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Technopolis Development: An Assessment of the Hsinchu Experience

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ABSTRACT *The Hsinchu Science-Based Industrial Park (HSIP) in Taiwan is a government-led investment project located 50 miles south of Taipei established nearly 15 years ago. Its continuous growth in terms of revenue and investment has been recognized as a successful model of technology park development. Although regional development was not considered during planning, its economic achievement has indirectly impacted on the technopolis development in the long term. To accommodate the housing demands, the Hsinchu Science City Development Plan was prepared in 1991 to promote the technopolis development. However, it is regarded as a failed project. This paper will analyse the success factors of the park development and the failure factors of the Science City project. In addition, based on the Hsinchu experience, the institutional paradox of government-led technopolis development is discussed.*

Introduction

Production systems in the global economy have been revolutionized by technological changes. Cities which grew by traditional manufacturing industries are giving way to so-called technopolises where the economy is driven by high technologies. Technopolis development differentiates between spontaneous growth and planned occurrences. The former is common in the USA., such as Silicon Valley in California and Research Triangle in North Carolina, where technology-oriented regions have developed as a result of the uncoordinated actions of private business who happen to locate together due to the presence of commonly valued attributes, especially research universities, good climate and, perhaps, small-scale government investments (Luger, 1996). The latter is typical in Asian nations, where strategic investments, especially by central government, are intended to create technology-oriented cities to serve as engines of growth for their respective regions. Compared with the planned developments of Tsukuba Science City in Japan and Taedok Science Town in Korea, the development of Hsinchu Science City in Taiwan demonstrates some unique experiences in that the government-led projects in the production-oriented technology park (Hsinchu Science-based Industrial Park, HSIP) have successfully stimulated national and local economic development but failed in promoting the physical development needed in the context of a technopolis.

Taiwan is an island of 36 000 km^2, with a total population of 21.35 million in 1995. As one of the newly industrialized countries (NICs), Taiwan has experienced rapid economic growth in the past three decades. In 1965, the per capita

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GNP was a mere US$217, but it reached US$12 439 in 1995. However, criticism has been levelled that urban and regional planning/management in Taiwan has dismally failed to keep pace with its economic achievements. The experience of the Hsinchu Science City project has evidently demonstrated that the management of physical development is much more difficult and complicated than the promotion of economic growth in the case of technopolis development. This paper is intended to shed some light on the critical factors that have influenced the success of the technology park and the failure of the development planning of Hsinchu as a technopolis. The assessment of Hsinchu's experience should provide some valuable information to planners in countries where governments are involved in planning and development of technology parks and technopolises.

Global Economy and the Technopolis

The increasing globalization of economic activities has been the most significant development in the world economy during the past few decades. 'Globalization' of an economic activity is qualitatively different from 'internationalization'. It is a more advanced and complex form of internationalization, implying a degree of functional integration between internationally dispersed economic activities (Dicken, 1992). International labour division associated with globalization is not only enabled by information technology and advanced international transportation, but was also enhanced by the extraordinary events which occurred in 1989, including socialism's collapse and the end of the Cold War. With the opening of the Berlin Wall in November 1989, an extraordinary sequence of events began unfolding to, ultimately, transform global economic geography. Communist governments were ousted throughout Eastern Europe, and later subsequently in the former Soviet Union (Berry *et al.*, 1993).

Cities are the regional economic centres exercising urban functions to serve their peripheral areas. They are complex places that offer a variety of supportive services and benefits that have developed into a sophisticated and dynamic balance to respond efficiently to their distinctive opportunities and needs. Restated, the value must result from the 'functions' that are encouraged in the city rather than from the 'shell' that is provided by the physical infrastructure. Influenced by the growing borderless economy, the nature and structure of these economic activity centres and regions are correspondingly transformed. Cities interact each other and are directly or indirectly inter-linked as a network of global cities. In addition to the conventional global network of 'national capital cities', cities linked in different functional networks are designated according to their major economic functions, e.g. 'airport city' (Conway, 1992); 'seaport city'; and 'technopolis' or 'technopole' (Hodgson, 1992; Castells & Hall, 1994). Among them, 'technopolis' can be viewed as a city of technology in which activities pivot. In addition, technopolises are places where the arts of science and the application of scientific knowledge are the driving forces of a region's economic activity.

