業聚落形塑過程中的角色-以南部科學工業園區爲例 (Role of Science Park in the

Formation of High Technology Industrial Cluster – Case of Southern Taiwan Science Park) ：成功大學都市計畫系孔憲法教授

13:30- 15:00　午餐

14:10-14:50　“Flash Session”

14:10-14:20 南部科學工業園區 TFT-LCD 產業聚落規劃經驗分享 (The Planning Experience of TFT-LCD Industrial Cluster in Southern Taiwan Science Park)：成功大學都市計畫系博士班閻永祺同學發表

15:00- 16:00　分組討論 1：透過夥伴關係及合作提昇價值鍊的整合性(Partnership and collaboration to accelerate integrate in the value chain)

分組討論 2：驅動創新之政策 (Policies that drive innovation)

分組討論 3：開擴園區的新領域 (Exploring the new horizon of STPs)

分組討論 4：發展地方以建構園區 (Building local capabilities to develop STPs)

16:00-17:00　休息及“Flash Session”

16:15-16:55　“Flash Session”

16:35-16:45 以台灣中小企業爲例，探討在地研發量能於新興醫療器材產業聚落中所扮演之角色 (The role of local innovation capacity in the emergence of a SME-based medical device industry cluster: an experience in Taiwan) ：金屬工業研究發展中心黃博偉博士

19:30-22:30　晚餐

2008.09.16

09:00-10:30　主題討論 2：快速發展經濟體以進入全球經濟 (Fast Tracking Developing Economies into the Global Economy)

10:30-11:00　休息

11:00-12:30　主題討論 3：創新及企業文化與科學園區發展及成功的關係 (Innovation and business country culture in relation to the development and success of STPs)

12:30- 14:00　午餐

13:10-13:50　“Flash Session”

14:00-15:00　分組討論 5：科學園區的人力 (Staffing of STPs)

分組討論 6：設計一座科學園區：做大決定 (Designing a STP-making the “big choices”)

分組討論 7：育成：育成產業的最新發展 (Incubators: what are the new developments in the incubation industry?)

15:00-16:00　休息

15:15-18:00　IASP 會員大會暨 2011 年會主辦國選舉

20:00-23:00　正式晚宴

<u>2008.09.17</u>

09:00-10:30　主題討論 4：各城市與其科學園區：發展當地經濟 (Cities and their science parks – growing local economies)

10:30-11:00　休息

11:00-12:30　主題討論 5：科學園區的影響力 (Impact measures for STPs)

11:25-11:40 竹科創新群聚指標研究 (Research on Innovation Cluster Indicators of the Hsinchu Science Park) ：科學園區管理局馬維揚研究員

12:30- 13:20　閉幕式

13:30- 17:30　科技之旅：南非創新中心 (The Innovation Hub)

18:00-21:30　惜別晚宴

論文發表

為園區國際化，出席 IASP 年會可謂推動此國際行銷業務的重要媒介；透過國際活動的參與，能與世界各園區的專家學者交流互動，進而吸取更有效、創新的園區發展策略，而若能更主動地把握年會論文發表的機會，更是能提高園區的國際能見度，塑立園區專業優質形象。

本次年會台灣擺脫被動聽取的角色，站上講台與與會人士分享園區發展經驗，由竹科馬維揚研究員、金屬工業研究發展中心黃博偉博士、成功大學孔憲法教授及都市計畫系閻永祺同學代表台灣科學園區，分別就「竹科創新群聚指標研究」(Research on Innovation Cluster Indicators of the Hsinchu Science Park)、「以台灣中小企業為例，探討在地研發量能於新興醫療器材產業聚落中所扮演之角色」(The role of local innovation capacity in the emergence of a SME-based medical device industry cluster in STP: An experience in Taiwan)、「科學園區在高科技產業聚落形塑過程中的角色-以南部科學工業園區為例」(Role of Science Park in the Formation of High Technology Industrial Cluster – Case of Southern Taiwan Science Park) 及「南部科學工業園區 TFT-LCD 產業聚落規劃經驗分享」(The Planning Experience of TFT-LCD Industrial Cluster in Southern Taiwan Science Park)等題目發表演說。席間分享台灣在科學園區領域經營的成果外，更與聽眾在園區特色及行銷定位等議題上進行討論，透過競合的觀點闡明三園區的關係，界定竹科、中

科、南科分別在積體電路、精密機械及光電產業區隔中所扮演的角色。

頒發 IASP 會員證書

本次年會係中科管理局第一次以正式會員身份參與，故會議主席 Chachanat Thebtaranonth (泰國科技部副部長兼科學園區管理局局長)於 9 月 16 日會議正式晚宴時親自介紹並頒發會員證，由楊局長文科代表接受證書，象徵中科園區國際化的第一步。頒發儀式介紹中科不僅讓世界各園區代表認識台灣的第三個新世代園區，也讓台灣科學園區在世界舞台更發光發亮！是此行另一重要收穫。

國際合作

開會期間與各國代表及友人面對面交流，互道近況增進友誼，這種人際溝通的完美媒介平台，成就了不少合作計畫，例如去年年會與越南和樂科學園區、英國曼徹斯特科學園區及西班牙Murcia園區等代表談論簽署MOU姐妹園區等，便是透過此種模式洽談未來共同合作方案。

爲增進中科與各國園區密切往來及建立國際雙方關係，本次年會行程也安排與大邱科學園區代表討論雙方國際交流案。大邱科技園區發展迄今近 10 年，爲韓國知識經濟部、大邱市政府及鄰近大學所共同捐助成立之財團法人機構，主要目標以帶動大邱及韓國地區產業、扶植策略性工業及創新產業爲主，其營運模式及發展趨勢，足供中科參考。

年會期間中科管理局與大邱園區雙方會談甚歡，一致達成共識在短期內簽署合作備

忘錄，主要內容包括促進貿易及交流雙方資訊、協助擴展產業群聚等，希望透過這個合作備忘錄所建立的交流基礎，共同創造園區永續競爭力、站穩世界舞台；此舉對中科園區而言，將有助國際化之落實與增進科技外交之實質關係。

中科管理局楊文科局長(左三)、投資組王宏元組長(右二)、亞洲科學園區協會李鍾玄主席(右三)及大邱園區姜園長(左二)於餐會席間討論雙方國際交流，確認簽署合作備忘錄，締結姐妹園區。

IASP 會員大會暨 2011 年會主辦國選舉

IASP 會員大會除報告協會一般行政業務如財務狀況外，最重要的重頭戲便是由會員國投票選出 3 年後的年會主辦單位。本次投票結果由丹麥哥本哈根 - Scion-DTU 科學園區贏得 2011 年年會的主辦權。

Scion-DTU 科學園區於 1962 年設立，爲世界上歷史最悠久、丹麥最大的大學型科學園區(university-based science park)，座落於丹麥哥本哈根及瑞典交接的 Medicon Valley 中心，區內有 170 家廠商及 4,000 位從業人員，主要發展生命科學(Life Science)產業。其轄下管理兩個基地，一位於丹麥科技大學學區內，進駐廠商主要爲小型公司及該大學自創產業。另一基地位於 Hørsholm，廠商皆爲較大型、研發成果較成熟之公司。

南非年會主辦單位與丹麥 Scion-DTU 科學園區代表手持年會會旗，象徵承接 2011 年會主辦權。

科技之旅：南非創新中心 **(The Innovation Hub)**

南非創新中心位於豪登省中心，普勒托利亞東方，占地 60 公頃；該中心是豪登省（Gauteng Province）政府投資數十萬蘭德發展智慧型經濟產業的基礎設施，以建設豪登省成為一「智慧」型省份。南非創新中心也緊鄰普勒托利亞大學，使其易於整合研究機構及大學的量能，目前該中心已成為非洲高科技產業的群聚，並公認為一國際化的科學園區。

南非創新中心的企業目標包含：

※ 創造一個可整合高科技創業者、世界級企業、教育、研究和創投量能的環境，並搭配網絡等相關設施，以支持高科技公司的設立和成長。

※ 提供關鍵性附加價值的企業服務，協助地區中技術豐富的企業成長、國際化及永續發展。

※ 增加地區性高科技財富和知識密集的社群，促進創新文化並激勵公司和知識型研究機構的競爭力。

心得與建議

第25屆IASP年會增進對科學園區如何運作、維持並成長的瞭解。簡報內容都包含最佳的實務及具影響力的資料。隨著知識經濟時代的來臨，經濟全球化趨勢日益明顯，各國或地區的發展都面臨著激烈的國際競爭。為了強占國際競爭的致高點，各國各地區特別是發達國家和地區，高度重視發展高技術含量、高附加值和高競爭力的高新技術產業，積極組織國家中各個部門、各行業和社會中各種力量，改善及發展國家創新體系，企圖繼續主導世界經濟發展的航向。各國政府，特別是地方政府緊緊抓住本地所擁有的技術資源，努力營造有利於高新技術產業發展的空間環境，實施合理的產業政策和地方政策，重點支持發展潛力比較大、適合本實際的高科技產業發展，促進有利於持續創新的企業家相互作用的區域形成。

一般來說，各國和地區的高科技產業在發展過程中，又主要呈現出以下兩方面的特點：一方面，高科技產業要求在全國乃至全球範圍內組織資源和開拓市場而特別是在計

算機技術、交通通訊技術等技術革命和經濟全球化的推動下，使得高科技產業發展的全球化趨勢日益明顯。另一方面，高科技產業發展的全球化過程中，無論是高新技術大企業還是小企業，都必須植根於當地特殊的經濟、技術和社會文化環境中，從中汲取營養，不斷增強企業和區域的國際競爭力。所以，在發達國家國內，高新技術產業傾向於在本國特定的地域上集中發展。同時，在全球範圍內，發達國家的高技術跨國公司在向國外擴張的過程中，不僅需要研究東道國的市場，而且還必須研究當地的社會文化以及人們的風土人情，了解消費者在市場中的消費偏好，充分考慮到當地的法律法規，考慮到當地技術系統的標準和規範，甚至了解當地的政府機構的決策及其導向。所以，跨國公司在國外設立的生產基地或研究開發機構也傾向於在發展中國家的資金、技術、人才密集的發達地區或大中城市設立。

綜觀各個國家高科技產業的發展，除了一般意義上的高科技產業發展的高投資、高風險、高收益的特點，高科技產業發展的空間群聚的特徵日益明顯。而且，高科技企業的群聚，已經形成了一個全球化的高技術群聚現象。高科技產業群聚產生的「群聚效應」，不僅僅是在一定的地域範圍內實現了技術、資金和人才等重要生產要素的群聚和快速的流動，以及區域內的快速組織和配置高新技術產業發展的資源，更爲重要的是，由於群聚效應產生，使得群聚區域不斷吸引外來的企業特別是跨國的高科技公司系其R&D部門機構的進入，加速了國際間先進技術、管理經驗的外溢和擴散，使得技術、知識和信息等快速流動，促進了新技術知識的創新和發展，大大縮短了高技術產品的生命周期，不斷增強了高新技術產業本。和區域經濟發展的競爭優勢，進一步提高了本國的經濟發展的國際競爭力。而且，從理論上看，產業群聚不僅降低了企業之間交易成本和產業之間相互學習的成本，還便利了政府管理協調和產業引導。

針對我國現有高科技產業群聚的投資、研發、產業以及環境等方面的特點，提出以下幾方面建議：

在投資方面，要強化前期投資和風險投資，一方面爲潛在創業者提供有效的前期支持，幫助他們拿出有價值的商業計劃；另一方面要建立高科技風險投資機制，吸引國內外有經驗的風險投資的注入，通過其專業化的服務提高新興企業的成活率。此外要完善投資退出機制，特別是高科技企業上市機制，減少投資者的後顧之憂。

在研發方面，首先要改革和完善技術轉讓機制，通過強化和擴大現有技術轉讓機構職能，推進研發成果向商業應用的轉化；其次要在研發人員中大力提倡創業精神，通過業餘的管理課程進修以及高科技MBA學位課程培養研發人員的創業意識和經營能力；最後還要發展強化高科技產業群聚內部的網絡文化，通過正式和非正式的交流，充分發揮群聚的網絡效應。

在產業方面，首先要注意整合群聚內部凝聚力，形成產、學、研三方的對話交流機制，加強群聚內不同發展階段企業之間的合作。其次要注意大力宣傳推廣本群聚內高科技企業的成功案例，爲後來的新生企業樹立榜樣、提供激勵。

在環境方面，首先要努力提高群聚的區域吸引力，包括正確選址和科學規劃，以及積極建設配套生活服務設施，避免盲目冒進。其次要注意採取行銷手段，向國內外大力推薦本產業群聚在技術、資源和區位等方面的特點與優勢，促進群聚實現良性的滾動增長。

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Research on Innovation Cluster Indicators of the Hsinchu Science Park

Plenary Session 5:

Impact measures for STPs

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Research on Innovation Cluster Indicators of the Hsinchu Science Park

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Executive Summary:

This paper specifically creates a set of innovation cluster indicators for the Hsinchu Science Park and shows how they relate to the development of nearby regions and related industries. It aims to provide a conceptual framework for explaining the cluster's competitiveness (or competive advantages). This paper analyzes the arising of industrial clustering effects based on a framework of innovation formed of four factors : economy, innovation, talent and environment, from which Hsinchu City receives the most significant impact, followed by Hsinchu County.

Keyword: Innovation Cluster, Competitiveness, Evaluation

I. Introduction

Industrial cluster analysis relies on a broader sense of competitiveness analysis for evaluation of industrial performance. The encompassingly integrated indicators advantageously enable an analyst to explore the future outlook of an industry, other than appraising its past performance. Rather than confining the studied objects to individual enterprises, the cluster analysis encourages policy makers as well as scholars to take into account a regional or national economy from the perspective of clusters formed of relevant enterprises and supporting infrastructure. It therefore requires a new analysis framework for government, enterprises and other decision makers to fully realize how the clustering process has positively facilitated the development of many enterprises at relatively low cost. As a result, the past decade has seen much effort on the research of industrial policies focused on industrial cluster development.

This paper specifically creates a set of innovation cluster indicators for the Hsinchu Science Park (HSP)and shows how they relate to the development of nearby regions and related industries. It aims to provide a conceptual framework for explaining the cluster's competitiveness (or competive advantages). Comparsions are also made with other regions (or science parks) in Taiwan.

Since 1997, we have been doing a series of statistical researches on the economic infrastructure of a wider range of HSP-influenced regions. The adopted methodology emphasizes strict accuracy and all indicators have been verified for their statistical significance, with each variable's contribution assessed using statistical method.

The analysis focuses on providing practical results based on easily accessible data and commonly used analysis methods, although either being far from perfection. The challenge lies in trying to derive satisfactory causal relation with limited amount of time series data. However, even it is unlikely to obtain meaningful results from tests based on our derived causal relation model, understanding the correlation between the economies of HSP and its neighboring regions is of more vital importance. Despite numerous challenges encountered in the process of statistical analysis, this year's reports will be all the more robust and convincing.

Our research goal is to develop a set of HSP innovation cluster indicators for measuring, and hopefully being useful in the enhancement of, HSP's competitiveness. This project will, after comprehensive theoretical and empirical research, build a set of innovation cluster indicators which take into references such cluster indicators as the annually updated Silicon Valley Index, the Index of Massachusetts Innovation Economy and the index proposed by the National Tsing Hwa University based on "Development of HSP innovation cluster indicators" published in 2006. Our set of indicators also takes into account Taiwan's economic and social environment.

Industrial cluster analysis is fundamental to industrial decision-making. Besides providing tools for analyzing innovation systems, industrial cluster analysis serves as a tool for cultivation and growth of national strategic industries through furnishing guidelines for the development of innovation systems.

Cluster analysis provides a forum for constructive enterprise-government dialogue. It not only discerns common problems, but also identifies common development opportunities, as well as public and private investment opportunities.

This project is divided into six parts, with the first part being this introduction. Section 2 briefly reviews industrial clustering theories, covering topics of competitive advantages of industrial clusters, industrial clusters and competitiveness enhancement for regional industries, and innovation industrial clusters, with emphasis placed on the exploration of high-tech industrial clusters and their impacts; Section 3 addresses methodology for science park evaluation, with a view to developing an indicator systems focused on science parks. It covers evaluation systems, comprehensive evaluation of the science park, topic-based evaluation and development evaluation; Section 4 focuses on the HSP innovation cluster's main indicators, including the development of the HSP industrial clusters, the Silicon Valley Index, the Index of Massachusetts Innovation Economy, and the required indicators for HSP; Section 5 describes the 2007 HSP Innovation Cluster Indicators, which are further analyzed in detail under categories of economy, innovation, talent and environment; Section 6 concludes the research and makes recommendations, giving outlined meanings of each indicator, suggestions and direction for future research.

II. Innovation Clusters

In a global economy nowadays, an enterprise can only achieve high return through long-term competitive advantage secured by constant innovation to generate high efficiency that is particularly essential to high-tech industrial clusters. This is evidenced by the supporing data of a study on the Silicon Valley's semiconductor industry. Saxenian (1981) divided the semiconductor industry's processes into three phases (or categories), namely research and development phase, manufacturing phase and assembly phase. The research and development phase involves in itself a series of direct technological innovation activities. The manufacturing phase contains relatively less amount of innovation activities while the assembly phase encompasses the least amount of innovation activities. Studies show that most of the research and development processes which encompass the highest amount of innovation are carried out in the vicinity of the Silicon Valley (up to 79%). The manufacturing processes which have less amount of innovation activities are mostly done outside the Silicon Valley - mainly distributed in the United States, Europe and Japan (with Silicon Valley accounting for only 36%). The assembly processes with the least amount of innovation contents are almost not conducted in the Silicon Valley, which accouts for a mere 3%, with the majority part (88%) distributed in the third world countries. Obviously, other than factors like labor cost, the research and development processes center around the Silicon Valley mainly for the innovation advantage it brings forth. The innovation advantage is a major source of benefits for industrial clusters, especially for high-tech industries which rely on fast-paced technology advancement.

An innovation industrial cluster facilitates its member enterprises to easily acquire technology knowhow and market information, to establish a platform for joint research, development, production and selling activities with external business world, and to maintain good linkage with suppliers and customers. It essentially ensures smooth proceeding of research and development, design and prototyping, creation of art of manufacturing, and production and selling.

2.1 Regional features of innovation

Four aspects determine the features of a technology innovation: 1. the development stage where the current technology resides. Technology development usually follows a spiraling path, starting with a breakthrough that pushes the technology into a new stage (in one sense, a new technology paradigm), followed by a mass of progressive innovations that gradually unleash all underlying efficiencies of the technology model until a stage of technology stability is reached on which a new cycle may begin. In all stages, innovations vary significantly in the difficulties and features involved; 2. the difficulty and manner of innovation diffusion; 3. the serial correlation between innovation activities. This is the degree of dependence on the results and experiences from prior researches. An innovation that depends on personal experiences tends to show higher serial correlation as it is susceptible to non-systemized knowledge. An innovation staged at the beginning of technology development will be low in its serial correlation as less knowledge is prerequisite; and 4. the knowledge base, which includes the body, property and the means of creation and dissemination, of the knowledge required by the innovation activities.

2.2 Formation of industrial innovation clusters

It is generally believed that people of all regions have the potential to innovate but it is also true that innovation potential gets fully developed only in an environment rich in innovation resources, efficient in fascilating innovation systems and highly repaying in innovation return. An industrial innovation cluster provides an environment with all ingredients required for good innovation.

The main ingredients in forming an industrial innovation cluster include the knowledge center, entrepreneurs and innovators, core industries, local governments and supporting environment. The knowledge center provides the fundamental for an industrial cluster's long-term development. Appropriate innovation environment ensures smooth technology innovation. Industrial development lays the ground for innovation to be commercialized for economic benefits. Entrepreneurs and innovators play the role of organizing for and implementing innovation. The local government is the central part of institutional innovation that includes creation of a supportive policy systems and innovation systems.

III. Methodology for Science Park Evaluation

The rationality of evaluation has long been a concerned problem in the fields of philosophy of science, theory of economics and management theory. Despite variations on the understanding and viewpoints of the rationality issue, people acknowledge the existence and complexity of the problem. In the transformation from general to specific scope, the science park evaluation issue inevitably has to deal with the problem of rationality which can be described in nine key aspects:

1. Rationality explained

The rationality indicates high degree of recognition as the evaluation has been conducted on experiential and theoretical basis. An evaluation needs to follow scientific principles, with observables (in the form of data or information) obtained and analyzed scientifically, transparently and in a repeatable manner. The rationality of evaluation therefore implies being scientific. An unscientific evaluation inevitably comes out with poorly recognized results and, of course, little rationality. But, due to subjectivity involved in evaluation, it is unlikely that an evaluation can produce results recognized by all people and rationality is therefore of only relative significance.

2. Criteria for rationality

There are absolute and relative criteria for rationality. The absolute criteria include consistency in the experiential and theoretical basis of evaluation and recognition, authenticity of observables and logics of inference. The absolute criteria are mainly used for discerning a single-result evaluation while the relative criteria are used for comparing multiple evaluations on the same objects.

3. Objectives of evaluation

The science park evaluation has three objectives: to derive rules for science parks development in academic aspect, to summarize the operation performances and development variations for science parks in management aspect, and to uncover problems along with science park development in the aspect of decision making. The actual evaluation deals with three non-distinctive aspects mingled together, differed only by their emphasis. The theoretical, management and decision aspects in evaluation exactly correspond to the development processes from theory to implementation. Objectives are the driving forces for and the basic values of evaluation.

4. Selection of evaluation indicators

The development and attributes of a science park is an indivisible whole object of evaluation. But due to the limitation of perception, they have to be mentally decomposed into multiple units with each being a “perception unit” represented by an evaluation indicator. The whole assessed object is then approximated by a representative composite indicator system. Obviously, this is merely an abstract approximation instead of a factual equation. The composite indicator system can be made to more closely approximate actuality with more evaluation indicators, at higher cost of evaluation of course. Lower cost of evaluation can only generate smaller composite indicator system which produces results far deviated from actuality.

5. Qualitative versus quantitative indicators

Of the science park development and attributes to be assessed, some are beyond quantitative description. Examples of these types of attributes include cultural development and environmental protection, for which qualitative indicators have to be used. A typical qualitative indicator graded as outstanding, good, fair and unqualified can usually be semi-quantitatively represented by the numbers 1, 2, 3 and 4, respectively. Quantitative indicators should be carefully selected in terms of the people's recognition and their trueness, namely reliability and validity. To increase the objectivity of the outcome, selection of evaluation indicators should emphasize much more on quantitative than qualitative features.

