Chinese Industrial and Science Parks: Bridging the Gap

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Abstract:
This article proposes the addition of a "bridge high technology" stage to Park's (1996) Asian development model, based upon field research and analysis of four "science and technology parks" in different regions of China: Shenzhen, Shanghai, Suzhou, and Xi'an. Initially established as learning districts to foster technology transfer from foreign to domestic enterprises, these specially configured spaces exhibit a variety of interactions indicating an increasing shift toward domestically generated technology for native companies. The mix and type of companies in parks at different locations within China reflect the locational comparative advantages of each place, whether as an outgrowth of local research or by government design.
Key Words: China, science parks, technology transfer

Article:
Introduction
As China aggressively seeks to raise the level of its industrial production and join the world economy as a key player, new strategies and institutional alliances emerge. In order to overcome almost two centuries of tumultuous political and economic restructuring, new programs nurture native enterprises by promoting geographic proximity to advanced foreign multinational company production facilities in specially constructed industrial and science parks. Companies in China's fifty-three nationally recognized high-technology zones reportedly increased their revenue by 35.7 percent from 1999 to 2000, contributing U.S.$10.6 billion to the national treasury (Li 2000).

The purpose of this research is to explore interactions in these specially configured spaces to determine if they represent a new model of developing world industrial learning districts. This study considers high-technology park dynamics in three leading Chinese regions: the Pearl River delta (Shenzhen), the Chang Jiang delta (Shanghai, Suzhou), and the interior West (Xi'an). The object is to extend the Asian development hypothesis typology proposed by Park (1996) to include an intermediary category of "bridge high technology" more appropriate for the new arrangements linking research and development in Chinese universities to a broad array of product applications. Examples of these bridge connections range from more durable asphalt formulated to withstand extremes of temperature in newly developing regions to improved pharmaceutical compounds, with multinational firms becoming more effective by establishing close ties with Chinese university scientists.

The primary research question posited here examines how China's strategy of using access to foreign high-technology companies in clustered new industrial districts assists the country's modernization through technology transfer, in terms of upgrading both product and process capability (Malecki and Oinas 1999). What is the role of multinational corporations in regard to local companies (e.g., to train local suppliers or to set up subsidiaries)? What is the relationship of Chinese companies to other connections such as government and university entities? And finally, how does the situation vary by location within China?

Several key terms require clarification as to their use in this research. Land set aside and designated for a particular type of company in China can be called an industrial park (*gong yuan*), a science and high-technology park (*ke ji yuan*), or a combination of these terms and facilities. Despite the different names for these new industrial districts (Park 1996; Wang and Wang 1998), multinational companies located in these areas primarily engage in the assembly and manufacture of relatively "clean" products that yield high profit margins, due to the stress placed on research and development at the headquarters location abroad. Examples include pharmaceutical companies that combine ingredients and package medicine at their Chinese facility and electronics companies that source components throughout Asia for assembly in and shipping from China. "Learning districts," or "learning regions" (Boekema et al. 2000; Oinas 2000), refer to places where information exchange occurs among local actors, resulting in significant innovations in process or products, leading to economic development (Malecki, Oinas, and Park 1999). Examples of these activities include the design and manufacture of new products targeted to fit the needs and capacity of the Chinese market.

Conceptual Framework

In an application of Markusen's "sticky places" framework (1996) to Asian circumstances, Park (1996) suggests that districts move through distinct stages, based on the strength of network links. The research discussed in this article adds an additional stage to this model (Figure 1).

Satellite multinational corporations, dominated by the branch plants of large multinational corporations, characterize the initial stage. National government directives support the growth of these satellites by providing affordable factors of production such as cheap land, plentiful labor, and tax breaks. The national state plays a particularly important role in Asian development by creating the zones, then placing and directing their occupants. Provincial and municipal authorities also serve as players in China. Industrial districts in Dongguan, a large municipality to the west of Guangzhou, illustrate this situation. By attracting inner China migrants who provide low cost labor for assembling component parts in branches of foreign companies, these parks provide a classic case of the satellite stage.