In recognizing the increasing importance of high-tech industries in terms of economic development and regional development, an increasing number of developed and less developed countries are encouraging the development of high-tech industries directly or indirectly. Developing a technology park or science park is frequently viewed as a prominent instrument to establish an

innovative milieu or core area of regional development (Goldstein & Luger, 1993). Such a trend has recently flourished in Asian countries (Luger & Lee 1994). The Hsinchu Science-based Industrial Park (HSIP) in Taiwan is a government-led project with nearly 15 years of experience. It is contended by Castells & Hall (1994) that at least 15 to 25 years are necessary for a technology park development to reach full impact. Assessing the Hsinchu experience in terms of technopolis development should provide valuable information for pertinent individuals and agencies.

The geographical area of a technopolis is composed roughly of two parts: the technology park(s) that serves as the engine of economic development, and the surrounding area where the regional development is influenced by the technology park. To review the technopolis development of Hsinchu, this paper discusses the development experience of HSIP and the planning of Hsinchu Science City Development. The critical success factors of HSIP and failure factors of the Science City project are analysed as well. Finally, in addition to the discussion of the future development of the Hsinchu technopolis, an institutional paradox of government-led technopolis development is discussed.

Development of Hsinchu Science-based Industrial Park

The Hsinchu Science-based Industrial Park (HSIP) is situated between Hsinchu City and Hsinchu County, 15 minutes by car from the centre of the city. Travel time to Taipei by freeway is about an hour and a half, to the CKS International Airport about 40 minutes, and to the major harbours of Taichung (south of the park) and Keelung (to the north) approximately two hours in each case (Figure 1).

While most technology parks are purely private sector real estate investments in western countries, Hsinchu is a purely government-led project planned and established by the National Science Council at the central government level, which started operating in December 1980. HSIP has attempted to attract investment by high-tech companies and spur the growth of high-tech industry in Taiwan. Over the past 15 years, the Taiwan government has allocated a total of US$483 million for the HSIP. These funds have been used primarily to develop and maintain the park's physical and non-physical infrastructure, and for educational institutions within the park area. Currently, HSIP includes 424 ha of developed land; another 156 hectares of land is currently under development.

The number of companies in the HSIP grew from seven in 1980 to 180 in 1995. HSIP companies are classified into six categories: integrated circuits (IC), computers and peripherals, telecommunications, optoelectronics, precision machinery and materials, and biotechnology. HSIP firms' combined sales reached US$11.3 billion in 1995. Of the companies inside the park, 36 are foreign-owned and 144 are locally owned. Aggregated investment reached US$5.6 billion by the end of 1995 (Tables 1 and 2). Local sources accounted for 88% of HSIP investment capital, while foreign sources accounted for 12% (HSIPA, 1996a).

The significant contribution of HSIP's production has been widely recognized and confirmed in the literature (Wang, 1991; Luger & Lee, 1994; Lin & Yang, 1994). More specifically, HSIP plays an influential role in Taiwan's high-tech industrial development. HSIP houses nearly all the IC manufacturing companies