6. Impact of indicator’s measurement unit and scope

In comparing multiple science parks, the “unit” adopted for an evaluation indicator has significant impact on the measured value of the indicator. For example, changing the patent measurement scope from “patent application” to “patent approved” causes major changes in the measurement outcome, despite no substantial differences being created in the measured targets. Moreover, some indicators generate outcomes with much different meanings when measured in absolute versus relative manners. For example, the indicator “scientific & techical employees” measured in absolute numbers differs from that measured in terms of the “scientific and technical employees as the ratio of the whole company’s employees”, which has significant impact on the evaluation results.

7. Subjective judgements in evaluation

Four subjective judgements exist in the evaluation of the science parks: (1) selection of evaluation indicators; (2) determination of each indicator’s measurement criteria; (3) assigning to each qualitative indicator a “fuzzy” score (such as "stronger", "strong", "fair" and "weak"); and (4) weighting of each indicator. Subjective judgements are inevitable in any evaluation while objective evaluation is an ideal case. An evaluation system can only be evaluated by its results in the sense of satisfaction or recognition.

8. Differentiated evaluation among multiple systems

Evaluation of the same science park based on different perspectives and interests usually come out with varying results, which is significant more specifically in the ranking of companies considering the company's R&D technology and the company's being headquarter, branch or factory. Compared to most of the objectively selected evaluation indicators that have win common recognition among different evaluation systems, the subjectively determined weights for these indicators are the major causes of varied evaluation outcome. Therefore, multipl evaluation systems can negotiate to reach a consensus on these weights in order to balance among the differentiated evaluations.

9. Operation status of the assessed objects

In the management of science parks, the government always has to deal with a need for comparing the operation status among multiple science parks at a specific time horizon, for comparing the development level of a specific science park at different time horizons, and for comparing the development level of multiple science parks at different time horizons. It is obvious that dynamicity and time comparability should be taken into account in the determination of the indicators' weighing coefficients at different time horizon.

IV. Construction of HSP's Innovation Cluster Indicators

4.1 Development of HSP's Industrial Clusters

The HSP's industrial clusters have been developing in three phases: the PC-oriented phase in 1980s; the IC-oriented phase in 1990s and the innovation-oriented phase in 2000s. Currently the IC industry and optoelectronics industry are among the best developed industries with remarkable success in terms of scale.

As of the end of June, 2007, HSP has established for its IC industries a supporting system based on professional division of labor that includes 128 IC design companies, five wafer materials vendors, five mask producers, 17 wafer fabrication companies, 11 packaging companies, three testing companies, three lead frame manufacturers, six silicon wafer suppliers, five test equipment suppliers, 17 process equipment and tools suppliers, five EDA companies and one liquid nitrogen supplier. The scale and completeness of such a well formed peripheral supporting system is nowhere else seen other than in the United States and Japan. Small but highly entrepreneuric, most companies have achieved remarkable development by focusing their limited resources in specialized fields, with a manifested potential of seizing a greater market share.

Taiwan's semiconductor industry, after more over 20 years of development, has formed up a complete world-class team of high-tech industrial players comprised of up-, mid- and down-stream manufacturers, with total output of NT$800 billion in 2003 and NT$1.3933 trillion in 2006. However, it took Taiwan's flat panel display industry only seven years to become a leader in manufacturing and supplying, with 40% of global market share. The total output reached NT$410 billion in 2003 and doubled in 2006, to a level of NT$823.3 billion. Taiwan started in 1992 its production of small-scale (below 10 inches in dimension) TFT-LCD panel. It did not engage in the production of then prevailing high-tech fashion of TFT-LCD panel over 10 inches in dimensioned until 1998. Taiwan's global market share of TFT-LCD panels first caught up with South Korea in 2005 and reached 48.8% in 2007, outperforming South Korea's 37.7%. Currently most South Korea's competitive manufacturers are procuring or seeking help from Taiwan.

Under the coalition of government and participating companies, the TFT industrial cluster has gradually developed into completeness, stretching from Longtan and Hsinchu in the Northern Taiwan, through the Central Taiwan Science Park, all the way to Tainan. The narrow strip of production clusters along the west coast highway including Taoyuan, the Central Taiwan Science Park and Tainan's TFT-LCD industrial cluster park is an indication of Taiwan's gradually formed TFT industrial clustering effect, which will contribute to the industry's overall international competitiveness.

Taiwan's critical status in global TFT-LCD production has attracted world-class upstream key component suppliers to invest in the science parks and industrial zones, forming more closely linked industrial clusters and establishing Taiwan as a major global supplying system for TFT-LCD. The overall domestically supplied components have overtaken imported components and therefore the production cost has dropped significantly. Meanwhile, the on-going momentum of industrial flourishment has spurred the will of domestic equipment acquisition by domestic players.

4.2 Indicators HSP Should Establish

Among the two sets of indicators – the Silicon Valley Index[1] and the Index of the Massachusetts Innovation Economy[2] – those emphasing economic performances and innovation are best candicates for HSP.

These include, take the Silicon Valley Index as an example, 1. Innovation, 2.Employment ,3. Income.

They also should include, from the Index of the Massachusetts Innovation Economy, 1. Industry Cluster Employment and Wages, 2. Corporate Sales, Publicly Traded Companies, 3.Occupations and Wages, 4.Household Income, 5. Manufacturing Exports, 6. New Business Incorporations and Business Incubators, 7. New Business Incorporations and Business Incubators, SBIR, 8. Corporate Research and Development Expenditures, R&D, 9. Patent Grants, Invention Disclosures, and Patent Applications, 10. Technology Licenses and Royalties, 11. Educational Attainment and Engineering Degrees Awarded.

Qi and others (2006)[3], in their study on the development of HSP's innovation cluster indicators, proposed 23 indicators based on the Index of the Massachusetts Innovation Economy. The proposed framework is compresensive with most of proposed indicators focusing on economic and innovative dimensions. However, the study is supported by underestimated industrial data which cover only a short period (two or three years) of time series, resulting in inadequate power of explanation. This study is carried out on the basis of their study and tries to make some corrections.

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1 Silicon Valley Index: http://www.jointventure.org/publicatons/index/2007%20Index/index.html

2 Index of the Massachusetts Innovation Economy: http://www.masstech.org./institute/the_index.htm

3 Qi, Yu-lan, Chun-xing, Huang and Rui-hua, Liu (2006), *Development of Innovation Cluster Indicators for the Hsinchu Science Park*, a research project commissioned by the Science and Industrial Park Administration , March 2006

But what indicators can be used for measuring the competitiveness of a science park? Based on the investigation of Ma, Weiyang (2007 a & b)[4], Many indicators are proposed by science parks and scholars for measuring a science park's competitiveness. To derive a representative and meaningful indicator, a science park's objective, industrial types, number of employees, size and regional characteristics must be taken into account. Our survey shows that many parks and scholars have pointed out that a universal indicator for all science parks does not exist and it is difficult in fact to measure all science parks with one single indicator. As parks vary with regions, meaningful measurement will be possible only among parks with similar unique characteristics. An overall measurement carried on all science parks inevitably will produce distorted outcome.

The emergency of cluster is reflected in the apparent increase in employment, salary and added-value in relation to national or global economy. Although the past studies did not draw consistent conclusions regarding to the effect of different development factors on economical development, however, through the establishment of suitable index, we can consider these development factors, this study will analyze the cluster indexes of Hsinchu Science Park in the following 4 categories: (1) Economy, (2) Innovation, (3) Talent and (4) Environment. The cluster index of Hsinchu Science Park will base on this innovative infrastructure. The relationships among these 4 factors are shown in Fig.4.1, the economic outcome of cluster is decided by the innovative activities; the innovation of regional industrial cluster is derived from technical innovation, upgrading of personnel and the establishment of new business within the industry; which in turn, would be influenced by "Innovation", "Talent", and "Environment". We would show the cluster development of Hsinchu Science Park through various cluster indexes.

The following parts including different year's annual comparison of various indexes, comparisons of different counties and cities, comparisons between different industrial clusters and nation-wide comparison have been completed. The work to be completed includes the international comparison of same index and analysis of competitive power.

[4] Ma, Wei-yang (2007a), *Investigation of Science Parks' Sustainability and Competitiveness*, p48-53, TIER Review, Jan., 2007

Ma, Wei-yang (2007b), Research on the Sustainability and Competitiveness of Science Parks(2007), 2007 IASP-ASPA Conference

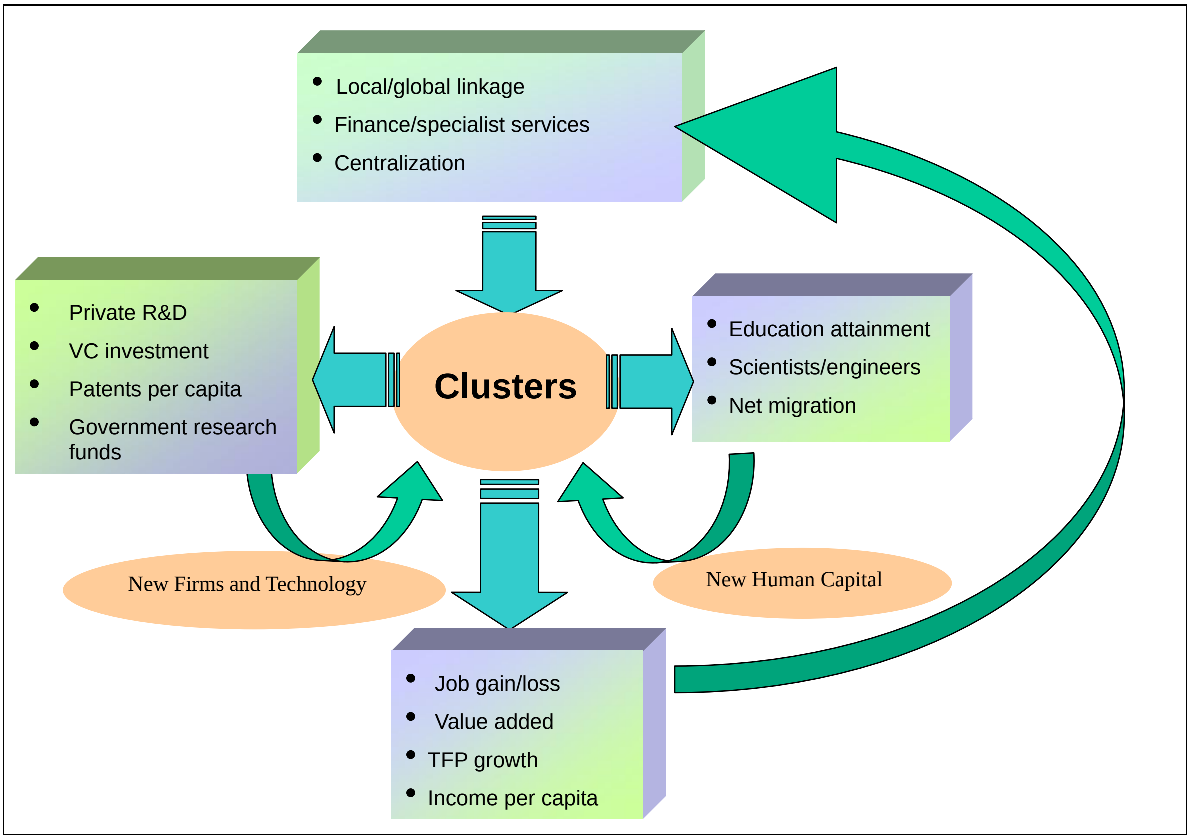


fig. 4.1. Relationship between HSP industrial cluster indicators and sub-indicators
Source:Qi, Yu-lan, Chun-xing, Huang and Rui-hua, Liu (2006)

V. 2006 HSP Innovation Cluster Indicators

5.1 Economy

This indicator contains five figures including employment ,wages ,value-added, no. of companies, income, with a view to showing HSP's performances from different aspects of economic achievements.

1. Employment

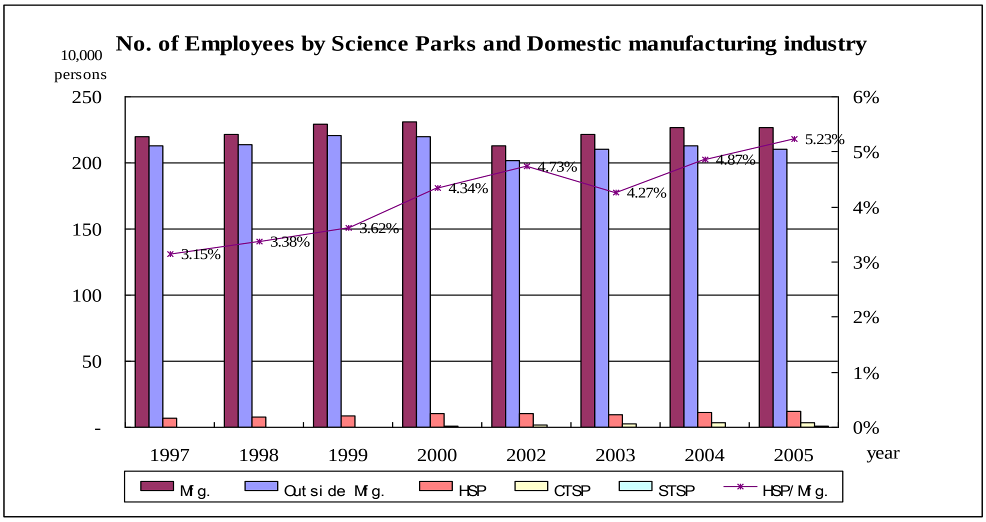
The employment indicator is comprised of two sub-indicators: no. of employees by science parks and domestic manufacturing industry,no. of employees by hsinchu science park and domestic manufacturing industry.These indicators show that:

(1) Between 1997 and 2005, HSP's total employment as a percentage of the total employment of domestic manufacturing industry rose steaily.

(2) Between 1997 and 2005, HSP's total employment as a percentage of Hsinchu County's total employment rose from 40% to 53.5%.

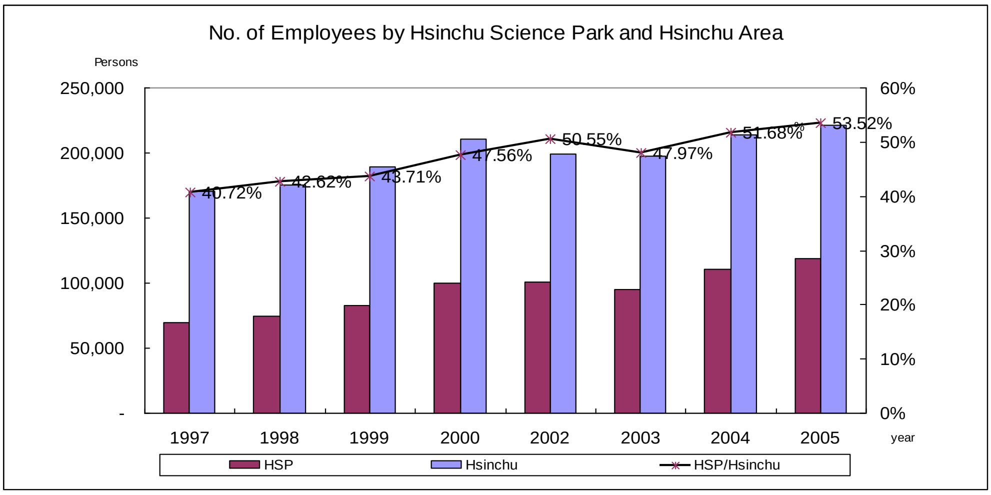
Employment sub-indicators:

1a. No. of Employees by Science Parks and Domestic Manufacturing Industry



Source: 1. Industrial Cencus Report; Ministry of Economic Affairs, R.O.C., compiled for this project.
2. Southen Science Park: STSP Central Science Park: CTSP Manufacturing Industry: Mfg Outside Manufacturing Industry:Outside Mfg

1b. No. of Employees by Hsinchu Science Park and Hsinchu Area



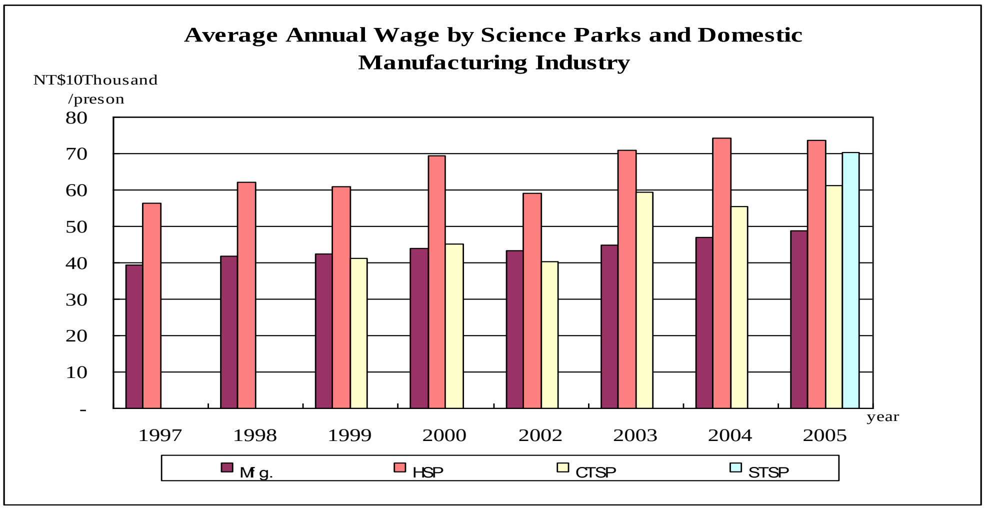
Source: ibid.,1a

2. Wages

The wages indicator is comprised of one sub-indicator: average annual wage by science parks and domestic manufacturing industry. This indicator shows that, between 1997 and 2005, HSP's average wage for its employees was on the rise and exceeds that of the domestic manufacturing industry by 36%-59%.

Wage sub-indicator:

2a. Average Annual Wage by Science Parks and Domestic Manufacturing Industry



Source: ibid.,1a

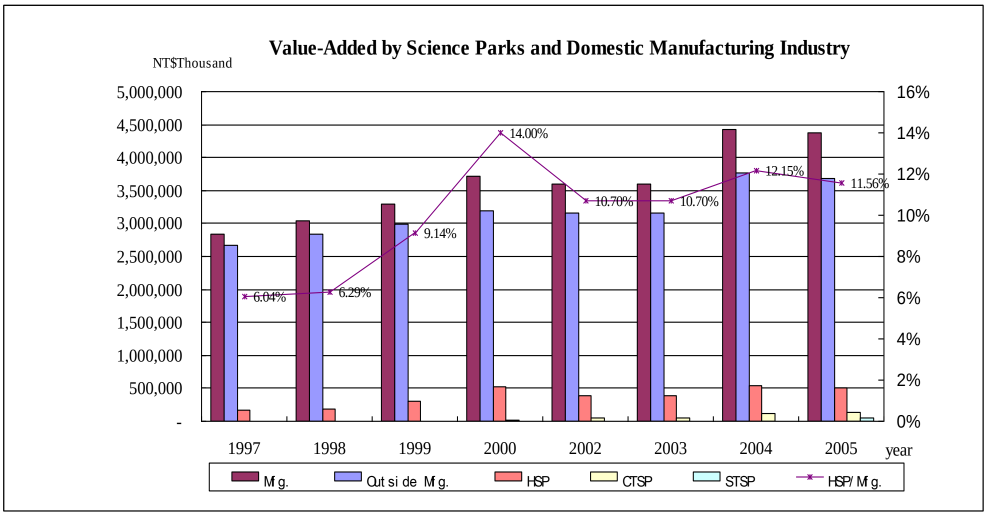
3. Value-Added

The value-added indicator is comprised of three sub-indicators:value-added by science parks and domestic manufacturing industry,value-added per capita by science parks and domestic manufacturing industry,value-added ratio by science parks and domestic manufacturing industry.These indicators between 1997 and 2005 show that:

(1) HSP's value-added per capita was on the rise, leaving out the year 2000 which was the peak.
(2) HSP's value-added ratio to the domestic manufacturing industry peaked at 2000 and slightly slided since then.
(3) HSP's value-added exceeded the domestic manufacturing industry by over 10% since 2000.