Stage 2, the *advanced hub and spoke* business arrangement, involves the addition of local suppliers and start-up companies that provide components to or buy products from the foreign-based multinational. Parks such as the China-Singapore Suzhou Industrial Park (CS SIP), featured in this research, typify such a district. In this case, the multinational companies utilize a greater number of higher skill laborers and closer ties to local suppliers than do companies in stage 1. In stage 3, *advanced satellites*, small new firms and other spin-off businesses related to the multinational produce goods using components obtained elsewhere, but new spin-off firms and local research and development (R&D) ties begin to appear. Xi'an's technology parks, profiled in this research, provide just such an example. Stage 4 incorporates *pioneering high technology* domestic companies, characterized by complex and extensive locally embedded supply and market linkages not related to the multinationals. Innovations based on local R&D, along with locally devised production and/or distribution systems, provide a distinctive feature at this stage.

This research proposes an extension of that model based on network-component location, an additional bridging stage between the third and the final stages. The *bridge high technology* stage, an intermediate stage 3A, applies particularly to Chinese start-ups. "Bridge high technology" companies engage in local production but depend on research, development advice, and finance obtained from Chinese universities and related institutes, separate from the networks and channels of overseas multinationals. The most active entrepreneurial educational institutions that support these parks include Peking University, Qinghua University, Fudan and Jiaotong. These institutions of higher education offer nurturing incubator settings that funnel investment and advice to local firms in an attempt to compensate for an insufficient number of experienced business advisors to mentor companies through the uncharted waters of China's transitioning economy. Examples of these university-business ties occur in Zhangjiang Hi-tech Park, in Shanghai-Pudong, and in Shenzhen Hi-Tech Industrial Park (SHIP). Research institutions provide the essential bridging component between the initial stage of production, dominated by advanced offshore companies and their satellites and spokes, and the final stage, in which locally generated high-technology-pioneering firms become globally competitive.

Some past studies regarded universities as unimportant to the growth and development of new industrial districts (Park and Markusen 1995). This study updates the observations of six years ago to reflect developments in the growth of domestic R&D organizations and features their contribution in China. Observations of dynamic industrial districts constitute a moving target. Descriptive theories and categories periodically need updating to reflect current strategy in response to new conditions and capabilities, leading to this study's proposed "bridge high technology" conceptualization.