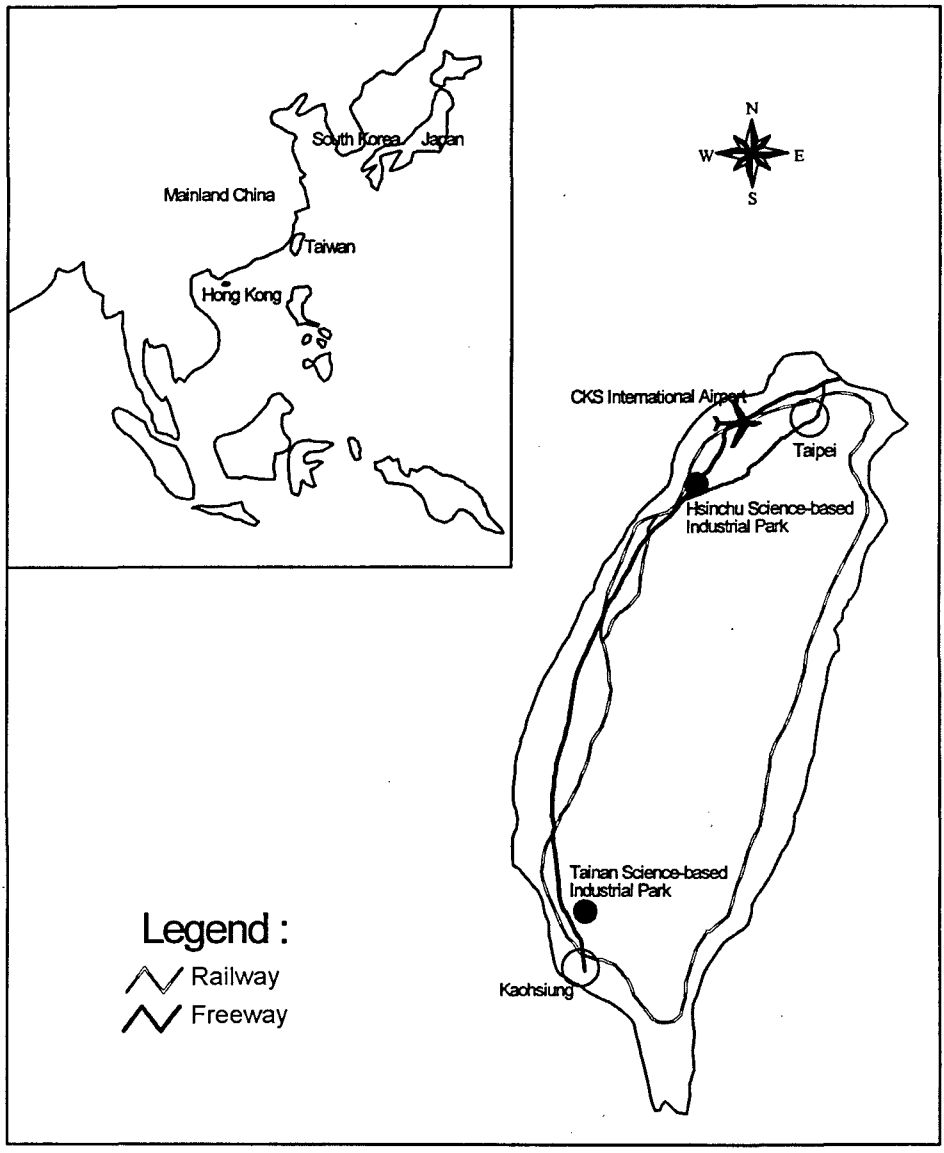

Figure 1. Geographic location of Hsinchu Science-based industrial park.

in Taiwan. IC products are the key components that the island's high-tech industries have heavily relied on, and are Taiwan's largest import items since the late 1980s. With 47 firms in operation, HSIP's computers and peripherals industry in 1995 recorded total sales of US$4, 493 million. According to statistics, the total value of information products from Taiwan in 1995 was US$21.3 billion, US$19.7 billion of which was accounted for by hardware products. Taiwan is the world's third largest supplier of information products, surpassed only by Japan and the USA. In many product categories, an extremely high proportion of Taiwan's output originates from the HSIP (Table 3). Among the leading

Table 1. Summary of HSIP operations

Year	No. of companies	Registered capital (US$ million)	Corporate sales (US$ million)	No. of employees
1982	26	38	NA	NA
1983	37	59	NA	3583
1984	44	110	238	6454
1985	50	144	264	6670
1986	59	177	450	8275
1987	77	546	866	12 201
1988	94	769	1737	16 445
1989	105	1345	2124	19 071
1990	121	2149	2443	22 356
1991	137	2377	2903	23 297
1992	140	2901	3406	25 148
1993	150	3072	4810	28 416
1994	165	4403	6706	33 538
1995	180	7088	10 940	42 257
1996	193	11 447	5834	50 792

Source: Hsinchu Science-Based Industrial Park Administration (June 1996) *Statistics Quarterly*.

Table 2. HSIP industries in 1995

	No. of firms		No. of employees		Corporate sales	
Industry	(No.)	(%)	(No.)	(%)	($)*	(%)
Integrated circuits	56	31	22 496	53	5591	49
Computers and peripherals	41	23	11 148	26	4593	41
Telecom.	30	17	4071	10	643	6
Opto-electronics	26	14	3270	8	379	3
Precision machinery and materials	18	10	1041	2	94	0.8
Bio-technology	9	5	231	1	8	0.2
Total	180	100%	42 257	100%	11 308	100

Note: *Unit = US$ millions).
Source: Hsinchu Science-Based Industrial Park Administration (1996a).

companies, Acer Incorporated established itself as the sixth largest supplier of personal computers in the world in 1995 (HSIPA, 1996a).

Critical Success Factors of HSIP

Location factors are frequently treated as the determinants of technology park development and discussed by geographers and urban planners. Technology, market, labour and capital are the four basic elements required for high-tech industries to survive. Technology parks with location factors deemed appropriate to capture and maintain these four elements usually enjoy a higher likelihood of success. Location advantages such as proximity to a metropolitan

Table 3. Market share of HSIP's information products

Product type	Taiwan's world ranking	World market share (%)	HSIP companies' domestic market share (%)
Monitors	1	70	56
Desktop computers	3	10	52
Image scanners	1	64	50
Portable computers	1	27	42
LAN adapters	1	38	39

Source: Hsinchu Science-Based Industrial Park Administration (1996a)

area, easy connection to good air transportation, affiliation with a university and R&D institutions, and high-quality living environment are considered prerequisites for technology park development in many related reports. However, they are not sufficient conditions. As Castells & Hall (1994) pointed out, the California culture for Silicon Valley development cannot be copied easily in other places. Luger & Goldstein (1991) concluded in an extensive study that park policies and procedures are also critical factors influencing the success of park development. Many technology parks have failed, despite appropriate location factors.