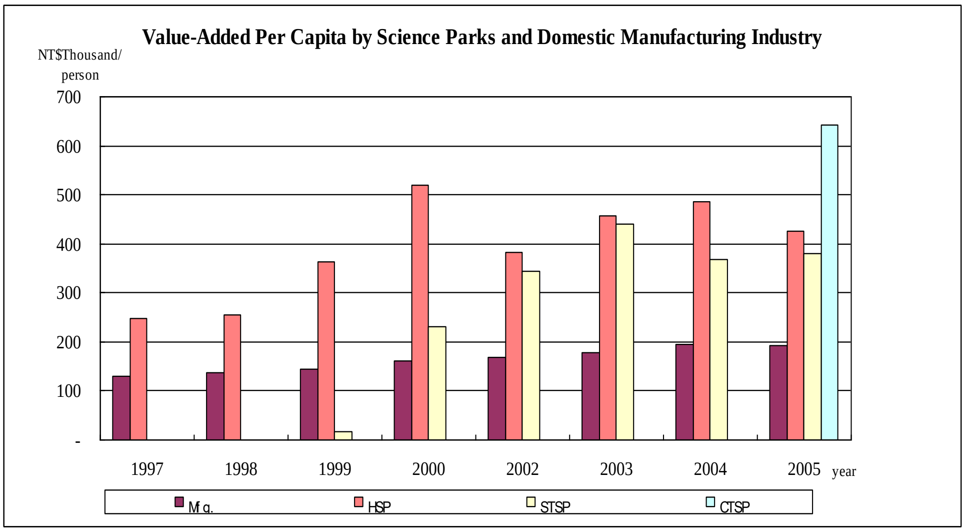
Value-added sub-indicators:

3a. Value-Added by Science Parks and Domestic Manufacturing Industry



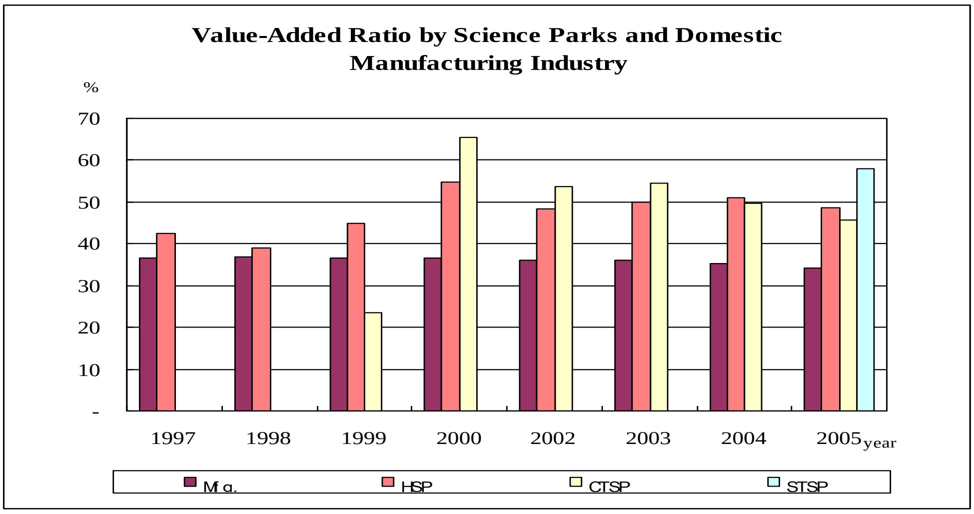
Source: ibid.,1a

3b. Value-Added Per Capita by Science Parks and Domestic Manufacturing Industry



Source: ibid.,1a

3.c. Value-Added Ratio in the Science Park by Science Parks and Domestic Manufacturing Industry



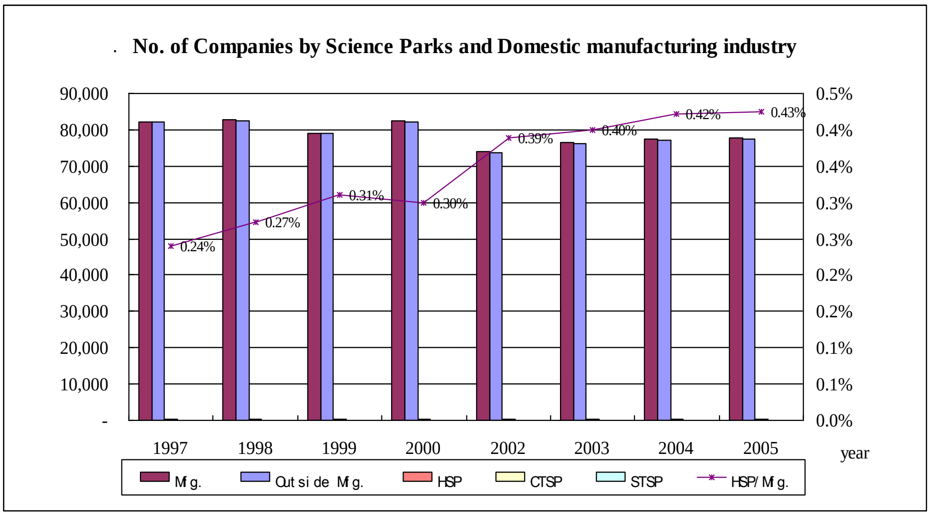
Source: ibid.,1a

4. No. of Companies

The number-of-companies indicator is comprised of one sub-indicator: no. of companies by science parks and domestic manufacturing industry.This indicator shows that, between 1997 and 2005, HSP's number of companies was on the rise, with the ration to domestic manufacturing industry rising, too.

No. of companies sub-indicator:

4a. No. of Companies by Science Parks and Domestic Manufacturing Industry



Source: ibid.,1a

5. Income

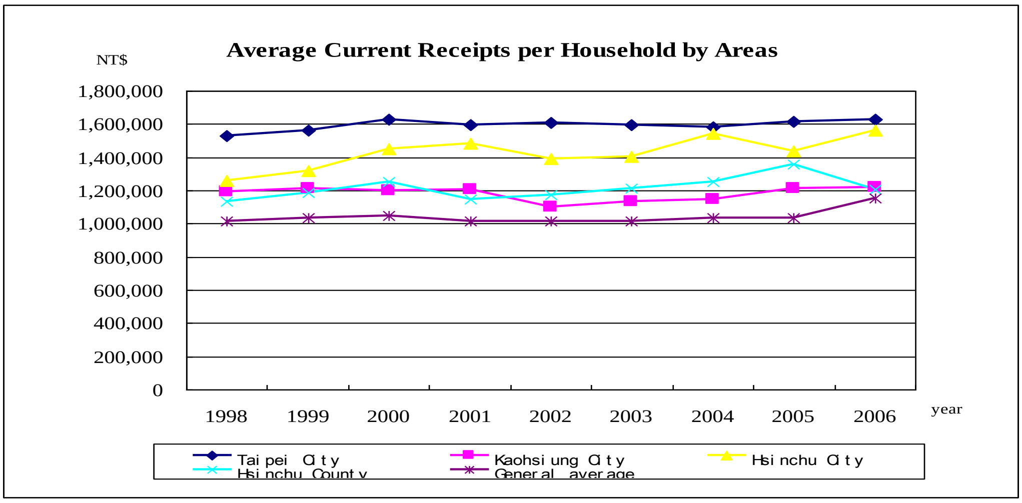
The income indicator is comprised of two sub-indicators: average current receipts per household by areas, average annual disposal income per capita by areas.This indicator shows that:

(1) Between 1998 and 2006, Hsinchu City had an average income per household ranked the second nation wide, exceeding that of Taiwan and Kahhsiung City.

(2) Between 1998 and 2006, Hsinchu City had an average income per household exceeding that of Kaohsiung City starting from 1998, with slight lag behind that of Taipei City.

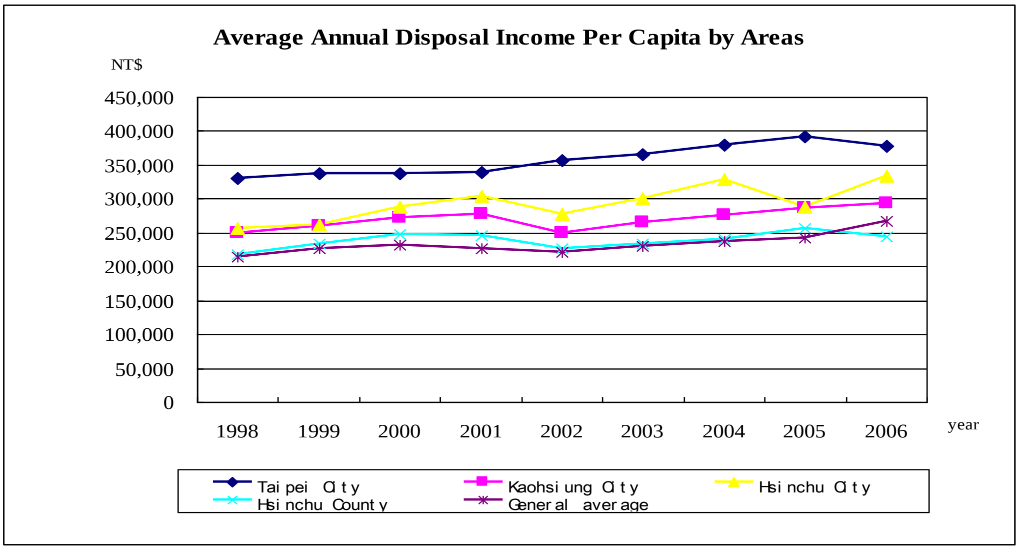
Per-household income sub-indicators:

5a. Average Current Receipts per Household by Areas



Source: Directorate General of Budget, Accounting and Statistics, Executive Yuan, R.O.C.,compiled for this project

5b. Average Annual Disposal Income Per Capita by Areas



Source: ibid.,5a

5.2 Innovation

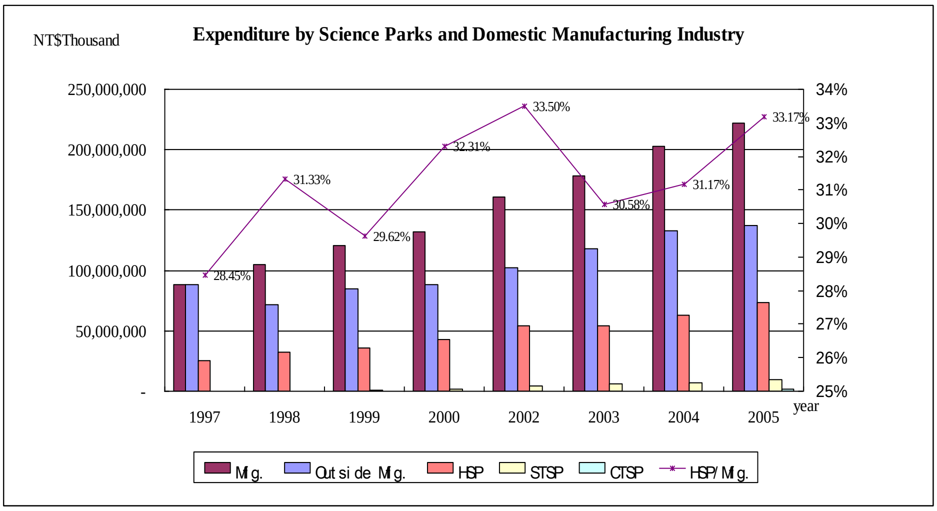
This indicator contains nine figures including R&D expenditure, R&D expenditure ratio, approved patents, technology trade, new business incorporation ,small business innovation research SBIR, with a view to showing HSP's innovation capacity from different aspects of economic achievements.

6. R&D Expenditure

The R&D expenditure indicator is comprised of one sub-indicator: R&D Expenditure by Science Parks and Domestic Manufacturing Industry.This indicator shows that, between 1997 and 2005, both nation-wide and HSP's R&D expenditure was on the rise, with HSP's figure taking up 30% of the nation-wide figure.

R&D expenditure sub-indicator:

6a. R&D Expenditure by Science Parks and Domestic Manufacturing Industry



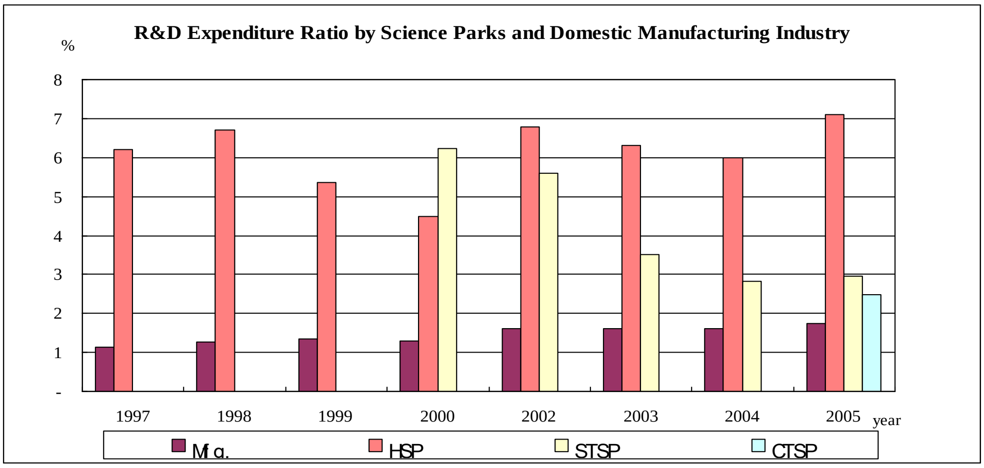
Source: ibid.,1a

7. R&D Expenditure Ratio

The R&D expenditure ratio indicator is comprised of one sub-indicator: R&D Expenditure Ratio by Science Parks and Domestic Manufacturing Industry.This indicator shows that, between 1997 and 2005, HSP's R&D expenditure ratio was 3.5-5.5 times of the nation-wide figure.

R&D expenditure ratio sub-indicator:

7a. R&D Expenditure Ratio by Science Parks and Domestic Manufacturing Industry



Source: ibid.,1a

8. Approved Patents

The approved patents indicator is comprised of two sub-indicators: Top 100 US patent grants, percentage of US patent granted for Hsinchu. These indicators shows that:

(1) HSP's top 100 US patent grants as percentage of the nation-wide figure dropped 10 percentage point from 41.5% in 2004 to 31.7 in 2006.

(2) Between 2002 and 2006, Hsinchu's US patent grants as percentage of the nation-wide figure were 18-22%.

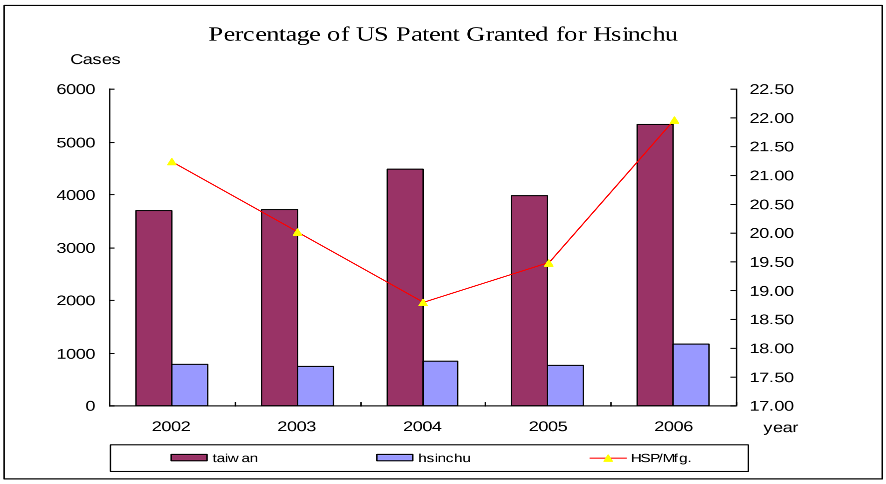
Patent application sub-indicator:

8a. Top 100 Patent Grants

2006	No of HSP	HSP	Mfg.	HSP/Mfg.
Top 10	5	954	2472	38.60%
Top 20	8	1126	3148	35.80%
Top 100	25	1474	4655	31.70%

Source: USPTO, U.S.A.; Business Week, R.O.C.,compiled for this project.

8b. Percentage of US Patent Granted for Hsinchu



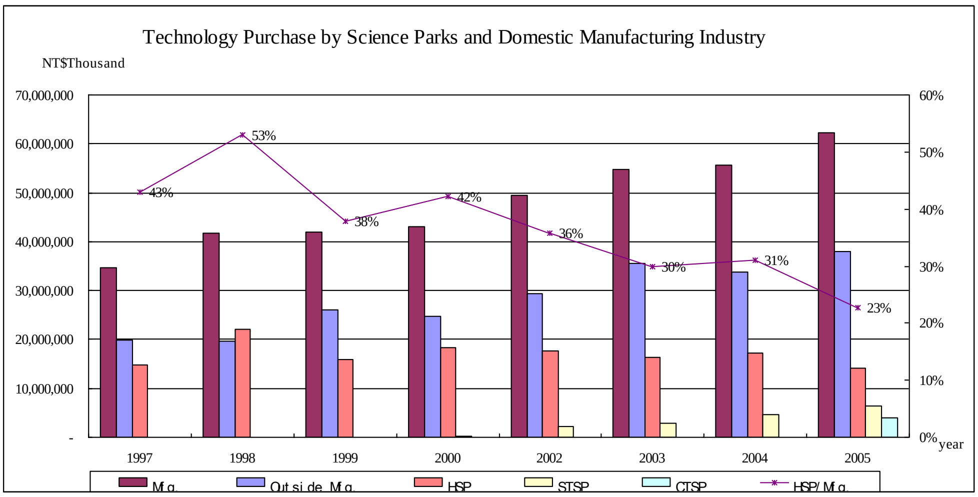
Source: ibid.,8a

9. Technology Trade

The technology trade indicator is comprised of two sub-indicators: technology purchase by science parks and domestic manufacturing industry,technology sale by science parks and domestic manufacturing industry.These indicators show that: Between 2002 and 2005, HSP's technology purchase ratio decrease while technology sale ratio increased, indicating its achievements in the development of independent technology.

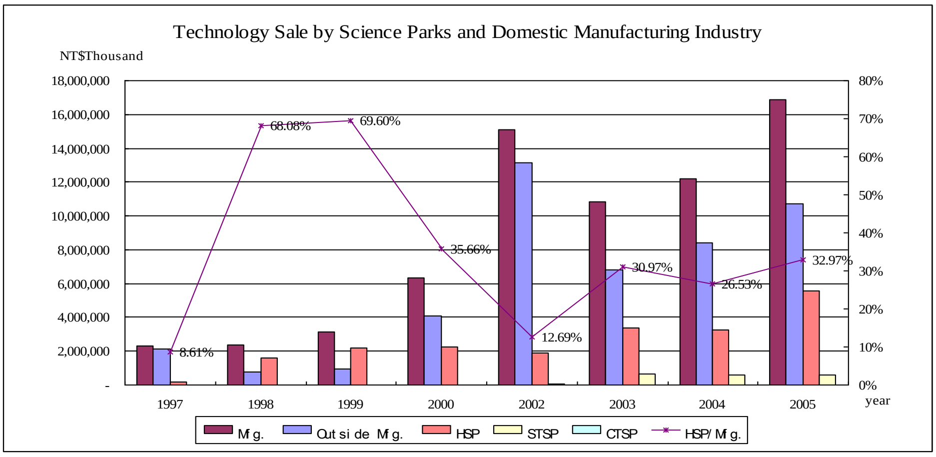
Technology Trade Sub-indicators:

9a. Technology Purchase by Science Parks and Domestic Manufacturing Industry



Source: ibid.,1a

9b. Technology Sale by Science Parks and Domestic Manufacturing Industry



Source: ibid.,1a

10. New Business Incorporation

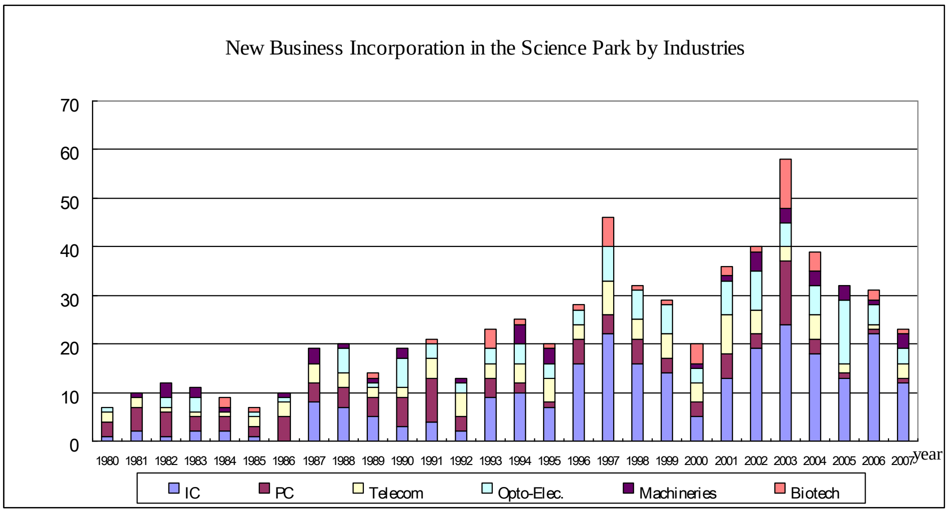
The new business incorporation indicator contains one sub-indicator: new business incorporation in the science park by industries.This indicator shows that:

(1) Since HSP's establishment in 1980, the number of new companies incorporated peaked at 1997 and 2003, with an average of 20-40 new companies formed annually between 1987 and 2007.

(2) Between 1980 and 1990, most of the newly incorporated companies were in the business of personal computer and peripheral industries. The trend was taken over by IC industries after 1990 and the electricoptical industries have been on the rise since 2000.

New business incorporation sub-indicators:

10a. New Business Incorporation in the Science Park by Industries



Source: HSP Adminstration, compiled for this project.

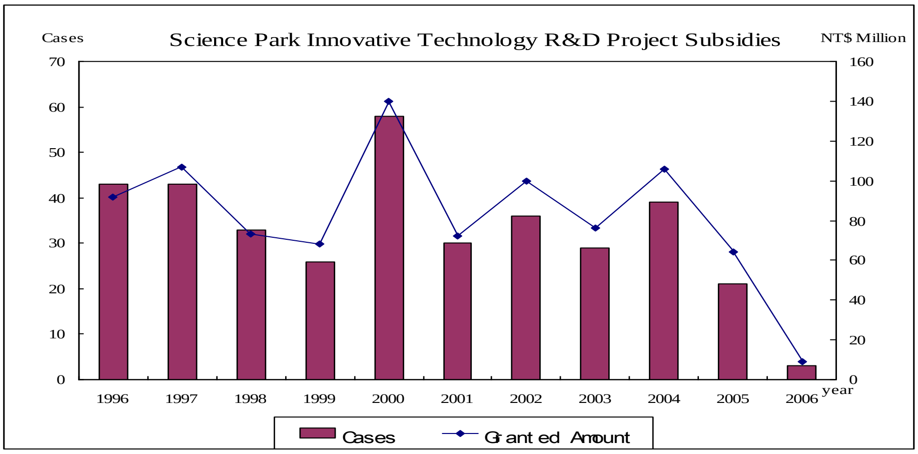
11. Small Business Innovation Research

The SBIR indicator is comprised of two sub-indicators: the science park innovative technology R&D project subsidies and science park innovative technology R&D project subsidies percentage. These indicators show that:

(1) Between 1996 and 2006, the dollar amount and number of R&D projects receiving governmental subsidies peaked at 2000, with trough being in 2006.
(2) Between 1996 and 2006, an average of 25% of R&D projects received governmental grants. Starting in 2001, grants has seen a downward trend.

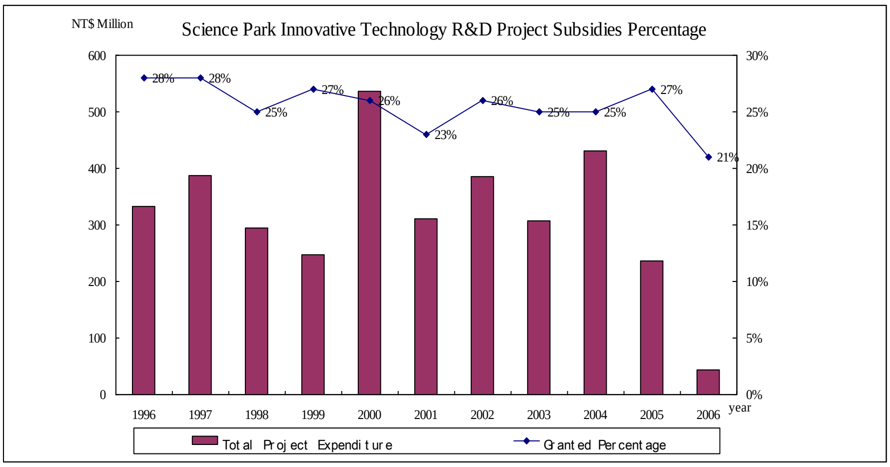
Sub-indicators for Governmental R&D Subsidies:

11a. Science Park Innovative Technology R&D Project Subsidies



Source: ibid.,10a.