Given that HSIP has successfully achieved its pre-defined operation goals, identifying critical success factors of HSIP is a worthwhile task undertaken herein to compare with other success models. In political slogans, it is very easy to attribute success to the excellence of the government's lead and support. However, if the right actions are not taken, government-led projects do not automatically deserve success. The question is, what are the right actions to be undertaken by the government? As Porter (1990) contended, if industries clustered in a certain area are to be successful in a global market, they must be supported by certain factors with a competitive advantage. Important factors, although incomplete, that may have been forming the competitive advantages of HSIP are identified and discussed below.

Development Strategy

The development strategy is important to a park's survival and success. Economic theory suggests that a country in the early economic development stage should encourage inward investment via transnational companies and then develop sufficient technological capacity so as to improve and rejuvenate existing industries. In contrast, the developed nations should emphasize basic scientific research and its technological applications, particularly in respect of key technologies (Castells & Hall, 1994; Luger & Lee, 1994). The production-oriented strategy of HSIP's early development and targeting at the information industry has paved the right path for successful operations.

Location Advantage

Although location factors are not sufficient conditions, they influence a park's competitive advantage. HSIP enjoys almost every success factor identified previously (Luger & Goldstein, 1991). For instance, within a radius of two miles, HSIP

can easily gain access to two universities with sound reputations in engineering (National Chiao-Tung University and National Tsing-Hua University); an advanced research unit (Industrial Technology Research Institute, ITRI); and interchanges of the two major freeways. In addition, CKS international airport and Taipei (the biggest metropolitan area in Taiwan) can be reached by car within 45 minutes and 75 minutes, respectively. Since HSIP is a production-oriented technology park, firms have heavily relied on the CKS International Airport for transporting imported components and exported products. The proximity to Taipei metropolitan is not only beneficial to HSIP for so-called proximity to innovative milieu and convenient recruitment of skilled labour, but also critical to the production links made with existing electronic firms in Taipei. It is often overlooked, that most early established firms in HSIP are subsidiary investments and spin-offs of electronic firms in Taipei, Acer Incorporated being one of them (Hsieh, 1994).

ITRI is important to HSIP in terms of providing directors and managers of R&D and technical fields, utilizing R&D facilities and offering technical consulting. Regarding the connections with two universities near HSIP, Kung (1995) confirmed that two universities are important to the training and recruitment of technology labour for HSIP; however, their contributions to the technology acquisition of HSIP are trivial. As is generally accepted, the prohibition of private business involvement in faculties of a public university is the major obstacle to university spin-off.

Physical Environment

Recruiting high-tech professionals is the most direct method of acquiring technology. However, they are not numerous and most live in a high-quality living environment in well-developed nations. Undoubtedly, recruiting high-tech professionals is not an easy task for a new technology park. It is not just a matter of how much to pay; rather, it is a matter of how to provide an environment that is attractive to families of high-tech professionals and high-tech companies, since most high-tech professionals are relatively young. Most are married and their children attend school. Meanwhile, high-tech companies prefer to be located in a high-quality environment for the corporation's image.

To provide an attractive environment, the new town approach of HSIP's physical planning is a positive contribution. Not only was the landscape carefully planned, but mixed land use was planned to provide industrial, residential and recreational areas. The industrial areas, in addition to standard factory buildings and sites for custom-designed factories, include green areas set aside to give the park a unique verdant environment. The residential areas include not only housing, but sports facilities. Most importantly, the National Experimental High School in HSIP is the most important resource valued by employees' families, particularly those having returned from overseas. The school is the only 'national' school in Taiwan that provides an educational service from kindergarten to senior high school with bilingual programmes.