11b. Science Park Innovative Technology R&D Project Subsidies Percentage



Source: ibid.,10a

5.3 Talent

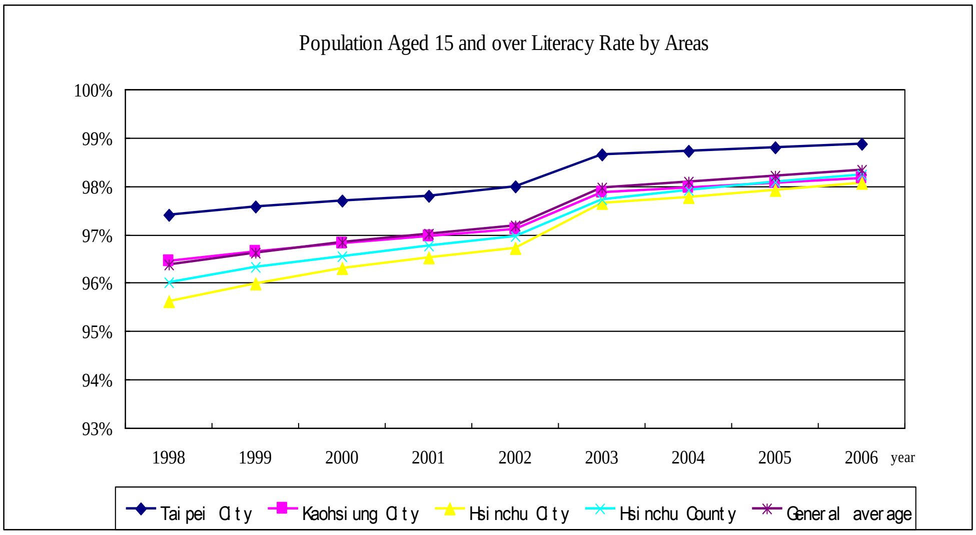
This indicator includes three figures including literacy rate, primary education, higher education, for evaluation of the quantity and quality of HSP's potential human resources.

12. Literacy Rate

The literacy rate is represented by a sub-indicator: Population Aged 15 and over Literacy Rate by Areas.This indicator shows that the Hsinchu population literacy rate slightly lags behind that of Taipei and Kaohsiung, despite its approaching 98% with an ascending trend. The nation-wide statistics show little variations among regions.

Literacy rate sub-indicator:

12a. Population Aged 15 and over Literacy Rate by Areas



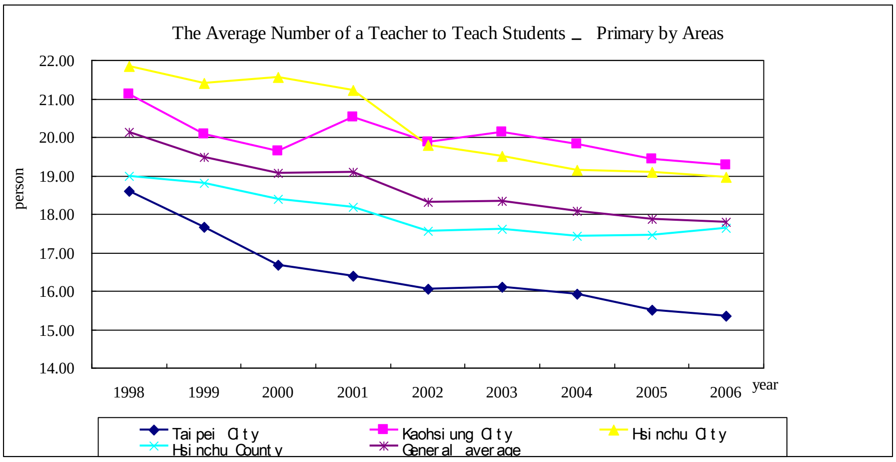
Source: ibid.,5a

13. Primary Education

The primary education indicator is represented by a sub-indicator: The Average Number of a Teacher to Teach Students - Primary by Areas.This indicator shows that Hsinchu's primary education has been steadily enhanced in its quality and scored bettern than Kaohsiung since 2002, but still lags behind that of Taipei and the whole Taiwan area.

Primary Education Sub-indicator:

13a. The Average Number of a Teacher to Teach Students – Primary by Areas



Source: ibid.,5a

14. Higher Education

The Higer Education indicator is comprised of three sub-indicators: the population over the age of 15 higher education -by areas, no. of employees with doctors or masters degrees in the science park and domestic manufacturing industry, no. of employees with bachelors degrees and above in the science park and domestic manufacturing industry.These indicators show that:

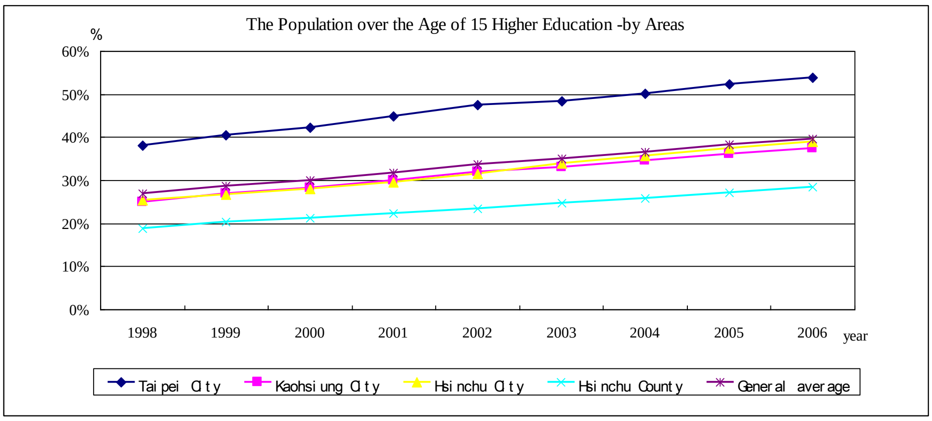
(1) Hsinchu City's population aged 15 and over receiving higher education is of about the same rate as that of Kaohsiung City, slightly higher than that of Taiwan area but lower than that of Taipei City. Hsinchu County has a rate lower than these areas.

(2) Between 2001 and 2006, HSP has a percentage of employees with Master or Phd degrees exceeding that of the domestic manufacturing industry by 14% to 16%.

(3) Between 2001 and 2006, HSP has a percentage of employees with Bachelor's or higher degrees exceeding that of the domestic manufacturing industry by 17% to 20%.

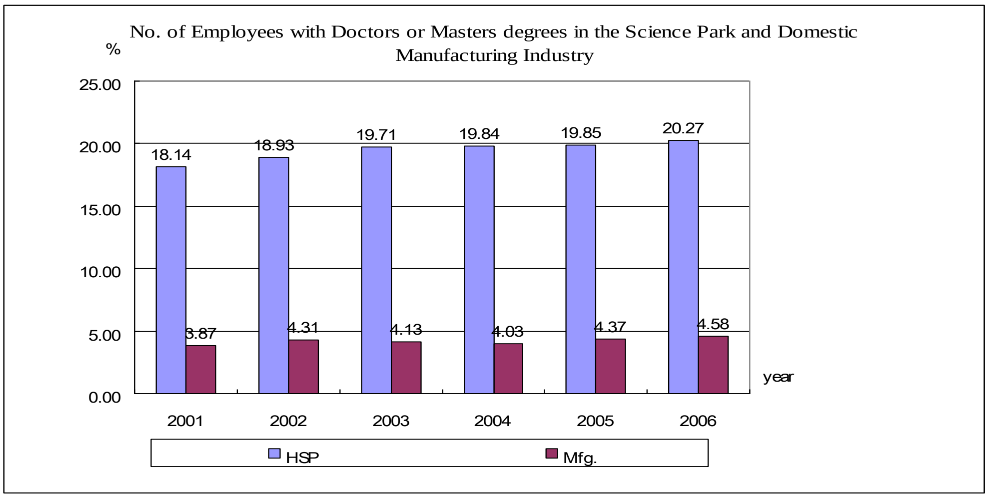
Higher Education indicator:

14a. The Population over the Age of 15 Higher Education - by Areas



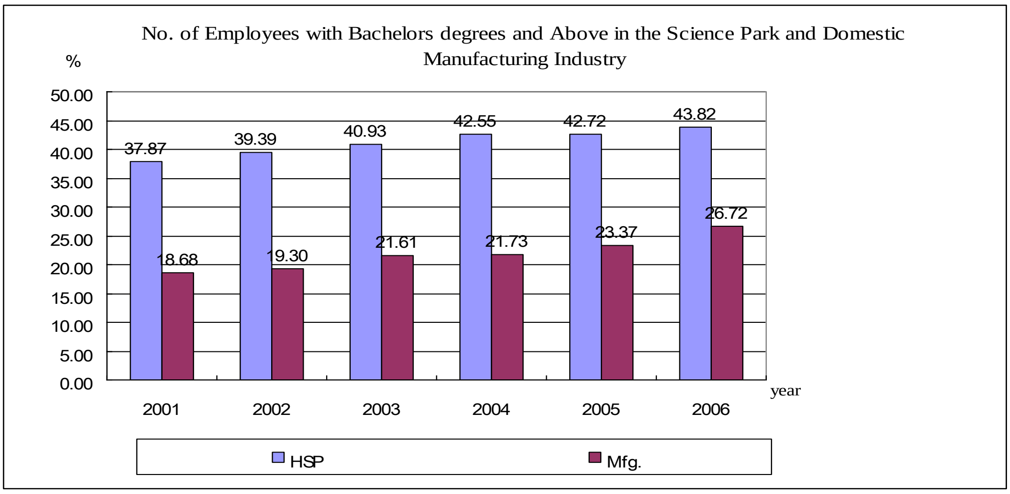
Source: ibid.,5a

14b. No. of Employees with Doctors or Masters degrees in the Science Park and Domestic Manufacturing Industry



Source: ibid., 5a&10a

14c. No. of Employees with Bachelors Degrees and Above in the Science Park and Domestic Manufacturing Industry



Source: ibid.,14b

5.4 Environment

This indicator is comprised of five figures including specialty, science and technical service, vacancy rate ,internet utility ,public servant ,air quality to assess the quality of HSP's hardware and software environment

15. Specialty, Science and Technical Service

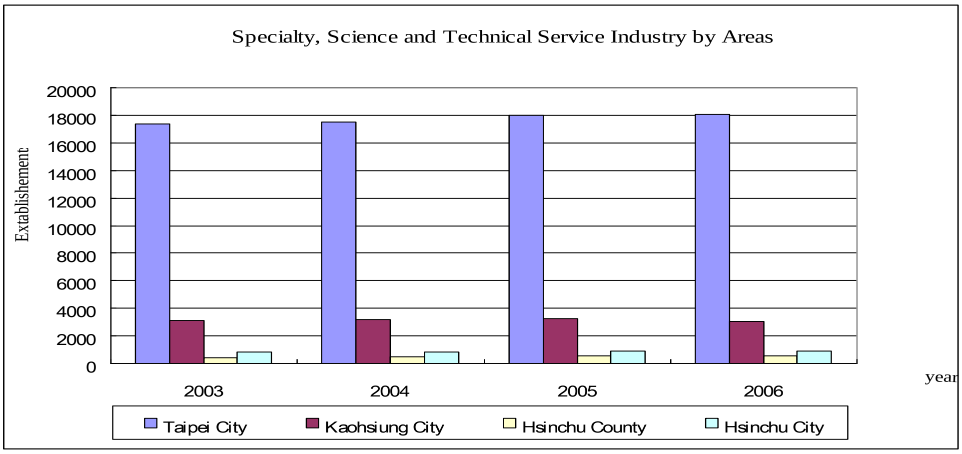
The specialty, science and technical service indicator is represented by a sub-indicator: Specialty, Science and Technical Service Industry by Areas.The indicator shows that:

(1) There are 883 services in 2006, compared to 833 in 2003, for Hsinchu City. There are 555 services in 2006, compared to 410 in 2003, for Hsinchu County.

(2) The rate of growth is 35.37% for Hsinchu County and 6.0% for Hsinchu City, compared 3.95% for Taipei City and -3.2% for Kaohsiung City.

Specialty, science and technical services sub-indicator:

15a. Specialty, Science and Technical Service Industry by Areas



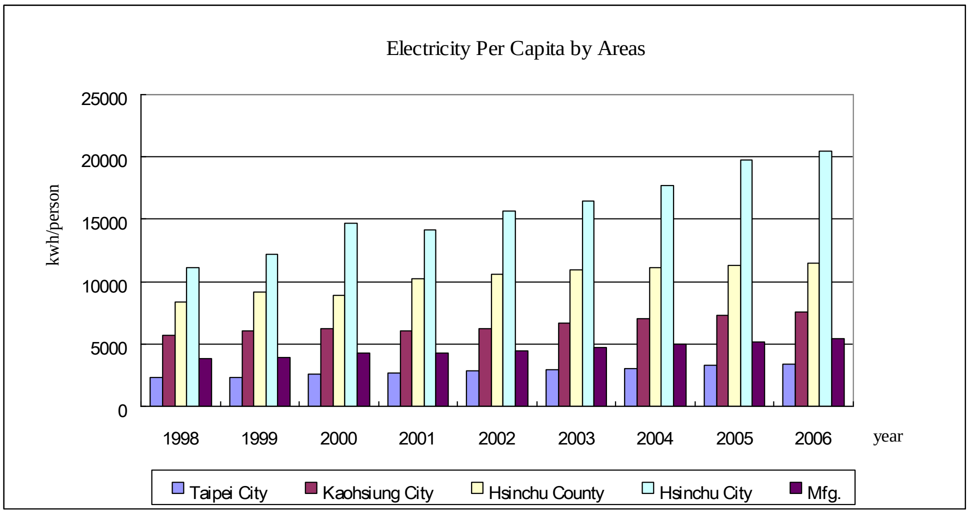
Source: Ministry of Economic Affairs, R.O.C.,compiled for this project

16. Electricity

The electricity indicator is represented by a sub-indicator: Electricity Per Capita by Areas.The indicator shows that Hsinchu City has a constantly growing demand for electric power at a rate similar to that of Taipei City, Kaohsiung City and the whole nation. However, both Hsinchu City and Hsinchu County have an annual compound growth rate far exceeing Taipei City, Kaohsiung City and nation-wide figures.

Electricity sub-indicator:

16a. Electricity Per Capita by Areas



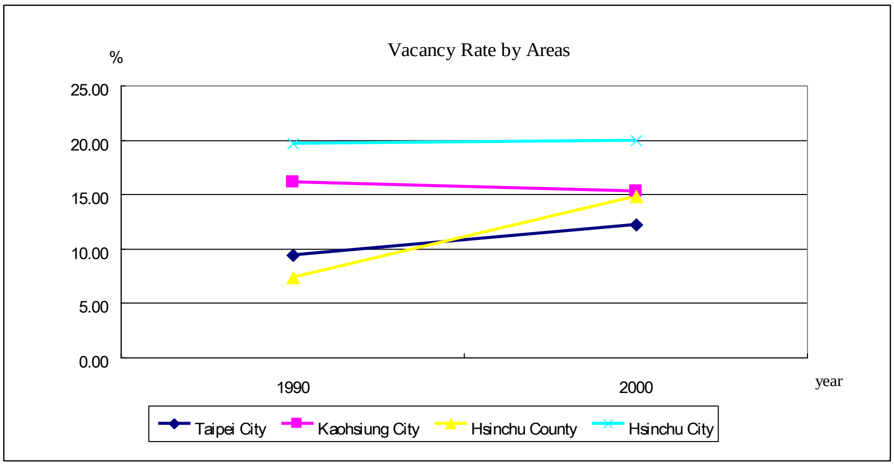
Source: Taiwan Power Company,compiled for this project

17. Vacancy Rate

The vacancy rate has one sub-indicator: vacancy rate by areas. The indicator shows that Hsinchu City's vacancy rate has been descending in the past decade while Taipei City's, Kaohsiung City's and nation-wide vacancy rates have been rising.

Vacancy Rate Sub-indicator:

17a. Vacancy Rate by Areas



Source: 1. :ibid.,5a
2. The census is conducted every 10 years.

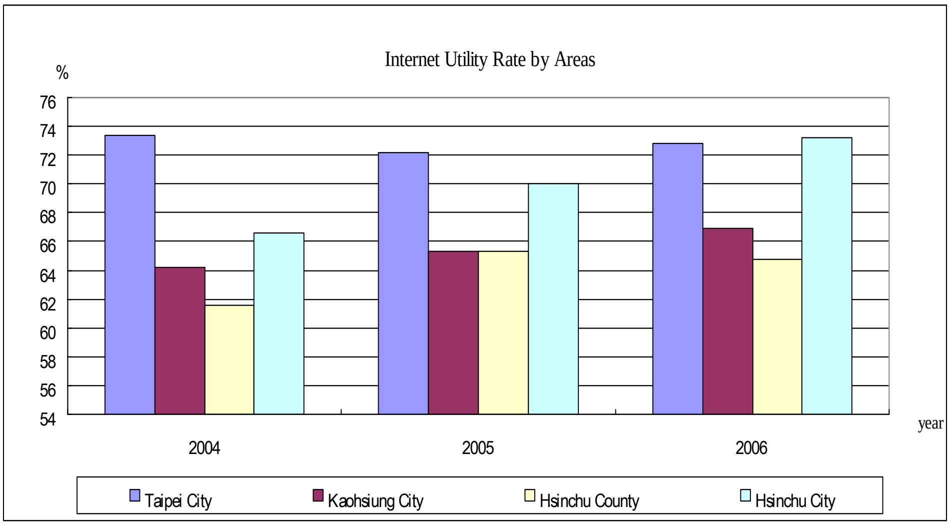
18. Internet Utility

The Internet utility indicator contains two sub-indicators: internet utility rate by areas, percentage of household with internet facility by areas.These indicators show that:

(1) Hsinchu City has an Internet utility rate of 73.2% in 2006, exceeding Taipei City's 72.8%
(2) Hsinchu City has 69.5% of household with Internet facility in 2006, ranked the second in the nation-wide figures, slightly lagging behind Taipei City's 72.4%.

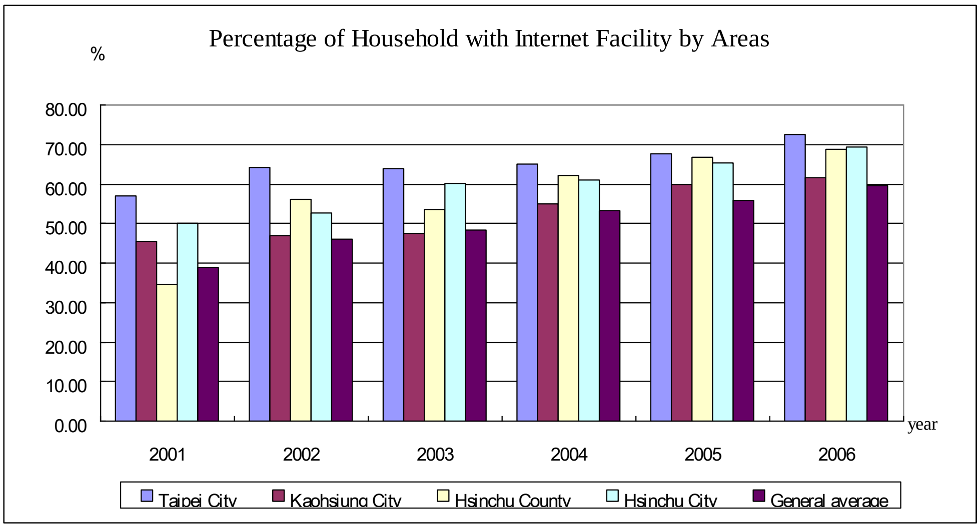
Internet Utility sub-indicators:

18a. Internet Utility Rate by Areas



Source: 2006 Digital Divide Report on Taiwan and Fukien Areas, published by Research, Development and Evaluation Commission, Executive Yuan

18b. Percentage of Household with Internet Facility by Areas



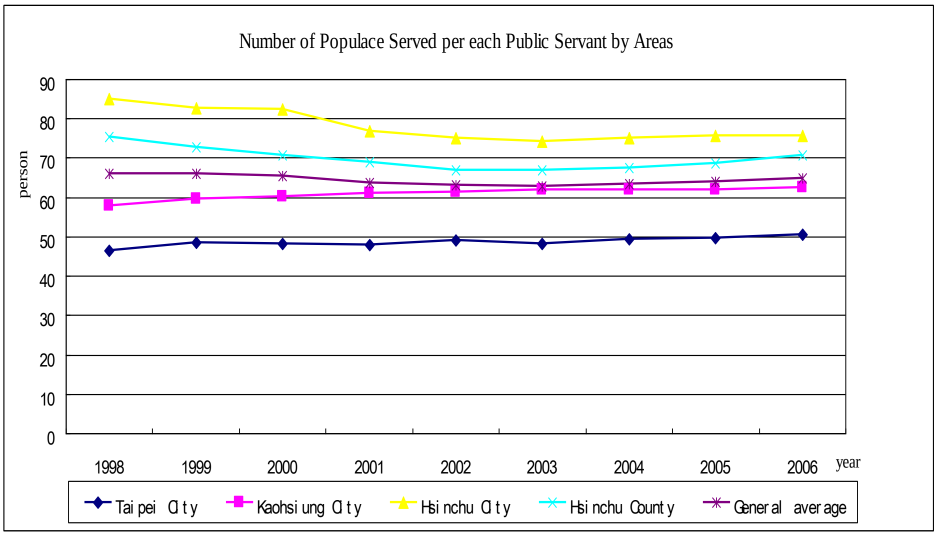
Source: ibid.,18a

19. Public Servant

The public servant indicator contains one sub-indicator: number of populace served per each public servant by areas.This indicator shows that:The number of populace served per each public servant was descreaing in Hsinchu City and Hsinchu County, while increasing slightly in both Taipei City and Kaohsiung City.

Public Servant sub-indicators:

19a. Number of Populace Served per each Public Servant by Areas



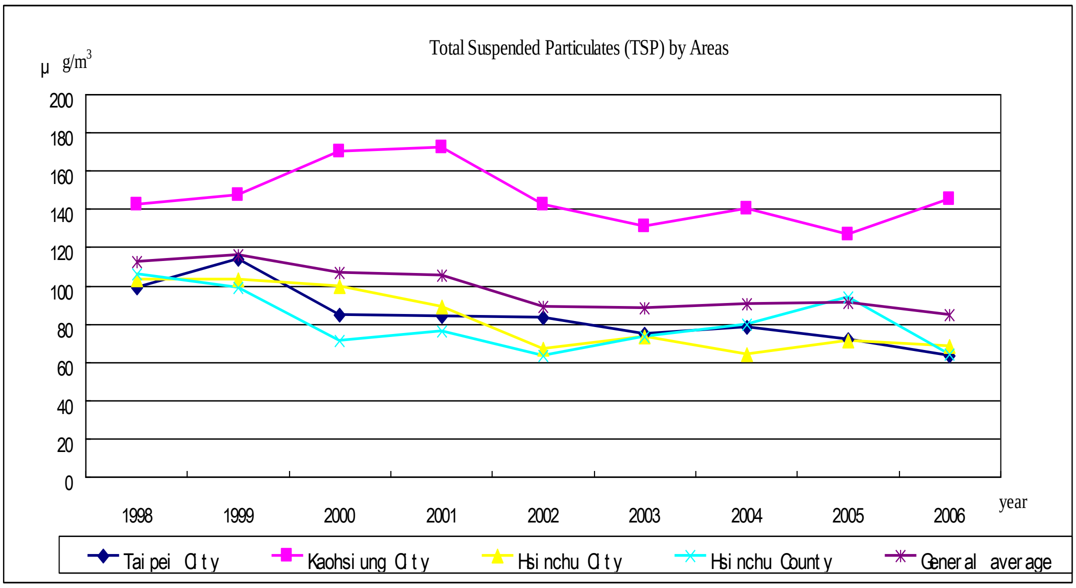
Source: ibid.,5a

20. Air Quality

The air quality indicator contains one sub-indicator: total suspended particulates (TSP) by areas.This indicator shows that:Kaohsiung City ranked first in 2006 in the total suspended particulates by areas, followed by Taipei City and Hsinchu City in sequence, with Taiwan area being the lowest.

Air Quality sub-indicators:

20a. Total Suspended Particulates (TSP) by Areas



Source: ibid.,5a

VI. Conclusion and Recommendations

This paper analyzes the arising of industrial clustering effects based on a framework of innovation formed of four factors, from which Hsinchu City receives the most significant impact, followed by Hsinchu County. In the following are described some of the specially manifested features:

1. Economy: HSP's total employment exceeded 100 thousands people since 2000, taking up over 50% of Hsinchu County's total employment since 2006, which means one out of every two employments in Hsinchu County was working in HSP. The average wage of HSP's employees exceeds the nation-wide figure by 40%-60%, making Hsinchu City's income and consumption top in Taiwan area. In 2006, Hsinchu City's average annual disposable income per household ranked the second among the nation-wide figures, being second to Taipei City. (Only Taipei City and Hsinchu City have disposable income per household exceeding NT$1 million.) Hsinchu City's average annual disposable income per capita was also second only to Taipei City's, with income from employment per household exceeding Taipei City's, topping those of Taiwan area. In 2006, the average consumption per household exceeded Taipei City's to top those of Taiwan area. On the hand, Hsinchu City's labor participation rate in 2006 reached 60.8%, the highest figure in six years and topping those of Taiwan area. The female labor participation rate also ranked the first nation-wide. Additionally, the unemployment rate was dropping in the fifth consecutive year. HSP's impact on local economies is obvious.

2. Innovation: HSP's R&D expenditure is about 30% of total national R&D expenditure. Its technology purchase and sale is also about 30% of the total national figures, with raito of purchase gradually exceeding ratio of sale. HSP's US patents granted is over 20% of total national figure. Among the national top 100 companies in terms of R&D expenditure and patents granted, more than 30 are in HSP. Combining the peripheral academic institutions such as ITRI, National Applied Research Laboratories, National Tsinghua University and Nationa Chiaotung University, Hsichu has established its position as Taiwan's innovation industrial cluster.

3. Talent: HSP has a percentage of employees with higher education (those with Master or Phd degrees) far exceeding that of the domestic manufacturing industry. HSP has actually pooled many of Taiwan's top-class talents (especially in the field of science and technology).

4. Environment: Hsinchu City tops in the nation-wide power consumption, both in production and in daily lives. It also exceeds Taipei City in 2006 and 2007 to top in the nation-wide ranking of degree of being digital. It is the top city of digital development, with leading Internet utility indicators. Hisnchu City also shows well developed hard and soft infrastructures, revealed by the nation-wide top ranking number of populace served per each public servant and environmental (air) quality.

Apart from research institutions and universities into the future should be included in a number of important indicators are as follows:

1. Environment indicators
2. Revenue indicators
3. IPOs and M&A indicators
4. Investment capitals indicators
5. Human resource indicators

6. Housing prices and the percentage of owned houses

Indicators need to be dynamically adjusted for quick response to globalization and to compete in fierce market domestically and abroad. In the following are listed some suggestions with regard to strengthening talents, capital and technology of the clusters.

1. HSP needs to establish its own innovation habitat

HSP has successfully incubated Taiwan's high-tech industries through the development stage, with achievements mainly focused in manufacturing. For ongoing and sustainable growth into the future, sources must be cultivated for technology innovation. HSP's international connection, one of its critical relied-on factors, is facing ever-growing challenge as a result of economic globalization and emergence of competitors. HSP is therefore in urgent need of more decisive advantage in order to boot its industrial competitiveness globally. Decisive advantage can be achieved through, besides establishing the aforementioned advantageous conditions, focusing on the stragegy based on the perspective of innovation economy to reinforce clustering effects of existing enterprises as well as to transform HSP into an innovation habitat that will host promising new enterprises. This environment will then enhance innovation activities among existing enterprises and attract innovative enterprises by the industrial clustering effects. The result will be synergetically augmented innovation cluster effects.

2. HSP needs to become the community for talents of science and technology in global economy

Talents apparently are more discriminative than technology and capital in their seeking of right environment to move to. Even if technology and capital may make short-term movement according to the condition of resources, they eventually follow talents to settle somewhere. This applies in the cross-strait economic interaction as well. Variations in economic conditions like cost and market will inevitably drive more Taiwan businessmen to invest in China for production, while Taiwan's clustering environment is critical in maintaining a talent advantage. Even with high mobility due to globalization, the Taiwan talents in science and technology will still see HSP as an ideal hometown so long as it provides them with a good living environment.

HSP will continue functioning as the vitality source for Taiwan's enterprises by maintaining entrepreneur innovation, attracting local and foreign talents, and attracting venture capitalists. Besides improving the quality of education and proposing measures for recruiting foreign talents, the capability to attract outstanding foreign students to study in Taiwan will allow HSP to sustain subsequent attraction, generation and exchange of global talents, creativity and business practices.

3. Government needs to be proactively implementing the development

The government may have to guide or coordinate manufacturers to focus on the development of certain key industries. Examples of these kinds of efforts include HSP, the IC , TFT-LCD policy and biomedical industries.

Land planning is a critical condition for the formation of an industrial cluster. The government used to complete the construction of an industrial zone before recruiting of enterprises, without first considering the special industrial clustering needs of manufacturers. In recent years, the government has changed its way of dealing with such issues by quickly providing cluster-effective lands to enterprises according to their needs.

The government should also assist existing or developing industrial clusters of which the lacked key and coordinating industries need to be attracted.By taking advantage of the high-speed railway transportation and the major investments made in the vicinity of the high-speed railway stations, the Western Taiwan district will become an area where many enterprises and releated industries can easily connect with each other to attain ultrahigh clustering effects that are rarely seen elsewhere globally. Such an advantage will enable Taiwan to maintain its strong industrial cluster competitiveness.

Based on the above observation and the analysis of various trends, Taiwan is in urgent need of a set of well constructed innovation cluster indicators, as well as continued long-term efforts in the accumulation and comparison of data for these indicators. The future study should be directed towards the adjustment of the indicator set and establishment of new indicators, along with comparison on international basis. The purpose is to establish a meaningful set of innovation cluster indicators through which industries, academic institutions and governmental organizations can achieve better and clearer global positioning when doing planning and making decisions.

XXV IASP World Conference 2008

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

Plenary Session 1:

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 precision machinery medical instrument and materials semiconductor equipment computers and peripherals micro-electro-mechanical systems (MEMS) industries
Semiconductor zone	microwave communication semiconductor power electronics special-purpose integrated circuit industries
Agricultural biotechnology zone	flowers and ornamental plants biopesticide livestock vaccine 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

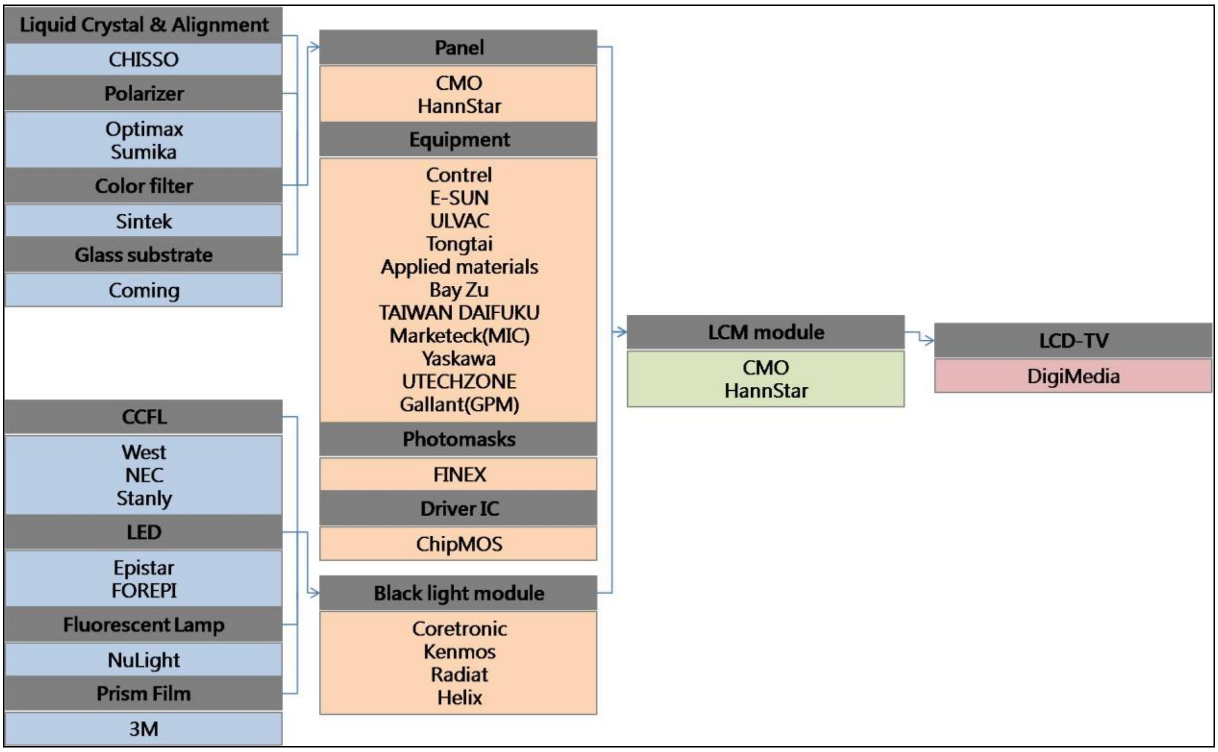
Source: adopted from www.stsipa.gov.tw/web/

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

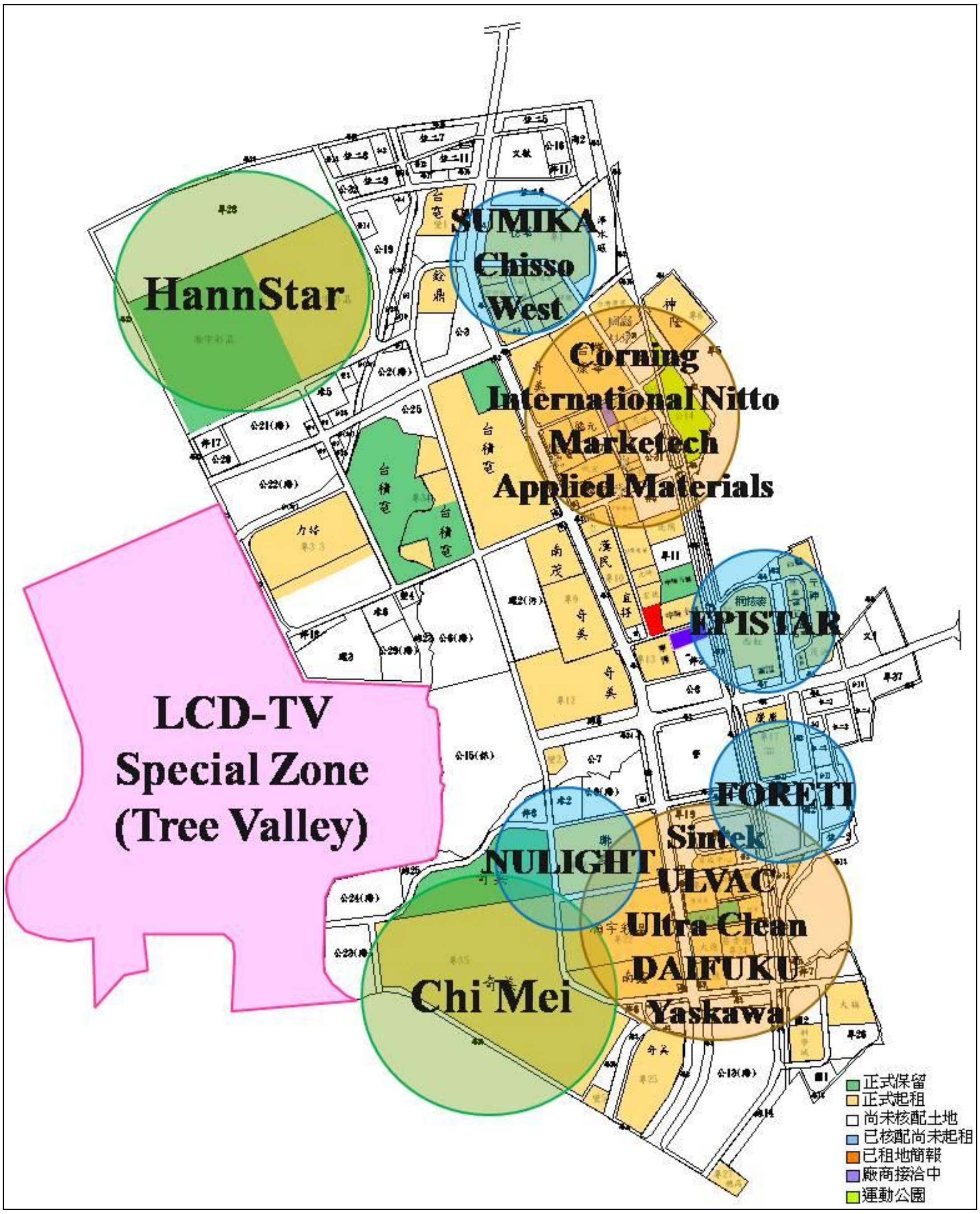
Product \ Place	Tainan SP	Taichung SP	Hsinchu SP	Taoyuan County
Black light module	5	1	1	3
Color filter	2	1	3	1
Driver IC	1	1	4	0
ITO glass	1	0	2	0
Liquid crystal	1	0	0	1
Panel polish	1	1	0	0
Polarizer	3	1	1	3
CCFL	5	1	0	1
Glass substrate	2	2	1	1
Photo mask	1	0	2	0
Prism film	1	0	0	0
LCD panel	2	2	4	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/

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The Planning Experience of TFT-LCD Industrial Cluster in Southern Taiwan Science Park

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Abstract

Taiwan has been vigorous with building science parks since 1980s. Besides the successful experience in Hsinchu Science-Based Industrial Park (HSIP), Southern Taiwan Science Park (STSP), which was established northeast to Tainan City in 1997, expanded and renamed as Southern Taiwan Science Park (STSP) in 2003, already become an important high technology industrial district in Taiwan and one of the world-class TFT-LCD industrial clusters. The output of Opto-Electronics industry is about 34 trillion US dollars in 2005 in which TFT-LCD industry occupied about 55 % of its output value and ranked number 2 all over the world. No more than 10 years, TFT-LCD already can compete with IC industry in Taiwan which developed over 20 years until now. Therefore, it is no doubt that TFT-LCD industry has great potentiality and already becomes the domestic industry and the core of government policy to promote the southern region development.

Due to the entrance of flagship company, CHIMEI, cooperation with different actors and different planning effort, STSP has constructed a TFT-LCD industrial cluster which has complete upstream and downstream industries of TFT-LCD production. However, rather than growing directly from the original blueprint, this recently burgeoning science park has struggled its way and adapted to many situations that had not been foreseen in the mid-1990s. But how it is developed and success is still a pandora's box needed to be conceptualized in the planning field on combing science park development with industrial clusters. Therefore, this paper focuses on understanding the planning process of how to govern the formation of STSP with industrial clusters, especially in the context of the confliction between different development goals, actors, institutions and ways to govern in city-region scale.

Key words: Southern Taiwan Science Park (STSP), Industrial Cluster, Planning Process

1. Introduction

Clusters have become a popular key word and new planning concept of discussion and analysis in contemporary debates on urban and regional development including "Third Italy", "Silicon Valley", and "Hsinchu Science-Based Industrial Park (HSIP). Regarding the theory of industrial cluster, there are many significant literatures highlighting the importance of the firm clustering in space. From Marshall's external economy, agglomeration economics studied by Weber and Hoover, Porter's analysis of national competitive advantage, to Saxenian (1994)[1] compared the case between Silicon Valley with Route 128. Porter (1990)[2] in his book "National competitive advantage" indicated that the competitive advantage in nation is dependent on their competitiveness, meanwhile, the cluster which has the external economy, innovation and cooperation effect, just could be the driving force to promote national and regional economy development. Therefore, how to promote the formation, development and upgrade of cluster, and make a cluster-based policy, is already becoming a hot issue in the planning field.

Tainan Science-Based Industrial Park was established in Tainan City of 1997, expanded and renamed as Southern Taiwan Science Park (STSP) in 2003. It now has 110 tenant companies in operation and a total of 47,006 employees in the park by 2006, total revenue of industries reached USD 12 billions in 2006. Undoubtedly, it is now an important high technology industrial district in Taiwan and one of the world-class TFT-LCD and Integrated Circuits industrial clusters. But how it is developed and success is still a pandora's box needed to be conceptualized. Therefore, the purpose of this paper is trying to combine the science park planning with cluster context to unfold the forces and processes that contribute (or failed to contribute) to the formation and development of high technology industrial cluster in Tainan.

2. Theory of Cluster and Science Park Planning

"High technology industrial cluster" is a combination of two terms welcomed by many – high technology and industrial cluster. Moreover, it has to be carried out in space. Since 1980s, the "high tech fever" or "high-tech fantasies" have swept most of the world (Makusen et al, 1986[3]; Massey et al, 1992[4]); and following Porter (1990), industrial cluster have become one of the hottest research and policy fields since 1990s (OECD, 1999, 2001)[5]. There are many ways to develop high technology industrial cluster in the spatial planning disciplines. Therefore, the following will be discussed the

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[1] Saxenian, A., 1994, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Cambridge MA: Harvard University.

[2] Porter, Michael E., 1990, *The Competitive Advantage of Nations*, New York: Free Press.

[3] Markusen, A., Hall, P. and Glasmeier, 1986, A., *High-Tech America: the what, how, where and why of the sunrise industries*, Boston, Allen & Unwin.

[4] Massey, D., Quintas, P. and Wield, D., 1992, *High-Tech Fantasies: Science Parks in Society, Science and Space*, London, Routledge.

[5] OECD, 1999, *Boosting Innovation: The Cluster Approach*.
OECD, 2001, *Innovative Clusters: Drivers of National Innovation Systems*.

two key concepts, cluster and spatial developing pattern briefly.

2.1 Cluster Development in Spatial Context

The emergence of industrial cluster concept can be traced to the late 19th century and Alfred Marshall's observations about industrial district in the UK (Marshall, 1890)[6]. According to his concept, when the firms start agglomerating in one place, it will produce the competitive advantage in terms of the phenomenon with specialized skills, subsidiary industry and technological spillovers (Krugman, 1991)[7]. Weber (1929)[8] proposed the agglomeration economics which emphasized the co-location can reduce operation cost by internal and external economics. These theories provide the important theoretical explanation about why firms have to concentrate in one place, and then indicate the ability to control the markets and production inputs will determine whether the concentration would happen. Maurel and Sedillot (1999)[9] also found that some highly firm-density areas in US and Japan have highly positive influence on their productivity.

In the early literatures, the term of cluster is similar to agglomeration, meanwhile, there are many scholars proposing different points. Saxenian (1994) discussed two experiences between Silicon Valley and Route 128 to describe the point that agglomeration can't completely explain why two regions under the same geographic concentration developed totally different. Therefore, Hill and Brennan (2000)[10] provided a detail definition in terms of competitive advantage and production chain. Industrial cluster with competitive advantage can develop a force to stimulate local and regional development in which cluster is a geographic concentration of competitive firms or establishments in the same industry that either have close buy-sell relationships with other industries in the region, use common technologies, or share a specialized labor pool that provides firms with a competitive advantage over the same industry in other places. Form the above definition, we can find that the firms with competitive advantage concentrating in one place not only could reduce the production cost in common, but also create the competitive advantage by fierce inter-firm competition and knowledge diffusion. Hence, critical to a region's moving to the next stage of development is that the indigenous industry begins to generate cluster economies.