Property Development

In addition to a high-quality physical environment, the property development strategy has contributed to HSIP's success in other ways: the 'lease only' policy

and the 'expansion' approach. Since HSIP is a government-led project, lands were acquired and developed by HSIP and then leased to high-tech firms at a relatively cheap rate. However, promising tenants were selected according to their high-tech attributes and development potential. Furthermore, HSIP may exempt collection of rental for no more than five years for land leased to a high-tech industry whose technology is deemed of great value to industrial development. The 'lease only' policy not only reduces the capital burden, but also helps high-tech firms to start-up. They have a higher likelihood of succeeding because their growth potential has been recognized in the review process. While other technology parks have limited growth space, the continuous 'expansion' of HSIP has provided opportunities for high-tech firms to grow and new investments to enter. Consequently, energy for HSIP can be continuously enhanced.

Administrative Services

In addition to the physical environment, efficient and high-quality administrative services are viewed as critical factors to high-tech firms. Service agencies in the HSIP include the Science Park Administration (SIPA), a customs office, two banks, a post office and a telecommunications station. SIPA operates under the auspices of the National Science Council at the central government level. SIPA's main responsibilities are to provide HSIP companies with comprehensive services and to maintain the park. SIPA's work includes planning, investment services, labour management, business services, building control, public works, land administration, computer network services, warehousing, sanitation, emergency services and security. Notably, some of the services are supposed to be provided or supervised by local governments or other governmental agencies. To improve efficiency and quality, they are transferred to SIPA by lawmaking. Owing to such a unique arrangement, the so-called 'one-stop' service was enabled. The customs service provided directly by the Ministry of Financial Affairs is particularly important to firms in HSIP owing to their heavy reliance on transportation speed to compete in the global market.

Taxation Incentives

Duty free and tax exemption statuses are exercised to encourage high-tech production and R&D in HSIP. Machinery and equipment imported for use by HSIP enterprises are exempted from import duties and dues, commodity tax and business tax. Within two years from the date on which it begins to market its product or to render services, high-tech firms in HSIP are eligible to select any fiscal year in the four-year period from such date for exemption from profit-seeking enterprise tax for a consecutive period of five years. Furthermore, if additional investment is made, a profit-seeking enterprise income tax due on additional income may be exempted for a consecutive four years. Taxation incentives not only enhance HSIP's desirability to high-tech investment, but also help the capital accumulation of high-tech firms in HSIP.

Social Culture

Local culture is a subtle but important factor in developing a technopole, as

emphasized by Castells & Hall (1994). It is believed that the Chinese social linkage between Silicon Valley and Hsinchu has helped the start-up of high-tech firms (particularly IC, computer and peripherals manufacturers). Statistics show that returning expatriates have played a vital role in HSIP's growth. By the end of 1995, the number of returned expatriates in the HSIP was 2080, and the number of park companies founded by members of this group was 79 (HSIPA, 1996a). With the knowledge and ideas they have brought back, returned expatriates have done much to raise the levels of technology and R&D in the HSIP. In addition, Table 4 depicts the nationality distribution of foreigners currently living in Hsinchu city during the year 1995. It provides us another clue to show the close social link between the USA and Hsinchu.

HSIP's Impact on Technopolis Development: An Assessment

Although regional development was not a primary motivation for establishing HSIP in the beginning, its continuous economic prosperity has eventually trickled impacts down upon technopolis development, although slowly. Wang (1991) conducted the first comprehensive evaluation of HSIP's social and economic impacts on technopolis development (including administration areas of Hsinchu City and County) based on official statistics from 1980 to 1989. He concluded that the regional economic effects owing to HSIP's additional job opportunities were not significant despite outstanding production performances of firms in HSIP. At that time, Hsinchu still had a population loss problem although it was slowing down. Castells & Hall (1994) comprehensively reviewed the HSIP experience in their worldwide investigation of technopoles. Other than a summary of previous findings regarding the appropriateness of HSIP's location, Castells & Hall (1994) investigated the role of government in particular, concluding that "Hsinchu provides material evidence of the impact of the developmental State on the new shores of the world economy" (p. 109). Obviously, the spatial impacts of local development takes a longer time than economic performance to be evident.

In addition to the aforementioned comprehensive reviews, many other investigations of HSIP's impacts have been undertaken looking at different aspects. Based on previous findings and updated supplementary data, in this paper the regional impacts are summarized in the dimensions of regional economic contribution, population and technology transfer respectively.