2.2 Science Park Development Pattern

There are many ways to develop industrial cluster in the spatial planning disciplines, various kinds of planned development arouse: science park, technopolis, technopole, among others. Many

6 Marshall, A., 1890, *Principles of Economics: An Introductory Volume*, New York: Free Press.
7 Krugman, P., 1991, *Geography and Trade*, Cambridge, MA: MIT Press.
8 Weber A., (1909) *Uber den Standort der Industrien* ,translated by FRIEDRICH C. J. ,1929, *Alfred Weber's Theory of the Location of Industries*, University of Chicago Press, Chicago), translated in Chinese, http://www.hcclib.net/pdf/default.htm.
9 Maurel F. and Sedillot B., 1999, A measure of the geographic concentration in French manufacturing industries, *Regional Science and Urban Economics*, 29(5): 575-604.
10 Hill, E. W. and Brennan, J. F., 2000, A Methodology for Identifying the Drivers of Industrial Clusters: The Foundation of Regional Competitive Advantage, *Economic Development Quarterly*, 14 (1): 65-96.

researchers have tried to categorize these mushrooming projects since early 1980s, Kung (1995)[11] collected and compared fourteen such attempts published between 1982 and 1994, in that collection of English literature, technopolis only came into the scope of such studies after 1991. Table 1 shows a selection of three category systems between 1991 and 2001. In this paper, I will discuss two development types - science park and technopolis in the context of Taiwan, while the former is existent and important to Taiwan's high tech economy, the latter is still in the making.

Table 1 Selected Category Systems of Science Park and Technology Related Project

Author	Couvidat & Guisti (1991)[12]	Castells & Hall (1994)[13]	ULI (2001)[14]
Generic Name	Technople (fr.) Science park (Eng.)	technopole	Business park
Categories (selected)	Incubator Business park Science park Technopolis (*technopôle*) Technopolis (*technopole*)	Science city Technology park Technopolis Techno-city	Industrial park Logistics park Research park (science park) Technology park Incubator park

In academic or professional arena, there is no globally accepted definition for either science park or technopolis. Science park definitions set by International Science Park Association (IASP) and Association of University-related Research Park (AURRP) have been widely adopted in literature. Some researchers gave science park a broader meaning, that is, to use it as the generic term to cover a range of high technology industry development types (Kung, 1995); others identify it as one specific type among the related industrial development categories (Couvidat and Giusti 1991; Castells and Hall, 1994; Spolidoro, 1998[15]; ULI, 2001). Couvidat and Giusti (1991) defined science park as "a model of organization for technopolis based on Anglo-Saxon tradition of university campuses, established on the outskirts of towns". Therefore, it is concentrated on "creation of pole of competence within specialized areas" different with the French-Japanese tradition in which it tries to integrate activities of different economic and academic sectors "over all urban services of the metropolis".

In Asia, technopolis was first invented in Japan and developed by MITI as an innovation-based regional policy tool in 1980 (Castells and Hall, 1994). The idea was soon directly introduced to its East

[11] Kung, S. F., 1995, *The Role of Science Parks in the Development of High Technology Industries: With Special Reference to Taiwan*, Cambridge, University of Cambridge, unpublished PhD Thesis.
[12] Couvidat, Y. and Giusti, J., 1991, *Science Parks: An International Atlas*, Paris, Syros.
[13] Castells, M. and Hall, P., 1994, *Technopoles of the World: The Making of 21st Century Industrial Complexes*, London, Routledge.
[14] ULI, 2001, *Business Park and industrial Development Handbook*, Washington, D. C., Urban Land Institute.
[15] Spolidoro, R., 1998, "The Paradigm Transition Theory: A Tool for Guiding Technopolitan Transformations", in Formica, P. and Taylor, D. (eds.), *Delivering Innovation: Key Lessons from the World-wide Network of Science and Technology Parks*, IASP.

Asian neighbors, including Taiwan. It already became a starting point for the study of effectiveness of different kind of planned project on the formation of high technology industrial cluster. Among the typology and comparison of various categories of planned high technology industrial development, Spolidoro's (1998) thought technopolis is a much more complex entity than science park, to move up the ladder to become a technopolis, a science park has to increase its efforts on: 1) promotion of research and industrial synergy at a regional scale, 2) establish an innovative regional planning and administration, and 3) make a regional project for the future. But in the past literatures, it still less to discuss the planning process of how to plan a successful cluster in science park.

3. Science Park Development in Taiwan

As a late-comer in industrial development, Taiwan started its way on high technology industrial cluster building, as a strategic trajectory leap forward in industrialization, and selected from advanced industrial societies the development strategies perceived as suitable to the island. United States and Japan in particular, have been the focus of such studies.

Economic decision-makers and planners in Taiwan had foreseen the need to upgrade its industrial structure from labor-intensive to technology-intensive in mid-1960s, and even before Porter's concept of industrial cluster, the growth pole and growth center prevailed in 1960s and 1970s and Taiwan's practice in export processing zone had led to the thought of building a new type of facility. Taking IIT as example in countering brain-drain, then Minister of Economic affairs K.T. Li (1969) raised the idea of "research park" to enhance cooperation between academic institutions and industries in order to stimulate the birth of technology-intensive industries. This is the forerunner of science park in Taiwan, and eventually the concept was transformed into the Industrial Technology Research Institute (ITRI) in 1973, which has played important role in the development of high technology industries and science parks in Taiwan. The concept of science park was re-introduced to Taiwan in 1976 when Premier C. K. Chiang commenced the planning and construction of "Hsinchu Science-Based Industrial Park (HSIP)", it was clearly a follower of American research park model and instructed by advisory experts from Research Triangle and other US parks (Kung, 1995), to build a campus-like environment on a large tract of land for science-based industrial activities.

HSIP was established in 1980, in the beginning, it was not generally considered as a realistic approach, against Taiwan's contemporary labor-intensive industrial structure and low per capita GDP. However, when it painstakingly overcame two downturn cycles and started fast-growing in late 1980s, the park administration SIPA soon found it difficult to acquire land for further expansion because of landowners' resistance. As industrialists from local and overseas started to recognize Taiwan's potential in high technology industries, HSIP became the hotspot of investment inquires, and SIPA began to face great pressure and started its new mission of finding potential site outside of Hsinchu for expansion. Tainan was eventually chosen as the site for the second science park project, but through a period of fierce battles among candidates. The island-wide local interest in attract science park project did not cease after the first competition between 1989 and 1993, many new proposals came up with local and central elections, some did find a good opportunity and received positive reaction from central government. Thus, gradually, the number of science park project accumulated, some are proposals to accommodate spill-overs from existing parks, some are initiatives to form new clusters. For the convenience of management, NSC and SIPA organized them into three groups in 2004 – Northern, Central and Southern Taiwan Science Parks, the oldest and biggest science park within each cluster serves as the mother park and regional administration center, other sites as satellite parks (Table 2, Figure 1). In 2006 total number of science park in operation, construction and planning mounted to twelve, Premier J. C. Su ordered NSC to organize a special team to evaluate the situation.

Table 2 Science Park Projects in Taiwan

	Name	Year	Area (ha)	Target Industries
Northern Taiwan Science Park	Lungtan S.P.	2004	76	LCD
	Hsinchu S.P.	1980	632	IC,C&P,OE,TC,PM,BT
	Hsinchu B.P.	2003	38	BT
	Chunan S.P.	1999	138	IC,C&P,BT
	Tungluo S.P.	1999	353	Defense industry
	Ilan S.P.	2004	592	TC
Subtotal	**1829**			
Central Taiwan Science Park	Houli S.P.	N/A	246	IC,OE
	Taichung S.P.	2002	413	OE,BT,PM,IC
	Huwei S.P.	N/A	97	OE,LCD
	Yunlin S.P.	2003	97	BT,OE,TC
Subtotal	**853**			
Southern Taiwan Science Park	Tainan S.P.	1995	1038	OE,BT,IC
	Kaohsiung S.P.	2000	570	OE,TC,BT
	Kaohsiung B.P.	2004	8	BT,MED
Subtotal	**1616**			
Total	**4298**			

Note: BT – biotechnology, C&P – computer & peripherals, LCD – TFT-LCD,
Med – medicine, OE – opto-electronics, PM – precision machinery,
TC – telecommunications

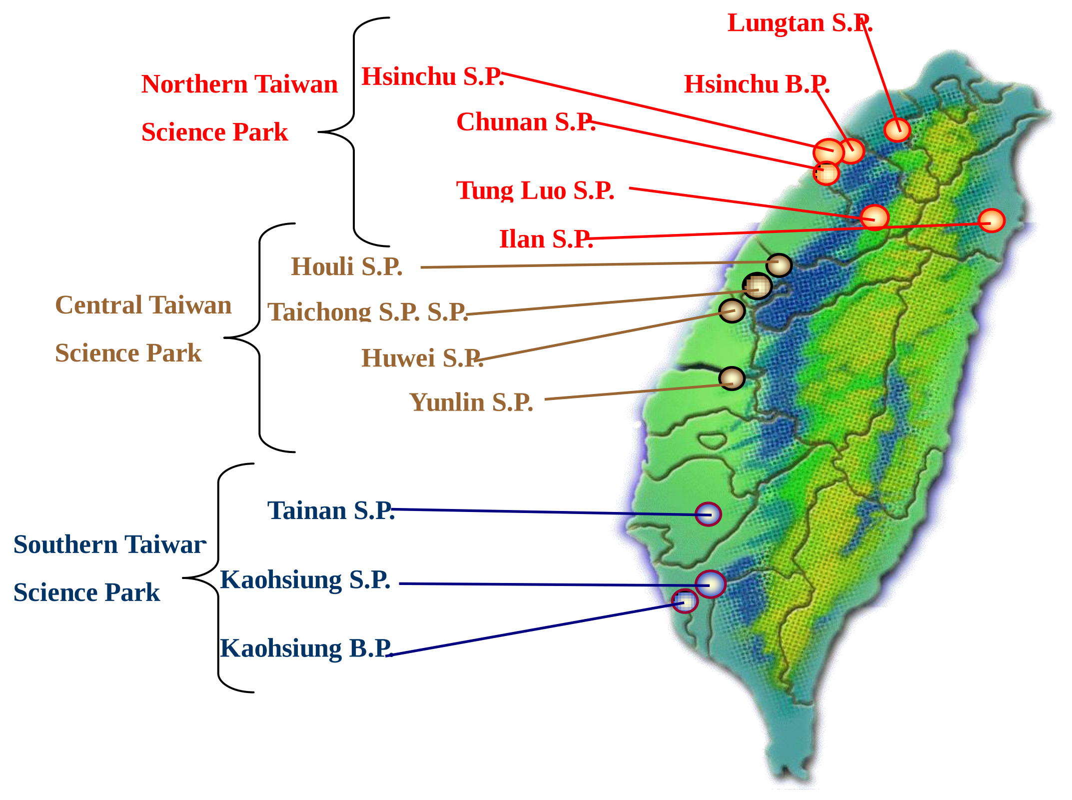

Figure 1 Science Park In Taiwan, 2006

The high interest from local politicians and fast growing number of science park in Taiwan largely reflect the successful side of HSIP story, but there is another side: HSIP is an independent territory within local district. From the very beginning until now, following American model, science park in Taiwan is a specialized form of industrial park which dedicated to "R&D-based industrial activities" and their direct supportive land uses, priority attention is not paid to the accommodation of other urban activities. This is clearly reflected in HSIP's land use plan that residential areas account for only a small portion of the total park area, and they are distributed at peripheral locations.

4. The Planning Process and Development of Tainan Science Park

In late 1980s, NSC and Council for Economic Planning and Development (CEPD) started a new phase of thinking for national development in the future. National Cheng Kung University (NCKU), National Taipei University and other research institutions were called to assist policy research simultaneously in different project. The author was a member in NCKU team, and involved in two studies, one concerns the science park development experience outside of Taiwan, another was an evaluation of potential sites for the second park in Taiwan. Evaluation from different research institutions indeed were quite similar that the Southern Region was at the best choice to set up the second science park, because of its existing academic and research capacity and industrial strength. But in the real world, other political considerations came in, and since early 1990s, a series of fierce competition from local governments began, finally in 1994, a sugarcane field between three townships in Tainan County was chosen. The process was well documented in Kuo (2001)[16].

In the beginning, the purpose of developing TSP was to provide land for spill-over investment from HSIP, also as a tool, hopefully to extend high technology industries to the south, in order to balance the North-South Divide in Taiwan. As the political process moved on, it seems that more cry for a science park with its distinct nature and industrial future arise from academic and local arena, SIPA officials and HSIP leading industrialists also expressed their goodwill that they wish "Tainan will not be the second Hsinchu" (Lin, 1997)[17]. The original Plan mainly focused on developing microelectronics and precision machinery, semiconductor and agricultural biotechnology industry. But, no one really knew whether TSP would have the attraction to lure high tech investment and if so, what high technology industries other then the IC and PC industries in HSIP may become the champion at TSP.

When the sugarcane field was transformed into industrial sites, the first investors were mainly the leading companies of the leading industries at HSIP. Most notably, the IC leader TSMC and UMC immediately signed agreements with SIPA to rent 40 hectares land each; TSMC announced a ten year NT 400 billion dollars investment plan, and UMC followed with a NT 500 billion investment plan within a fortnight. These investments were targeted at building then next generation 12" silicon wafer fabs, thus, TSP is also cited as the "Hometown of Twelve-inch Wafer" in Taiwan; with other IC companies investment, TSP was expected to surpass HSIP as a future center of more advanced IC production site in Taiwan. Biotechnology industry was also viewed by many with rosy eyes, for example, Taiwan's food processing industry leader decided to team-up with Taiwan Sugar Co. and US pharmaceutical firms to invest a biotechnology plant. The 650 ha industrial land is soon nearly rented out in the first year. It seems that IC industry extended from HSIP would become the major industry in TSP, followed by biotechnology.

However, in 2000, the author participated in a multi-disciplinary research team at NCKU on the industrial development strategies for TSP, even without much concrete statistics, during the surveys, team members first sensed that opto-electronics industry could become very important for TSP and that the development pace of TSP maybe exceed most people's expectations (Hung, Huang & Kung, 2000)[18]. It is generally recognized as a good sign, because it means that Tainan Science Park may have its own industrial development way. Indeed, based on the experience of HSIP and the investment from HSIP leading tenant companies, investment atmosphere has been kept quite optimistic and actual industrial growth in TSP has been also very good in general. STSPA provides open access to quite a few

[16] Kuo, J. L., *Science Park and Regional Development: Regional Changes Induced by the Establishment of the Tainan Science-based Industrial park*, Taipei, National Taiwan University, unpublished Master's Thesis, 2001. (in Chinese)

[17] Lin, Y. C., "Tainan Will Not Be the Second Hsinchu", *CommonWealth Magazine*, August, 122-128, 1997. (in Chinese)

[18] Hung, M. H., Huang, W. H., Kung, S. F., 2000, *A Study of Industrial Resources Input-output and Development Strategies for Tainan Science Park*, Tainan: National Cheng Kung University (sponsored by TSP). (in Chinese)

industrial statistics on internet. As shown in Figure2, within eight years of operation, number of tenant firms increased to 91 and number of approved firms increased to 157 in 2005, compared to HSP which spent over 13 years to reach the same level. From 2001 onward, number of firms in opto-electronics industry has taken the lead, followed by biotechnology industry; but in 2004 precision machinery firm outnumbered biotechnology and resumed the second place.

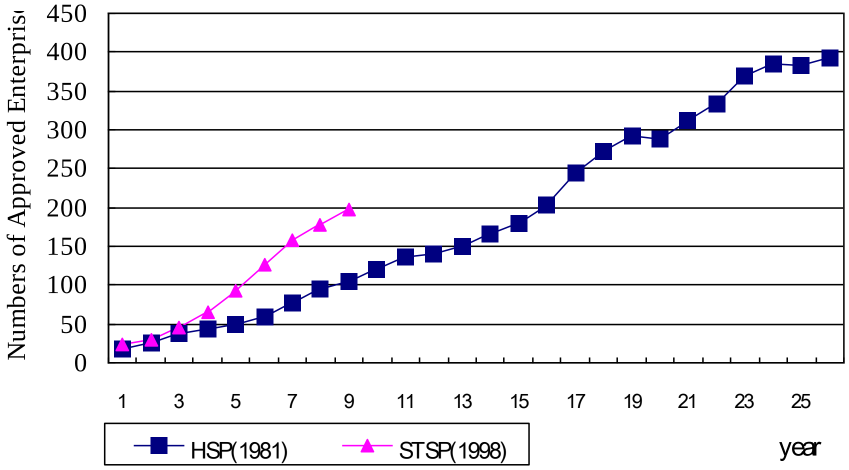

Figure 2 Comparison between HSP and STSP in number of enterprise unit
Source: www.stsipa.gov.tw/web/

For the growth of employment in TSP, data are available between 2001 and 2006. As shown in Table 3, total number of employees in TSP approached ten thousands in 2001 and exceeded forty five thousands in 2006. Opto-electronics industry account for more than sixty percent of employees in the park, followed by integrated circuits industry which employed nearly nine thousands, and account for twenty percent of the industrial personnel in the park. Precision machinery industry had a great leap forward between 2003 and 2004 and is on the third place in 2006.

Table 3 Number of Employees in Tainan Science Park (2001-2005)

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

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

Judging from the figures of total revenues of tenant firms, as shown in Table 4, TSP business also grows very fast. After the first two years of preparation, total sales of the tenant companies reached NT$ 25 billions in 2000, and exceeded NT$ 450 billions in 2006. In the beginning, branch plans of integrated circuits companies from HSIP contributed most to the park revenues, but the opto-electronics industry climbed up much faster and by 2002 it gained first place, it contributed more than seventy percent of total revenues earned. Integrated circuits is still the second largest industry in terms of sales. Other industries are comparatively small in sales figure. Since STSPA's long-term operation depends heavily on management fees collected based on tenants' sales, the fast growing sales figure is undoubtedly a very good sign to STSPA.

Table 4 Total Revenue of Firms in Tainan Science Park (1998-2005)

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

Source: www.stsipa.gov.tw/web/ Unit: NT$ 100millions

4. Cluster Structure and Development at Tainan Science Park

Putting three indices together, undoubtedly, the leading industry in TSP is opto-electronics industry. It is an industry developed in TSP, rather than a collection of migrant companies or branch plants from HSIP. This is a very important point that NSC, SIPA and, more strongly expressed by, the local people have expected from the very beginning. Major opto-electronics firms in TSP are TFT-LCD manufacturers, including Taiwan's second and fourth largest TFT-LCD panel makers, Chimei Electronics and HannStar Display, both of them were established in 1998 at TSP. Because TFT-LCD is the most important FPD (flat panel display) material, Taiwan and South Korea are currently the two biggest TFT-LCD panel producers of the world, each account for slightly more than 36% of the world production, the importance of these firms to TSP, Taiwan or even the world is obvious.

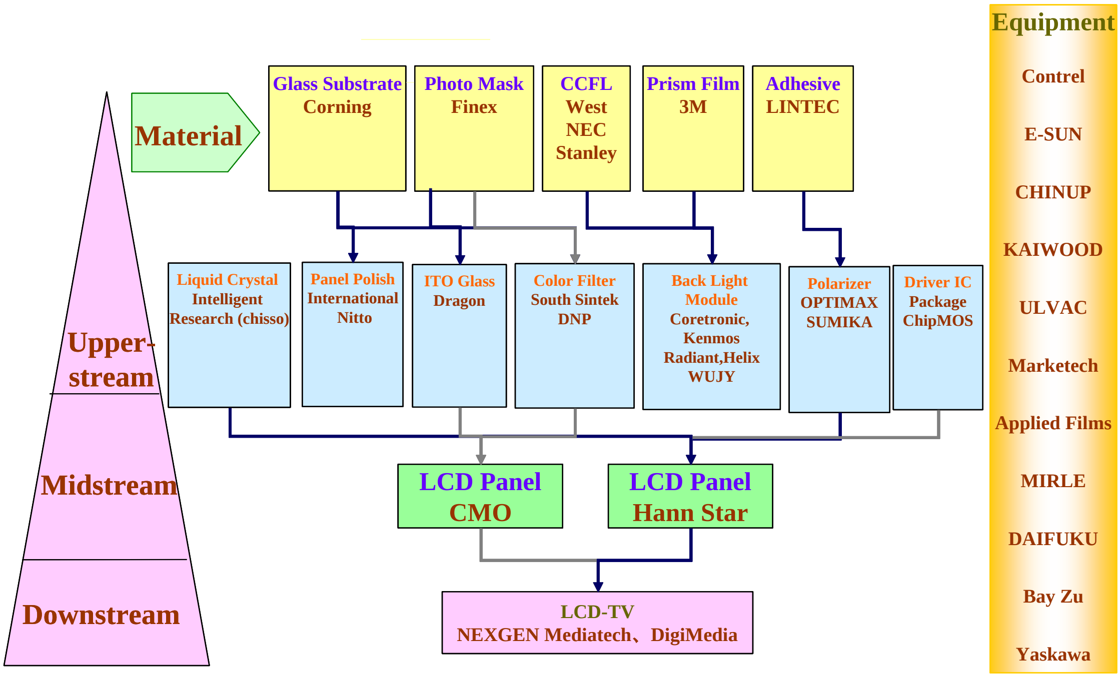

Figure 3 Optoelectronics Industrial Cluster in STSP

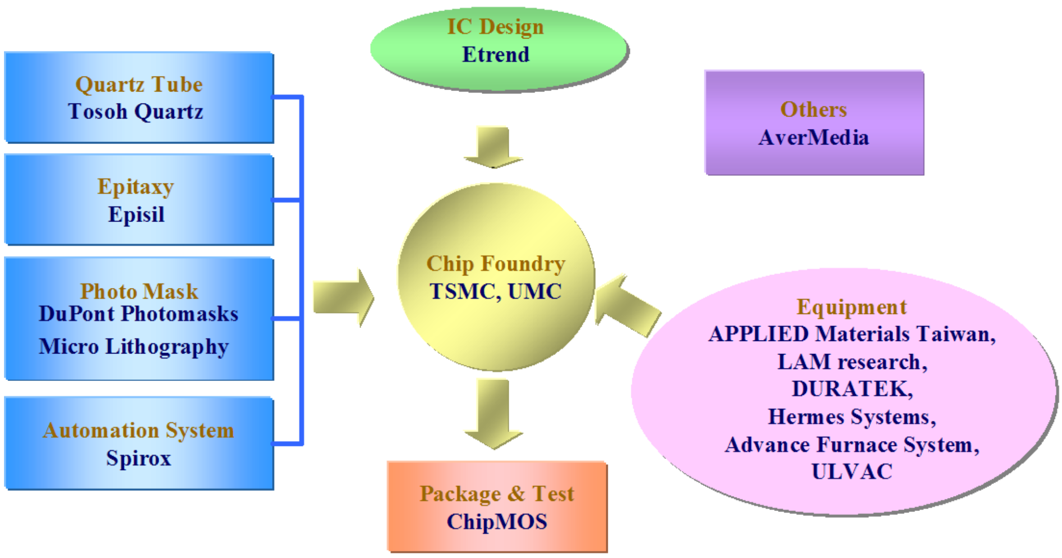

Figure 4 Integrated Circuits Industrial Cluster in STSP

TFT-LCD industry has clearly established a very complete production chain in TSP, and according to Chiou (2005)[19] and Wei (2006)[20], arguably the most complete one with largest number of firms in

[19] Chiou, H. L., "Technological Trends and Challenges of Large Display", in *Conference on The Challege Facing 40 Inches and Larger LCD-TV Technology Development*, held September 30, 2005 at STSP, Tainan, 2005. (in Chinese

[20] Wei, T. L., *A Study of the Effect on the Industrial Cluster and the Resources Crowding Out to Southern Taiwan Science Park after Establishing the Tree Valley Park*, Tainan, National Cheng Kung University, unpublished Master's Thesis, 2006. (in Chinese)

the industry in Taiwan. Thus, the TFT-LCD industrial cluster (figure 3) at STSP is mainly composed of opto-electronics firms and precision machinery firms, supported by chemical material producers. Moreover, integrated circuits which still the second largest and mature industry also has construct a complete cluster division of labor (figure 4).

It is surprising that this industrial cluster did not exist in Tainan area at all before the establishment of TSP. Except for STSPA's administrative efforts, many observers agree that the key player in the formation of this industrial cluster is Chimei Optoelectronics, it is invested by a key industrialist in Tainan, Mr. W. L. Hsu, often called as "Father of acrypoly in Taiwan". Mr. Hsu is a leading petrochemical materials producer in Taiwan, his flagship company is specialized in ABS/AS material production, established in 1959 in Tainan City and moved to Tainan County in 1970s. With that expansion, he also developed the Pao-An Industrial Park, beside his plants, to host some fifty firms that have close production ties with his company; he surely understood the advantage of clustering. In 1997 Mr. Hsu decided to venture into this new display business, later he described it as a "century-ever product". His industrial vision and operation have a long standing reputation in Taiwan and international markets, many industrialists followed his new decision. It is not surprising then, that the cluster has been formed within such a short period. It is also due to this industrial cluster, TSP firmly has a different industrial story, quite independent of HSIP's. From the distribution of optoelectronics industrial cluster in STSP, there are 54 enterprises, such as Chi Mei, having been approved by 2007 and 32,890 employees by January 2007 (about 65% of the total employees). In 2006, it reached annual turnover of US$9.4 billion and contributed to 71.4%.

IC industry cluster is the second largest industry at TSP, in terms of number of employees and total sales. However, it has been well known that due to the difficulties of attracting excellent engineers and R&D staff from HSIP and northern Taiwan, IC industry at TSP has not been able to build a comparatively strong enough cluster in terms of scale and production chain. Until Now, there are 25 enterprises, such as TSMC and UMC, and 10,549 employees by January 2007 (about 21% of the total employees). The IC industry reached annual turnover of US$32.4billion and contributed to 24% in 2006. Precision machinery industry at TSP is a very promising one, at the moment, quite a proportion of the industry's growth has been led by the opto-electronics industry, as its equipment supplier, hence we tentatively suggest that part of the firms in this industry belongs to the opto-electronics industrial cluster.

Biotechnology industry had been highly expected in the beginning years, due to Southern Region's traditional strength in agriculture and aquaculture industries, and the proximity of many long-established research institute in Tainan Area, and most notably, the Asian Vegetable Research Development Center (AVRDC) is right to the east gate of TSP. Compared with the two largest industries in TSP, biotechnology industry is still quite small in scale, but the number firms have been growing steadily, it is also not a formidable force at STSP; nevertheless, with the more specialized biotechnology parks in planning, whether this industrial cluster will continue to grow at TSP is worthy of further study. It already has a cluster group in the east side of STSP and the annual turnover in 2006 totaled US$58.7 million. Moreover, there are 31 enterprises having been approved by 2007.

5. Tainan Technopolis as a way to develop Industry Cluster

One of the objectives in Tainan Science Park Plan was to develop high technology industry cluster by integrating the regional resource of Southern Taiwan. In Taiwan's urban and regional planning system, Southern Region is composed of eight local authorities(figure 5): Jiayi City, Jiayi County, Tainan City, Tainan County, Kaohsiung City, Kaohsiung County, Pintung County and Penghu County which is also known as the Islands of Pescadores. Southern Region was a suitable place for manufacturing industries based on agriculture and aquaculture products. The Ten Great Construction Plan in 1970s utilized Kaohsiung Harbor to build series of steel and petrochemical industries in Kaohsiung City and County, gave the region a strong position in Taiwan's traditional industrial sectors. However, with the globalization of economy, and the hollowing out tides of traditional industries, the region has been in need of new industries for a profound restructuring.

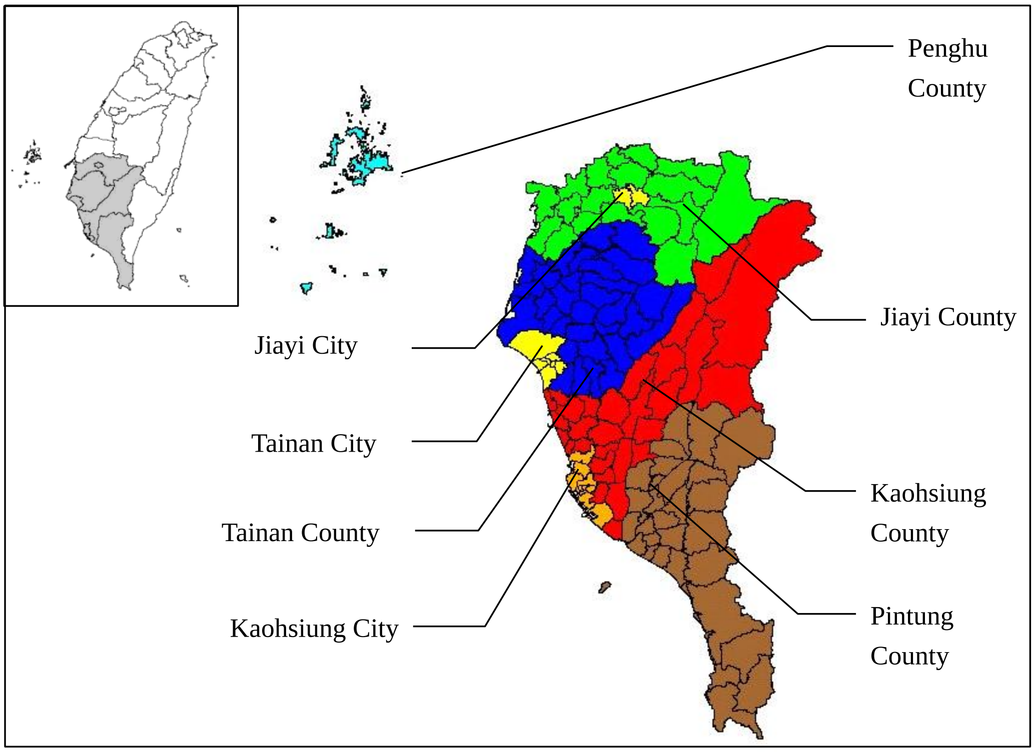

Figure 5 The map of Taiwan Southern Region

In earlier Comprehensive Territorial Plans, CEPD used to propose that the western corridor of Taiwan would proceed from a stage of five core cities in 1960s, to three metropolitan areas in 1990s, and eventually, with high speed surface transportation systems, transform into two living rings, and Tainan-Kaohsiung Metropolitan Area will be the core urban area of the South. Theoretically, regional development efforts in this twin-city metropolis should consider the strengthening of mutual communications, but actual development since late 1970s have led to a divisive development trends, with Kaohsiung Metropolis moving east- and southwards, while Tainan Metropolis have diluted its own core to become more multi-nucleus (Figure 6).

Figure 6 Metropolises, Industrial Poles and Transport Networks in Southern Region

5.1 The planning concept and confliction of Tainan Technopolis

The announcement of a science park in Southern Region in early 1990s soon inflamed chains of reaction within the region. In the final stage of site selection, there were two sites left for final choice, one located in Tainan County and another in Kaohsiung County each, and Tainan City is in the mid-way between the two. While the largest city in the region, Kaohsiung is quite far in the south. Because all the local authorities were eager to use the opportunity, fierce competitions (Table 5) finally led to the formation of two local development coalitions: Tainan Alliance (TTA) versus Kaohsiung-Pingtung Alliance (KKPA), the former was consist of Tainan City and Tainan County, the later was formed by Kaohsiung City, Kaohsiung County and Pintung County, even within the Alliance, the competition is also fierce. For example, in order to attract more firms sitting up in their own city, the Tainan City and Tainan County Government are competing for the subsidy subsidizing by different government to construct fundamental infrastructure including Airport, National Museum, and Bilingual School, etc.

Table 5 The projects competition in Taiwan Southern Region

	MOEA	NSC	MOTC	MOI	MOE
THG	• IP,ITRI	• TSP	• HSR Station • Airport	• STSP Specific Zone • HSR Specific Zone • Creative Industrial Park	• National Museum • Bilingual School
TCG	• TP,IP,ITRI	N/A	• Railway Underground • Connect Roads	• Land Readjustment	N/A
KHG	• IP	• KSP	N/A	N/A	N/A
KCG	• IP,EPZ	• KBP	• Airport	N/A	N/A

Note: THG (Tainan City Government); TCG (Tainan County Government); KHG (Kaohsiung City Government); KHG (Kaohsiung County Government)

The fierce competition reflect one of the key issues in Taiwan's territorial and regional planning, that is, which city is the primate city in southern region? It is related to the development history and planning history of Taiwan. To be brief, Dutch VOC started its operation at Tainan in 1624, and the city retains its capital position in Taiwan until late nineteenth century. This history gave the city a special cultural and historic dignity over other cities in Taiwan, although it gradually ceded its capital position first to Taipei in late 19th century, and then became smaller, in terms of population, than Kaohsiung in 1920s, and Taichung in 1980s. It is now the fourth largest city, but Tainan citizens and politicians have never given up the hope to become a "great city" again. The area surround Tainan City, maily the northern part of Kaohsiung County, and the southern part of Tainan County have been historically associated with the old capital, and still maintain tight economic and social interactions with Tainan City, these interactions have been continuously reflected in censuses as working and schooling transit trips, among others, together they form the Tainan Metropolis, with a population of 1.2 millions. Although relatively younger, Kaohsiung City has resumed as the largest city in the South for nearly a century, not long ago the third largest cargo harbor in the world, and still the center of steel, ship-building, petro-chemical and many other heavy industries in Taiwan, and it also has the glory of siting the first EPZs in the world and the second international airport in Taiwan, among others.

Owing to natural topography and development history, it is conveniently linked with central and southern Kaohsiung County and northern Pingtung County, together they form the Kaohsiung Metropolis with more than 2.5 million people. The competition eventually enlarged the perception gaps on regional development directions between TTA and KKPA, and many regional issues have since then become more difficult to get consensus, for example, big construction projects like trans-basin water project or new international airport in Southern Taiwan. Therefore, our Tainan Technopolis discussion will be focus on Tainan Area, rather than the bigger canvas of Southern Region.

5.2 The Development of Tainan Technopolis

Within Tainan Area, the formation of Tainan Technopolis depends on at least four different forces with their own interest agenda. These are: the central government and its representative in the area – STSPA, Tainan County Government (THG), Tainan City Government (TCG) and entrepreneur community (EC). They have the authority or resources in the planning and decision of key infrastructure and land use control that will influence the formation of "Tainan Technopolis". Some important development projects or proposals are shown in Figure 4. For STSPA, its core mission is to attract investment and develop high technology industries within the park. According author's personal contact with STSPA and information from reports or other local channels, STSPA have learned from HSIP's earlier experience. Beautiful landscape and sound residential supply in local market, R&D facilities, local industrial linkages, good relationships with local authorities, among others, all factors that can increase the attractiveness of the park environment is welcomed, and it is ready to co-operate. Especially with local urgent issues, the officials in STSPA have been very much inclined to observe in the field with local authorities directly, and host seminars and meetings to face local issues. They also teamed-up with local officers in promoting the park and local attractions domestically or going abroad. One important thing is that public facilities and open spaces in the park are basically open to the public, and the five retention ponds have worked well and proved that the downstream area are now even safer with flood than before.

Nevertheless, there is another area, although not directly attached to TSP, needed to be discussed – the Saluen Special District of High Speed Rail (SSD), since High Speed Rail will become the backbone of west corridor, SSD's spatial meaning for regional development cannot be overlooked (Figure 8). THG and STSPA have been basically consistent in this respect, ideally, to build a direct and shortest possible local link between SSD and TSP, thus, the tenant companies and area around TSP can grab most of the benefit from high speed rail; and to THG, also the benefit to SSD and its surrounding townships. The tensions between TCG and THG exist, especially after TTA won the battle from KKPA. Since TSP is located within THG administrative boundaries, under the "developmental localism", as termed by Yang and Su (2005), THG's goal is to utilize TSP as a growth pole to develop its surrounding area and retain most of the benefit within its jurisdiction and eventually made TSP the new center of the technopolis, rather than bypassed to Tainan or Kaohsiung City. Yang and Su (2005) neatly traced the key players that form the Tainan Technopolis "growth coalition" and their motives in three different stages. They found that the combination and change of members, their origin and interests largely explain the shifting focus of spatial development planning, and especially reflected, as a result, on the planning of the Southern Taiwan Science Park Special District (STSPSD) enlarged from existing TSP. The STSPSD Plan eventually passed all the environmental impacts, regional and urban planning evaluation processes in 2002, covers an area of 3,299 hectares with a target population of 150,000 residents, very likely to accommodate as many as possible the high-calibre migrants induced by TSP.

Except for core industrial land use and public facility sites, the Plan introduced a "floating zoning" mechanism to encourage and control residential and other investment, Yang and Su (2005) [21]believe that this new mechanism may further enhance the coalition between THG and conglomerate developers. It is doubtless that TCG and Tainan citizens have a different imagination the core and even the boundary of "Tainan Technopolis". The City boasts one of the best educational infrastructures in Taiwan, with a population of 750,000 in 2005, a relatively lower development density and many cultural and tourist attractions. In terms of industry, it has two large scale industrial parks developed by and co-managed with IDB – Anping Industrial Park and Tainan Technology Park (TTP), and most importantly, it has been the central place of Tainan Plain and is still the commercial center of Tainan Metropolis, and it is situated right in the middle of all the three high technology industrial projects developed since mid-1990s – TSP, TTP and KSP. They formed a "Tainan Technology Triangle" with Tainan City as its heart (Figure 10). However, TSP has been the "dragon head" of the parks, TCG has to solve the issue of how to attract high technology companies to consume in and employees to reside in the City. The City has a vacant residential land stock of approximately 2,000 hectares, nearly 50% of them are located in three major land readjustment projects, in the form of large tract of vacant blocks and sites serviced with all necessary public facilities. Therefore, TCG has been trying hard to persuade central government investing in extension or improvement of major transportation networks to or building facilities needed by high technology firms in the City. For example, the extension of East-west Highway Number 8 to the door of TTP may strengthen the linkage between two parks and encourage the formation of cross-border industrial clusters, the international convention center may attract more conferences in the City, and a transit railway from Saluen Station may link High Speed Rail, Tainan Airport and the City, all these will strengthen the City's central role within the current metropolis as well as dominating the formation of future Technopolis.

[21] Yang, Y. R. and Su, I. J., "The Growth Coalitions and Spatial Governance : A Case Study of Tainan Technopolis", *City and Planning*, 32:1, p1-23, April, 2005. (in Chinese)

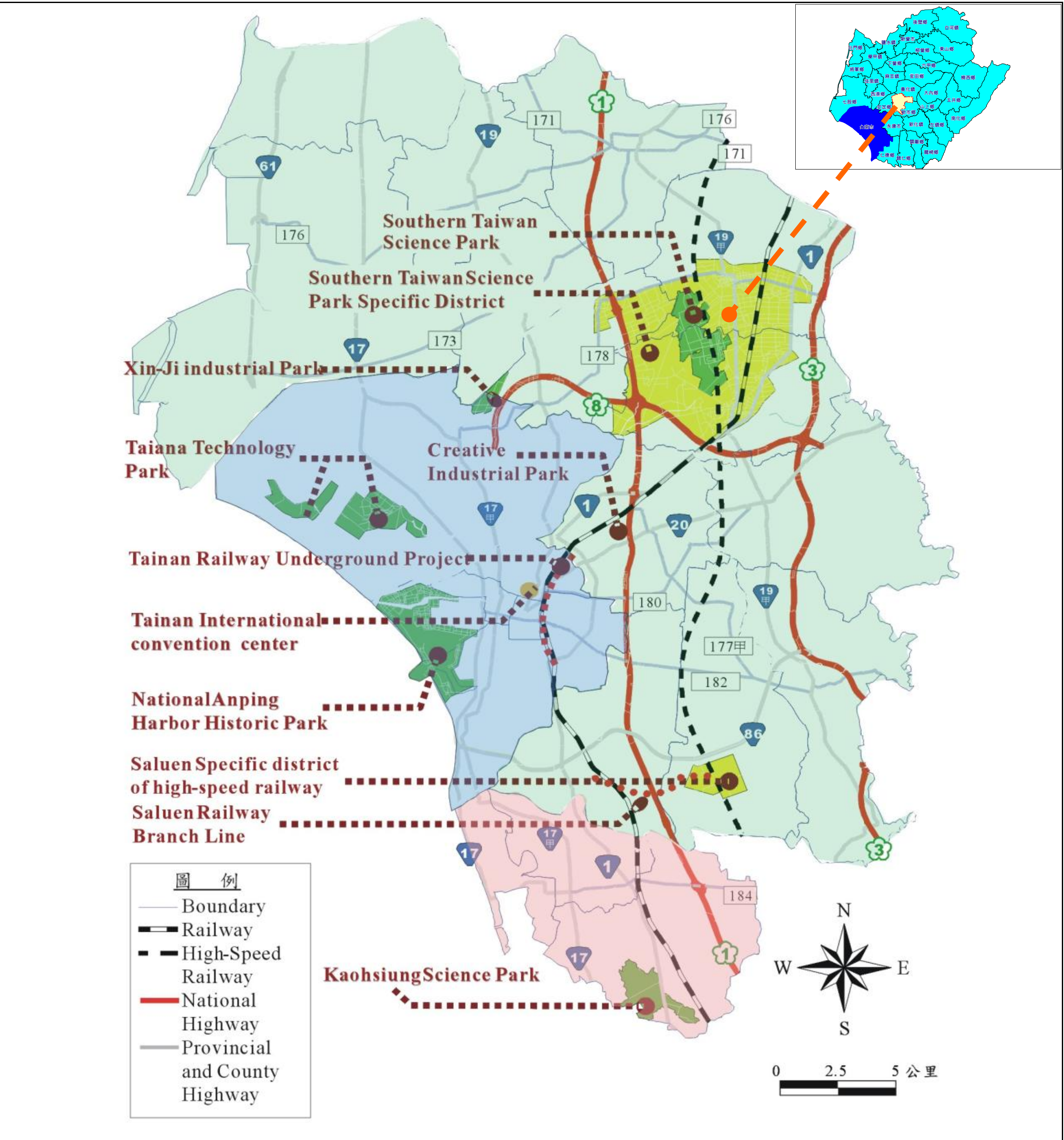

Figure 7 Major Industrial Poles and Development Proposals in Tainan Technopolis

5.3 Relationship between Business and Local Community

Business community has also played an important role in the process until now, but is little mentioned, except for the industrial development in TSP. During the past three decades, scale of enterprises in Taiwan has enlarged dramatically, in contrast, government budget deficit has increased astonishingly during last decade. Coupled with frequent elections, political and business coalition interplays on and under table increased. Thus, the planning of STSPSD has been very much the result of local growth coalition, as exemplified by Yang and Su (2005). As private enterprises' capital increased, their capacity in direct industrial property planning and development also increased. Wei (2006) studies the establishment of Tree Valley Park (TVP) and its impact on TSP industrial cluster.

Tree Valley Park, also known as the LCD-TV Special Zone (Figure 8), is developed on a 247ha land in STSPSD, adjacent to Chimei Optoelectronics Co. It is part of Chimei Optoelectronics' industrial development strategy in global TFT-LCD TV competition. Because when Chimei planned to enter the TFT-LCD market, it had the idea to replicated its success experience in building petrochemical industrial cluster to TSP. Yet, many of the targeted manufacturing activities were unlikely to be qualified by STSPA, it saw opportunities from STSPSD initiatives, and allied with THG in the project. TVP started construction work in April 2005, featured at housing some twenty firms. Because TVP take a lower management fee, one of Chimei's allied companies in TSP has moved to TVP in 2005. In this respect, using TVP as major production site, Chimei industrial cluster will not only save cost from co-location, but will also enjoy the management of TSP yet saving management fees at TVP's level. One must not forget to look at Chimei's global strategy, because the company invests not only in TSP and TVP, it also agreed to invest in KSP, more than this, it is also increasing investment in China, and especially at Ningpo. There are global and local considerations in the planning of MNCs, even team-up with politicians, they are not controlled by local authorities or even national government.

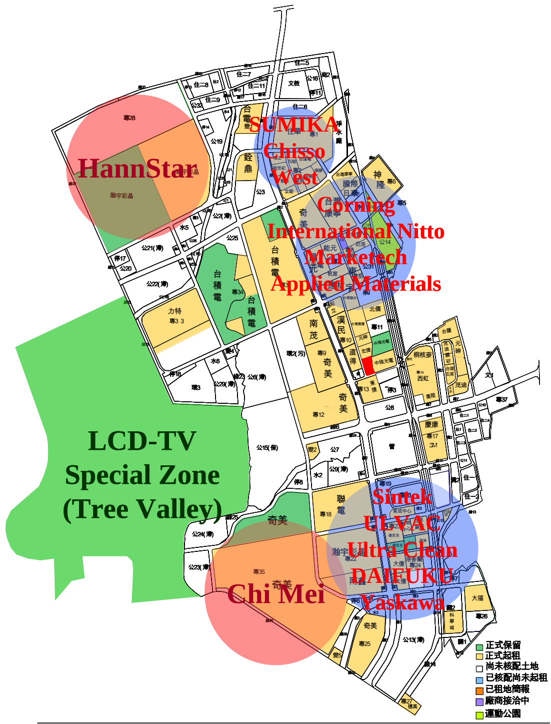

Figure 8 The location of LCD-TV special zone in STSP

In general, the objectives of industrial investors are similar to that of STSPA, the spatial result of their concern is more likely to be the "techno-region" as categorized by Spolidoro; and the goal of TCG and THG is closer to that of "technopole". As a retrospect, SIPA (1989) did saw the need for an inter-ministerial institution in central government to guide science park development towards science city and techno-regions development in Taiwan, that is similar to Spolidoro's idea of the mechanism needed for technopole development. However, it seems that the suggestion has never been adopted and enacted by government. Therefore, the studies of Hsinchu Science City are not only stored in cabinet, but also have no access to contribute to the case of Tainan. As a result, even SIPA, STSPA and local authorities have been working hard on the technopolis issues since the very beginning of TSP, there is as yet no formal institution in charge of the integration of their diverse imaginations, interests and strategies in Tainan Area, and what will "Tainan Technopolis" look like is still an open question.