Regional Economic Contribution

The average production value of each job in HSIP had reached US$120 000 per year in 1989, as targeted to be achieved in 1991 according to its operation strategy (Wang, 1991). According to HSIPA's recent estimation, HSIP has directly and indirectly contributed to regional economic development in job creation and local business income (HSIPA, 1996b). Some 43 372 jobs were provided by the park as of the end of 1995. Among which 20 633 persons (47.6%) are residents of Hsinchu City; and 12 533 (28.9%) are residents of Hsinchu County. For every 10 persons employed in the manufacturing sector, three are working in HSIP. In addition, 6000 jobs were created by the 200 satellite firms

Table 4. Nationality of foreign residents in Hsinchu

Year	USA	Philippine	Korea	France	Canada	Thai	Japan	Others	Total
1982	103	7	5	8	4	4	19	152	302
1983	155	7	2	1	7	5	36	165	378
1984	159	7	4	1	3	6	28	172	380
1985	185	3	7	1	10	10	26	163	405
1986	192	9	7	1	15	7	22	170	423
1987	283	10	10	4	18	6	51	169	551
1988	300	14	9	5	19	12	59	183	601
1989	381	19	9	5	25	20	82	254	795
1990	485	20	9	8	27	20	101	299	969
1991	672	29	14	10	31	22	121	353	1252
1992	401	18	18	11	15	36	44	279	822
1993	409	152	18	9	19	715	71	333	1726

Source: Hsinchu City (1996) *Annual Statistics of Hsinchu City in 1995.*

in Hsinchu area. Meanwhile, the labour structure in Hsinchu area was also enhanced by the creation of HSIP's jobs. In HSIP, the proportion of employees with at least a junior or technical college education exceeded 50%; the national average is 7.5%. HSIP workers' average age was 30 years; with females comprising 51.5% of the population.

In addition, as estimated, about US$1 billion was spent in Hsinchu region by the workers and firms located in HSIP during 1995, the 17 000 immigrated workers in 1995 have had a tremendous impact on the local housing market. The park also contributed to the city and county US$2.61 million and US$1.81 million, respectively, in terms of estate tax in 1995.

Population

For a long time, Hsinchu area (including Hsinchu City and County) suffered from population loss. For instance, the population in Hsinchu area was 648 145 persons in 1981, the year HSIP began operation, when there was a net social increase rate (immigration—emigration) of -1%. Since then, an increasing population has immigrated into the area. The population impact of HSIP was concluded to be insignificant by Wang (1991) when Hsinchu still had a net loss of 1972 persons in social migration in 1988. At the end of 1995, 42 257 jobs opportunities were created in HSIP, and the total population in Hsinchu area was 340 255, while the social increase rate reached 0.2%. Restated, Hsinchu area enjoys more immigrants owing to HSIP's development.

Comparing the local impacts of foreign direct investment in export processing zones (EPZ) and HSIP, Lin & Yang (1995) indicated that while EPZ created many jobs that mainly attracted young female singles who stayed in a single dormitory, HSIP created more jobs with higher income that attracted married couples with a higher education level. In terms of their population impact, this difference implies that HSIP created more housing and public service demand than EPZ. In fact, the average productivity of each employee in HSIP was US$17.3 million per year in 1993, whereas the national average was US$8.1 million. Higher consumption capability can be imagined. In fact, Wang (1993) investigated the consumption characteristics of HSIP employees, finding strong links with Taipei

Table 5. R&D expenditures and number of HSIP patents in 1994

	R&D expenditures (US$ million)	R&D expenditure sales (%)	Number of foreign patents (A/B)*	Number of domestic patents (A/B)*
Integrated circuits, computers and peripherals	169.95	5.8	541/165	648/68
Telecommunications	74.11	2.7	78/43	84/26
Optoelectronics	34.88	7.3	5/5	2/2
Precision machinery	17.70	15.4	27/13	8/5
Biotechnology	5.63	8.1	0/0	0/0
Total	2.89	6.7	1/0	0/0
	5.16	4.8	652/226	742/101

Note: *A = number of patents applied for; B = number of patents granted.
Source: HSIPA (June 1996) *Statistics Quarterly of Hsinchu Science-Based Industrial Park.*

City despite the fact that the local commercial environment in Hsinchu city had improved significantly.

Technology Transfer

Kung (1995), in the most recent assessment, examined the technology linkage of high-tech firms in HSIP through questionnaires and interviews. Kung found that 'self R&D' is clearly the most important way of enhancing technology strength for the 41 responding firms surveyed. Table 5 lists the R&D expenditures and number of patents of firms in HSIP in 1994. This table reveals that IC, computers and peripherals industries are the key areas of R&D investment. While the R&D expenditures sales ratio was 5.4% in HSIP, the national average was only 1%. However, Kung also concluded that except for the deep linkage between ITRI and high-tech firms in HSIP, not much technology transfer within the local area had occurred.

Based on the theory of endogenous technology growth and R&D expenditures, Luger & Lee (1994) investigated the experience of HSIP development, concluding that Taiwan possesses the essential ingredients to implement a strategy of endogenous knowledge-based growth. Moreover, HSIP's development model should be modified if an additional science park is to be developed.