6. Concluding Remarks

This paper examined literature on industrial cluster and science park (or technopolis), and taking Tainan Science Park's planning and development experience in more details, the author would like to share following observations with readers:

1) Taiwan has been relatively rich in experience of developing science park most of which are developed by government. HSP and STSP are developed in locations with different characteristics and different political situations, yet both parks have been quite successful in the growth and formation of high technology industrial clusters. Albeit the actual success industries were not the expected ones, we can conclude that it can't develop a successful science park without good driver enterprises with upstream and downstream industries, sufficient local inputs such as human capital and technologies, well-planned infrastructures, and well relationship with local governments and communities.
2) The case of Tainan Science Park well illustrated its industrial success, while accomplished with many multi-interest, disintegrated technopolitan imaginations and actions. Not only did they provide different kinds of infrastructure such as high-speed road, international conference center and accommodation, but also built intensive relationship among enterprises, local government and local community. But it is also caused the fierce competition to get the subsidies between local governments. It could be good or not, but form the planning perspective, it is important to establish an innovative regional planning and administration. Therefore, how to build a successful science park with competitive advantage clusters is not just an industrial development problem in the traditional sense, but also a governance challenge.

The author consider that in the case of Taiwan, suggestions made to SIPA in 1989 may not fit well with current political, administrative and global industrial climates, since the suggestion was made in the early stage of a more liberal political environment and far before the provincial level government was ceased to operation. However, as Taiwan experience show, science park with many industrial clusters may be well developed by a specialized agency, but technopolis planning and development combing with local industrial clusters need co-operations from dozens of authorities and local governments, and not to forget the business community and local organizations. This is a "regional governance" topic. Given the fact that today's industrial planning has to be made under globalization and democratic systems, it is doubtful that even science park initiatives have to be put in the framework of urban or regional governance. The last question left is how to create a long-term committed political and investment environment that Taiwan had enjoyed between 1970s and mid-1990s?

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The role of local innovation capacity in the emergence of a SME-based medical device industry Cluster: an experience in Taiwan

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The role of local innovation capacity in the emergence of a SME-based medical device industry cluster in STP：An experience in Taiwan

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Summary

With an aim to enhance innovation capability of a new established Science Park, The Southern Taiwan Science Park (STSP) Administration has tried a novel method of promotion. The purpose of this paper is to introduce a model whose mechanism is an interaction among government, academy, research institute, health-care institute, and industry. Representing an integration of local innovation capacity, the model could explain how the role of local innovation capacity could play in the emergence of a new industry cluster. The concept of the model came from the experience in promoting the Medical Device Special Zone, located at Kaohsiung Science Park in Taiwan. The decision-making process of STSP Administration is also described in this paper. The authors hopes the new model may inspire our counterpart some innovative idea and thus enriching the missions of Science Park.

Keywords:

Local Innovation Capacity, Medical Device Special Zone, Kaohsiung Science Park, Southern Taiwan Science Park, Medical Device Industry

1. Introduction

The contribution of Science Park to the development of high-tech industries and regional economy in Taiwan has been widely acknowledged (Liu et. al, 1998; Lai and Shyu, 2005; Chen et. al, 2006). Hsinchu Science Park (HSP), located at the northern part of Taiwan, is the first science park established in Taiwan and has already achieved remarkable worldwide reputation for its semiconductor and computer industry clusters. Encouraged by the successful experience and to balance regional development, the second science park Tainan Science Park (TSP), located at the southern part of Taiwan, was established in 1993 and rapidly renowned for its semiconductor, photo-electronic and biotechnology industry clusters. However, demand for more industrial land continued to increase. In response to the demand, the Taiwan government decided to expand the scope of TSP to more southern part of Taiwan and thus the Lujhu Science Park, renamed as the Kaohsiung Science Park (KSP) later, was established in 2001. In the same time, Science Park seemed to be booming all over the world and competition from other science park is increasing. Being the administrative institute of TSP and KSP, Southern Taiwan Science Park (STSP) Administration was pondering what added-value that KSP may offer to outperform other Science Park and attract investment.

In an era of rapid changing in technology and growing tendency of globalization, the STSP Administration realized that innovation capability of firms in Science Park is key to sustain competitiveness in the twenty-first century. In addition, a new type of competition seems to occur, that is competition between regional clusters (Carrie, 2000). Incorporating the trend and referring to literature related to the experience of developing industry cluster or science park all over the world (Dohse, 2007; Geenhuizen and Reyes-Gonzalez, 2007; Trippl and Tödtling, 2007; Bernstein and Singh, 2006; Fennelly and Cormican, 2006; Adeoti and Adeoti, 2005; Nosella et al., 2005), the STSP Administration asserted that KSP is not merely an extension of TSP but a new generation of science park with its own unique attributes. To achieve this vision, a more intensive relationship among government, local innovation capacity and industry shall be built. Hence, how to inject local innovation capacity into KSP became a strategy issue that STSP Administration has to put into practice. The Medical Device Special Zone Project, triggered in 2005, was a touchstone for STSP Administration to realize its strategy.

As a result of nearly three year's effort, the STSP Administration found a solution to solve the aforementioned problem during the executing period of the Project. The solution is a sophisticated process, which has been integrated as a practical model, of organizing local capacity into a platform. The purpose of this paper is to introduce this new model and explain how it works in the emergence of a new industry cluster without high-technology base; as well as how it transforms regional industry structure from traditional industry into high-technology industry.

This paper is organized as follows. Section 2 reviews the background of Medical Device Special

Zone Project. Section 3 describes the difficulty in promoting KSP. The model and its elaboration are placed in section 4. Two cases to illustrate the mechanism of the proposed model are described in Section 5. The conclusions are presented in Section 6.

2. An Overview of Medical Device Special Zone Project

Medical device industry is a branch of biotechnology industry by definition. Since the Taiwan government has identified biotechnology industry as a star industry of the 21st century, a great deal of resources has been allocated to strength the competitiveness of Taiwan's biotechnology industry as well as medical device industry.

Medical devices industry in Taiwan have developed over forty years and the annual quantity of many products have entered the top three of the world ranking, such as electric scooter, ear thermometer, electronic sphygmomanometer, etc.. Currently there are 484 medical device manufacturers in Taiwan (ITIS, 2006). The advantages of medical industry in Taiwan include complete laws and regulations of medical devices, superior doctor techniques and hospital level, excellent quality management and logistics capabilities, high technology base, like ICT, advanced materials, precision processing and mold & die technologies. These facts indicate that medical devices industry in Taiwan has quite sound industrial basis and global competitiveness. Taiwan is, therefore, very suitable to develop the medical devices industry.

KSP has an excellent geographical location surrounded by abundant research resources including three teaching hospitals and a medical center, namely Chung-Ho Memorial Hospital, E-DA Hospital, College of Medicine National Cheng Kung University and Chi Mei Hospital, ten public and private universities or colleges, such as National Cheng Kung University, Kaohsiung Medical University, and a non-profit research institute, Metal Industries Research and Development Centre (MIRDC). Besides, there are two industrial parks nearby to formulate a complete supply chain supporting KSP. Therefore, KSP is evaluated as a quite suitable base to develop medical device industry. By making an assessment according to the geographical strengths, characteristics of regional industry system and national technology policy, the STSP Administration came to a consensus that medical device industry is an appropriate industry to develop in KSP. An idea of "Medical Device Special Zone (MDSZ)" thus emerged. For further feasibility study, the STSP Administration decided to initiate Medical Device Special Zone Project (denoted as the Project in following text). With the purpose to induce local innovation capacity, the Project was subcontracted to MIRDC to execute.

Though the goals of the Project were to recruit investment, it was not met at the first year. A lot of unexpected difficulties frustrated the Project team. However, an achievement that the Project team was proud of is to establish a committee contains members coming from regional government, local academy, local health-care institute and local medical industry to promote MDSZ. This committee represents the possibility to integrate local innovation capacity.

3. Difficulty in Promoting Medical Device Special Zone of KSP

The difficulty was related to the characteristics of medical device manufacturers in Taiwan. According to the name list provided by Association of Taiwan Medical Device Industry and the Yearbook of Taiwan Medical Device Industry (2006) (IT IS, 2006), more than seventy percent of the medical device manufacturers in Taiwan are small and medium sized enterprises (SMEs) and more than ninety percent of them are not located at the southern part of Taiwan (See Table 1). Besides, most of them are confined to manufacturing low-risk classified as Class one product with little resources devoted to new product development. The characteristics of Taiwan's medical device industry limit the competitiveness of the industry and increase the difficulty in recruiting investment. Though many SMEs in this industry, other mature industry as well, are eager to upgrade product level by placing more emphasis on higher value-added activities, such as research and development (R&D) and innovative product development, they do not have enough resource nor advice about how to make the first move.

Table 1 The distribution of medical device manufacturers in Taiwan

Criteria	Percentage
Capital (in New Taiwan Dollar)	
> 1 Billion	3.9%
100 million 1 Billion	22.7%
From 50 million to 100 Million	12.0%
From 30 million to 50 Million	9.6%
From 10 million to 30 Million	24.1%
Less than 10 million	27.7%
Location	
Northern Taiwan	70%
Central Taiwan	18%
Southern Taiwan	11%

Note: Corporate with capital less than 80 million NT$ is defined as SME in Taiwan. The exchange rate of New Taiwan Dollar to US dollar is about 32 to 1.

Source: Association of Taiwan Medical Device Industry, 2006

To rescue these SMEs from the aforementioned dilemma and to attract them to cluster in MDSZ by meeting their needs, the STSP Administration and the Project team had outlined a "push strategy" to steer them to high-technology industry step by step.

The first step is to identify the potential investors. To further understand the problems of medical device manufacturers in Taiwan have encountered, the Project team had made a comprehensive investigation on the current manufacturers and distributors by means of interview and questionnaire. After analyzing the data collected from more than fifty samples, the Project team found that manufacturers equipped with the following characteristics are more likely to invest.

First, they are willing to develop toward high-risk classified products and have a strong will to stay in Taiwan.

Secondly, they are manufacturers of traditional industry with sufficient capital and also have a strong will to cross the boarder of medical devices industry.

Thirdly, they have geographical proximity to Southern Taiwan.

Fourthly, their value chain activities, like new product development and manufacturing, have strong reliance on local innovation capacity.

Once the targets have locked, the second step is to select the potential and proper products best fit the local innovation capacity as well as the regional industry system. Some considerations had led the Project team to make the choice in this step. A prior consideration is the opportunity and time for the product to be commercialized. The second consideration is the extent of connection for the product to the local R&D resources and regional industry system in technological aspect. Since most heavy industries are located in Southern Taiwan, metal and chemical related products, like dental and orthopedic implant, surgical instrument and precision medical devices, are suitable to produce in KSP. At last, the product must be high value-added, which means high-risk and classified as Class II or Class III product per Food and Drug Administration regulations, and hard to mimic. Consequently, the STSP Administration had selected dental and orthopedic product as the prior products to develop.

The third step is to make the linkage between local innovation capacity and firms which are potential to invest in Science Park. The key success factor of this step is the design an incentive that could push both sides to contact. Together with local government, research institute, universities and medical center, the STSP Administration searched the support from central government to devote additional budget to fulfill the strategy. A complementary project, namely “Project to Develop Dental Industry Cluster around Medical Device Special Zone of Kaohsiung Science Park”, was approved to develop high value dental product with an attendant requirement that final research results must be commercialized and transferable to private enterprise. This project was subcontracted to MIRDC again. As project leader, MIRDC was obliged to coordinate local innovation capacity and to work in collaborative ways.

The last step is to make sure the product prototype and process techniques are completely transferred to the firms joining the project and assist the firms to enter Science Park. The above processes constitute the conceptual structure of the model in the following section.

4. The Model

Etzkowitz and Leydesdorff (2000) have proposed a Triple Helix Model of University-Industry-Government (See Figure 1). However, considering the characteristics of medical device industry in Taiwan and integrating the steps mentioned in the previous section, we have modified the model by adding public research institute and health-care institute and the result is a pentagonal innovation model as Figure 2 shown.

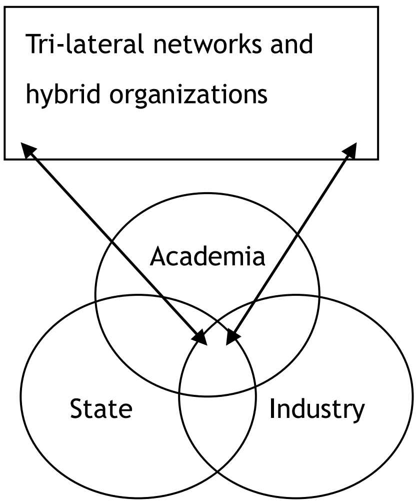
In this model, the importance of each entity is not equivalent and might adjust a little according to the product and capabilities of the firms. In the sphere is a brief description of the roles that each entity plays. The Government basically plays a role as policy maker, resource administrator and facilitator to trigger and support innovation process. The Government-funding-project is an incentive and positive driving force to start the cooperation among research institute, industry, academy, and health-care institute.

The research institute is the most important role in this model, which is responsible for the first three tasks in a typical new product development (NPD) process (See Figure 3). Academies, primarily universities in this model, are subcontractors of the firm as well as research institute. It is a little different from the cases that most papers had mentioned. The reason for this phenomenon is that the purpose of this program is to develop medical devices which could be commercialized as quickly as possible, which might contradict to the missions of universities. Therefore, academies act as auxiliaries in the model since they are good at researches of advanced technologies and have access to various specialists.

Private enterprises coming from medical device industries have participated in the project from the beginning but not for free. They are required to share part of the NPD budget and promise to invest in KSP. They received the techniques developed by research institute through joint R&D. Health-care institutes are invited to join the program because they could provide precious clinical information in the NPD process. Medical practitioners working in the health-care institutes are users of medical devices; and therefore their immediate feedback can help the engineers to improve the product at the early stage. Most important of all, their validation is an essential step of commercialization for medical devices.

As Figure 2 indicates, the intersection part of each sphere is a platform constructed by government, local universities, public research institute, heath-care institute, and private enterprises. The platform in the model possesses three functions. First, it provides a direct access to the local innovation capacity. Secondly, it builds a bridge for communication of each entity. Information and knowledge from each entity will converge to the platform and could share with each other. In the process of knowledge sharing and learning, some new ideas to create more innovative products may originate. Therefore, it is also a seedbed of creativity. Thirdly, it is a virtual incubator of new business. Similar concept has been introduced in some literature; the platform is more realistic, however, as compared to the case of Taguspark. (Durão et. al., 2005). Government funding contributes a lot at the emerging stage of this platform. The platform shall find its own business model to search for financial support, mainly from private sectors, to keep on running eventually.

Figure 1. The Triple Helix Model of University-Industry-Government Relations



Source: Etzkowitz and Leydesdorff, 2000, The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations, *Research Policy*, Vol. 29, p.111

Figure 2. The Pentagonal innovation model for a SME-based science park

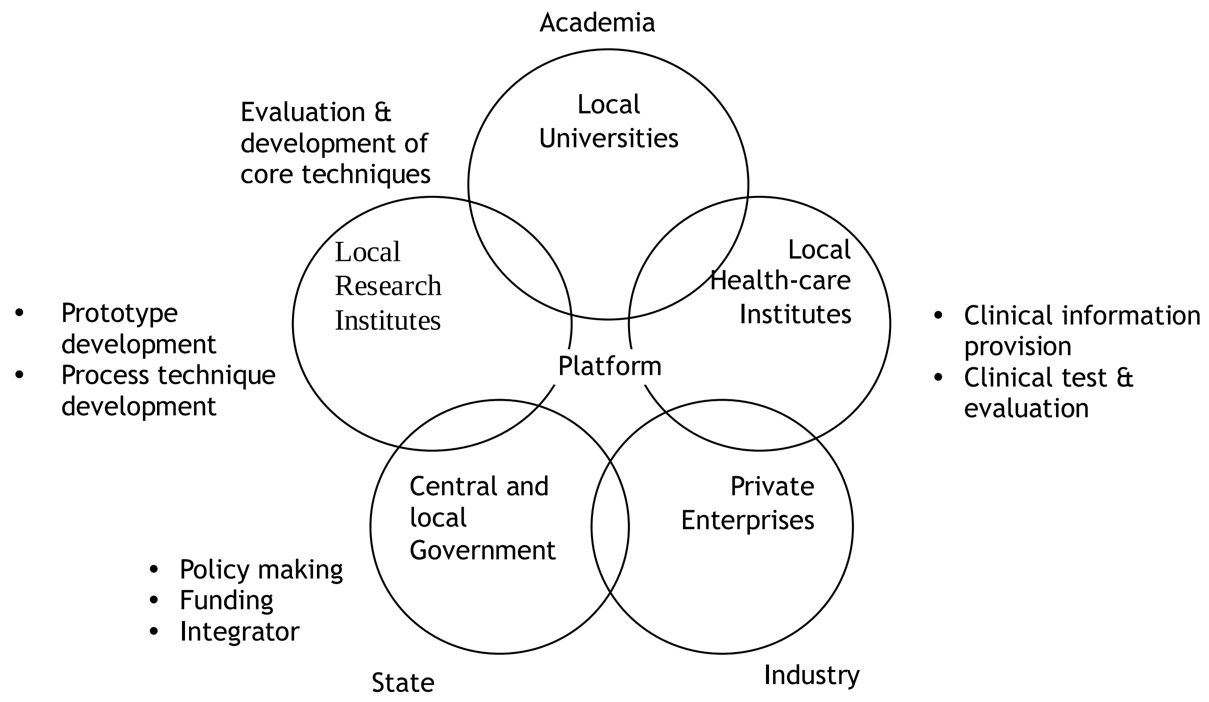
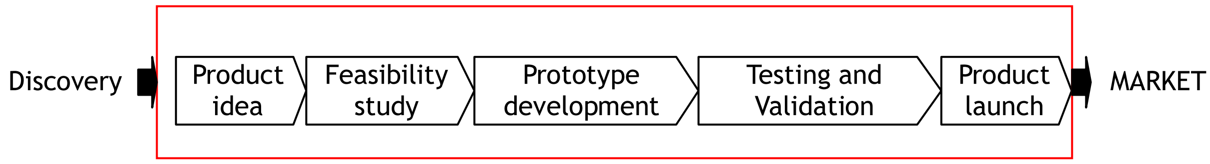


Figure 3. A typical new product development (NPD) management process



Source: Vuola and Hameri, Mutually benefiting joint innovation process between industry and big-science, *Technovation*, Vol. 26, 2006, p.5

5. The cases: tenant enterprises of Medical Device Special Zone

Two companies incubated by the model (for commercial confidentiality reason, the name of the company could not be revealed and denoted as Company A and Company B in this paper) have successful gained the entrance approval. The profile of these two companies is listed as Table 2 shows. Founded in 1982, Company A started from trading business of dental medical device and expanded its business scope to cover the development and manufacturing of dental instrument with own brand. The "Dental clinic technique evaluation and training simulation system" is an advanced product used to train future dentist and has great market potential all over the world. In spite the existing technology basis, Company A did not possess the core techniques, including spatial positioning and simulation, necessary for developing the target product. However, through the introduction of platform, Company A joined the project and outsourced the research to local university. By joint R&D with local capacity, a prototype was successfully developed in less than one year. With no geography proximity to KSP, the boss of Company A had no intention to run another business at Southern Taiwan initially. Attracted by the mechanism of platform, the boss of Company A has decided to invest in KSP so as to maintain the linkage with local innovation capacity.

Unlike Company A, Company B is completely strange to medical device industry. The situation that Company B faced is severe competitiveness of current product from developing countries. Eager to search for a high value-added product, Company B approached the platform actively. Since the core technique of Company B is metal forming and machining, the platform suggested the company to join the dental implant developing project. This program covered the whole value chain activities, including design, manufacturing, surface treatment, testing, certification, packaging, logistics and marketing, necessary for launching a dental implant to the market. In this case, the platform played a role as incubator. After 120 hour's classroom training and practice lasting for about nine month, the engineers of Company B are capable of designing dental implant and the first product prototype has come to shape in less than one year. The management of Company B is quite satisfied with the service of local innovation capacity and is now preparing to enter science park aggressively.

Table 2. Profile of Case Company

	Company A	Company B
Capital (in US dollars)	650,000	5,900,000
Employee (persons)	41	140
R&D personnel (persons)	11	12
R&D Budget (in US dollars)	300,000	160,000
Main Product	Dental medical devices and instruments	Screw, bolt, nut
Location	Taipei (Northern Taiwan)	Kaohsiung (Southern Taiwan)
Business Model	Dental and medical devices and instruments trading and repair service	Original Equipment Manufacturer (OEM)
Target Product	Dental clinic technique evaluation and training simulation system	Dental implant

Source: This Study.

6. Conclusions

Confronting the challenge in the future, the STSP Administration has identified innovation capability as the core competitive element to outperform other Science Park all over the world and has adopted a revolutionary way to promote KSP. In this paper, we have disclosed the methodology to incorporate local innovation capacity so as to assist the SME-based medical device industry in Taiwan to reinforce its R&D capability and to upgrade its product level. The methodology has been integrated into a model. The model is elaborated in this paper and two successful cases are introduced to demonstrate how the model works. The experience of driving the model in Taiwan might not be universally applicable. Further study and more verification of this model might be needed as well. Nevertheless, the authors believe the model has suggested a different proposition that other Science Park authorities may refer to. Right now the MDSZ Project is still in progress while another complementary four-year project is about to launch in next year to strengthen local innovation capacity around MDSZ. There are still a lot of work to do for the STSP Administration in the coming years, such as securing the support of regional government and maintaining the connection to local innovation capacity. Anyway, the authors hopes the new model may inspire our counterpart some innovative idea and thus enriching the missions of Science Park.

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