Planning the Technopolis: Hsinchu Science City

Integrating with local development was not seriously considered in the early phase of HSIP development. However, owing to the continuous and rapid growth of employment in HSIP for a decade, a shortage of housing with a high-quality living environment became a critical issue in the late 1980s. A movement for residential community development by the employees in HSIP and ITRI was sparked and promoted by the island-wide real estate price escalation in Taiwan. To accommodate the demand of housing development, SIPA proposed a comprehensive plan for the development of Hsinchu Science City to coordinate and integrate regional development (covering the area of Hsinchu City and Hsinchu County to a total of 1531.69 km^2) with HSIP's

development for a term of 25 years. The short-term target year is 1996 and long-term target year 2005. Major development concepts of Hsinchu Science City are described and discussed below (HSIPA, 1993).

Technology Development

To support technology industries located in HSIP and neighbouring areas, a metropolitan business centre and technology interchange centre to enhance the milieu of innovation and high-tech industrial development are to be developed. In addition, based on a regional development policy, a comprehensive R&D centre and renewal projects for existing industrial areas are to be promoted to upgrade existing industries in the Hsinchu area.

Living Environment

Planning and facilitating the development of residential communities for the technology employees are primary concerns. In addition to low-density community development in Shiangshan and Baoshan hillside areas, community renewal projects near HSIP are also to be promoted. These developments are aimed at diversifying the high-quality housing to be provided at an appropriate price in Hsinchu Science City.

It is planned that commercial centre and business buildings are to be developed by using existing industrial lands. Improving commercial and business facilities should be helpful to developing Hsinchu into an international city. In addition, as the Hsinchu area is rich in nature and cultural resources, it is expected to provide historic areas and parks for the residents in Science City.

Infrastructure Construction

In addition to construction projects that are already included in national construction projects such as the Northern Second Freeway, Western-Seashore Expressway and High Speed Rail projects, two important local construction projects are planned: a mass rapid transit system for Hsinchu area to improve the transportation service level and a teleport project to enhance the information infrastructure.

International Technopolis

Hopefully, the Science City will be internationally attractive to high-tech individuals in terms of a living and research environment. In other words, Hsinchu Science City aimes to become an international technopolis by improving the physical environment. In addition, implementation programmes are also proposed to promote international exchange of academic and R&D activities.

Failure Factors of Hsinchu Science City Project

The target year for short-term development of Hsinchu Science City project was 1996. As a performance assessment shows that none of the construction projects newly added to the development plan has been initiated to date, the government-led Hsinchu Science City project is obviously a failure. Critical failure factors can be summarized as below.

Unwillingness of Local Governments

Hsinchu Science City covers the administration areas of Hsinchu City and Hsinchu County. Although the Science City planning is directly initiated and prepared by HSIPA at the central government level, land-use control and infrastructure construction are under the official authority and are the responsibility of local governments. Not only is coordination difficult because the City Mayor and County Governor belong to two different political parties, but also because both local governments are strapped for financial resources; neither of the local governments is willing to promote regional development projects.

Difficulty of Land-use Conversion

Zoning is the main instrument of land-use control in Taiwan. Because of the four-tier administration structure, the approval process in applying for land-use conversion is not only time consuming, but also inconsistent among different review agencies. Furthermore, since most land in Hsinchu is in hillside areas, the Order of Building Prohibition in Water Resource Preservation Areas in 1990 stopped many development applications and infrastructure projects.

Insufficient Legal Basis for Private Construction of Infrastructure

In the development plan, most construction projects were planned for investment by the private sector. However, the only legal basis for public construction of infrastructure with incentives was not made available until 1995. Restated, private provision of infrastructure was totally impossible before, that time.

Organizational Powerlessness of Task Group

Recognizing the importance of coordination among different government sectors, the Task Group for the Promotion of Hsinchu Science City Development was formed in 1991. Members of the task group come from various related agencies in both local and central governments. Although the task group was expected to coordinate and promote the implementation of development projects, it has proved to be of limited effect. The task group has no power in the decision processes of resource allocation and land development approval. Six meetings of the task group have been held since establishment. At the end of 1996, the last meeting had been held a year earlier, in December 1995.

Future Development of Hsinchu Technopolis

Technology is the fuel that empowers economic development; advanced technology is the mark of a nation's strength. During the past 15 years, HSIP has played a prominent role in reshaping Taiwan's industrial base and bringing about the development of high-value-added products. The HSIP will continue to grow. According to HSIP's 10-year operation plan, the goals to be achieved in 2003 are sales revenues of US$50 billion, employee numbers reaching 80 000 and number of companies reaching 300.

In addition to the existing developed area of 424 ha, an expansion project of 156 ha is under way. The mixed land-use development of HSIP with a scale of

580 ha within an independent administration boundary allows HSIP to operate like a new town. According to the competitive advantage model (Porter, 1990), the personal computer manufacturing industry in Taiwan has established some leading advantages for global competition, and firms in HSIP should be able to maintain the prosperity of the information industry for some time to come. Based on the theory of growth pole and growth centre and by the nature of a technopolis where technology-induced economic activity provides the pivot for the urban development, spill-over effects on regional development resulting from HSIP's economic prosperity will become increasingly evident.

A system providing a full range of network services was installed in the HSIP in 1991. This system is widely used, particularly for Internet and World Wide Web access. In July 1995, with the government's National Information Infrastructure development programme under way, SIPA completed the installation of a park-wide asynchronous transfer mode (ATM) broadband network integrating automated customs clearance and other information systems. This effort should make HSIP more capable of accommodating the needs of an information economy.

Looking at the infrastructure required for networking, many ongoing projects are favourable for developing the Hsinchu technopolis in terms of urban development and global connections. Privatization of telecommunication services took effect in July 1996. Information flow will be stimulated and favourable to long-distance interactions. The newly completed Northern Second Freeway has relieved the traffic congestion between Taipei and Hsinchu significantly. In the future, a new high-speed rail station will be situated near HSIP, which will encourage Hsinchu's interaction with other local cities. The expansion project of CKS international airport into a regional air hub will definitely be helpful to international passenger transportation and cargo transportation between Hsinchu and elsewhere in the world.

Difficulties encountered in coordinating various governmental agencies at the central and local levels will continue to persist in future technopolis development. Similar to the nature of metropolitan development, an inter-governmental coordination mechanism is a critical factor influencing the efficiency and quality of public service provision. This issue might become even more serious owing to the continuing decentralization movement in Taiwan's bureaucracy.

Conclusion

Building a technopolis is not a policy that is likely to prove successful in the short term, as emphasized by Castells & Hall (1994). It might take 15 to 25 years for the full impacts to become evident, since the spatial development is organic in character, and networks and linkages are established over time. Judging from the 15 years' experience of HSIP development, spontaneous technopolis development is evident.

The economic success of HSIP (the core of the technopolis) has evidently stimulated the regional development of surrounding areas in the long term despite the fact that regional development was not planned, even not considered, in the earlier stages. While technology is treated as the cornerstone to make a technology park come alive, the market provides the energy for the technology park to survive in the long term. The prosperity of the PC manufacturing industry has played a driving role in the continuous growth of HSIP.

HSIP has long been criticized as 'not scientific enough' because it has more production firms than R&D labs. However, such production-oriented development is really the key for HSIP to maintain its economic vigour. As was argued by Luger & Lee (1994), HSIP's early success in production has made it more attractive and capable of stimulating indigenous R&D.

Although many technology parks were planned to be developed, not all projects produced favourable results. The performance of a government-led technology park project is a function of the support level and the efficiency of public administration. Since the HSIP project is a purely government-led investment project, the government's role should be of particular importance to HSIP's development and deserves discussion to conclude this paper.

HSIP's success has benefited from governmental support in many facets, as discussed earlier. Among those support items, however, the institutional set-up is critical in terms of administrative efficiency. The bureaucratic hierarchy in Taiwan is vertically a four-tier system (State, Province, City/County, Town/Hsiang), while the lower tiers are notorious for their poor efficiency, and difficulties of horizontal coordination among different government agencies are often complained of. Through lawmaking (Statute for the Establishment and Administration of a Science-Based Industrial Park), HSIPA is authorized to take over tasks of local governments in land use and building management, industry/business administration and public works, and to supervise the branch offices of related public services including customs office, high school, banks, post office and telecommunications station. With the centralization of authority to HSIPA, high environmental quality and efficient public service can be maintained for the residents and firms in the park. Furthermore, although it seems ironic for the National Science Council to sponsor the operation of a production-oriented park (HSIP), whereas the Ministry of Economic Affairs runs the research unit (ITRI), in fact, the role exchange has made collaboration and interchange much easier, particularly in the aspects of R&D and spin-offs.

Interestingly, while such an institutional set-up contributes so much to the success of HSIP, it becomes an obstacle to the implementation of Hsinchu Science City Development Plan as contended herein. How can such an institutional paradox be solved? This a question suggested for inquiry in future studies.

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