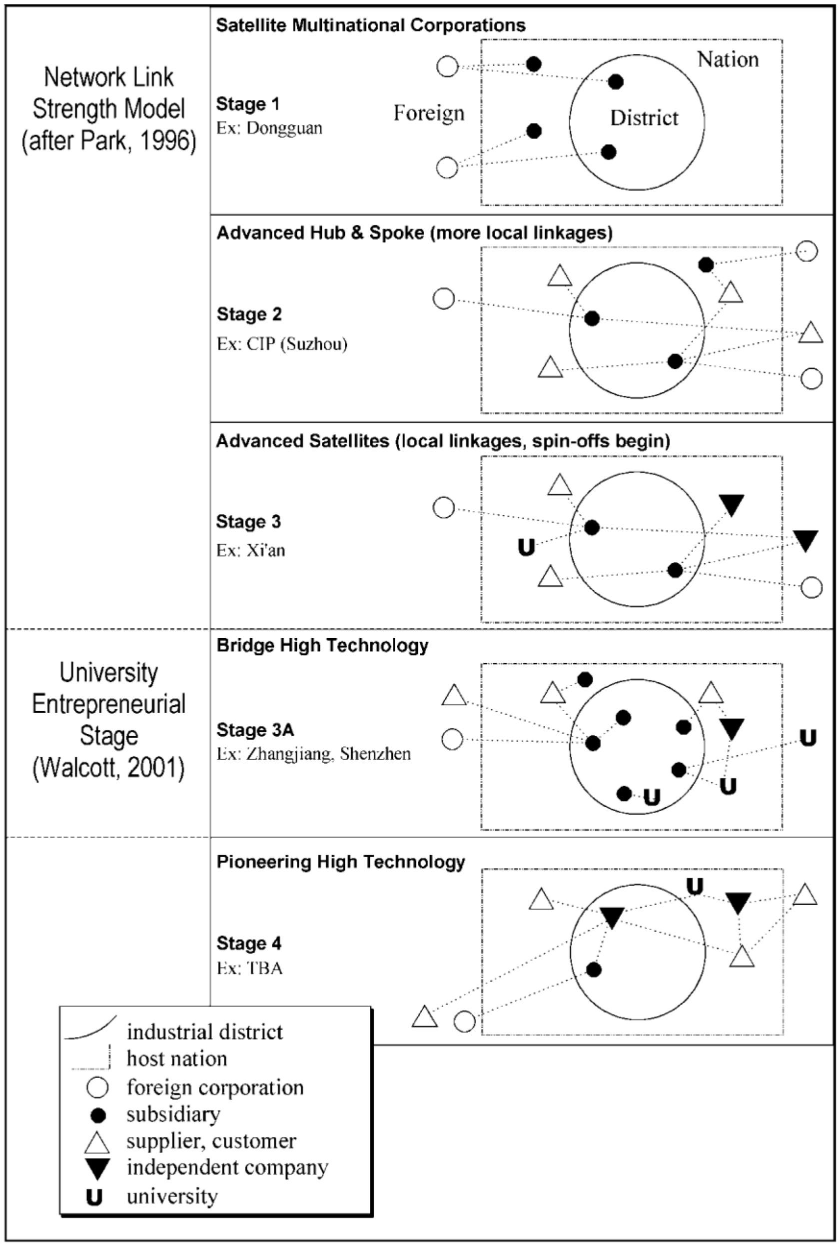

Figure 1 *Asian development model schematic.*

Other Asian examples, with varying levels of success in supplying marketable innovative products, include Taiwan's Hsinchu (Hsu and Saxenian 2000), Korea's Taeduck (Park 2000), Japan's Tsukuba (Castells and Hall 1994), and Singapore's Kent Ridge, all affiliated with an important research university and/or institute, as pioneered in the U.S. by Stanford's Silicon Valley technology complex. It is important to be tied to a global network to increase local corporate high-technology activity. However, Hsinchu's example foreshadows the contention of this article that the participation of local labor in a transnational technological community may be more important than the presence of transnational corporations in promoting international technology transfers.

The "bridge high technology" category reflects the ties that promote technology transfer at each location, as well as the multiplicity of types of companies and support structures at this development stage. Each of the four districts examined here highlights a particular company in order to explore the effects of their corporate structure, from a multinational to an incubator focused on encouraging local startups. Table 1 summarizes the types of companies and locations profiled in this research. The variety of company types demonstrates the fluid nature of China's restructuring economic landscape and the competitive advantage employed by different strategies at each site. The proliferating number of technology parks established throughout every region of China will prosper as they draw on desirable local advantages, such as those embodied in the examples featured in this research (Zou 2000).

Table 1 *Types of Companies, Science and Technology Industrial Parks Profiled*

Corporate Structure	Park/Year	Location	Company/Year	Function
University-affiliated enterprise	Shenzhen Hi-Tech Industrial Park (SHIP)/1989	Shenzhen	Kexing/1989	Northern university contacts support companies in leading Southern high tech park
Joint-venture multinational	SHIP/1989	Shenzhen	Harris/1993	North American global giant Hong Kong-Shenzhen outpost
State-owned enterprise	Zhangjiang Hi-Tech Park/ 1992	Shanghai-Pudong	Incubators/1992	Government-assisted local start-ups
State-owned enterprise	Xi'an Hi-Tech Industries Development Zone/1993	Xi'an	XIBI/1993	Military-industrial complex goes commercial
Multinational company	China-Singapore Suzhou Industrial Park/1994	Suzhou	Becton-Dickinson/1996	Singapore regional strategy, with American company, in Singapore affiliate park

Source: Development park and company booklets (Becton Dickinson 1999; XIBI 1999; Suzhou Industrial Park Administrative Committee [SIPAC] 2000; Shanghai Zhangjiang Hi-Tech Park 2000); Chesterton, Blumenauer, and Binswanger (1998).

Methodology

The three approaches employed in this research to assess emerging conditions in the selected industrial and science parks include: (1) a survey of and interviews with company and development zone managers in four targeted technology parks, (2) a case study of a representative firm in each park (Table 1), and (3) an analysis of the territorially specific locational advantage associated with the four development zones. These data provide important indications of the ongoing global-in-local discourse (Sassen 1994; Dicken 1998).

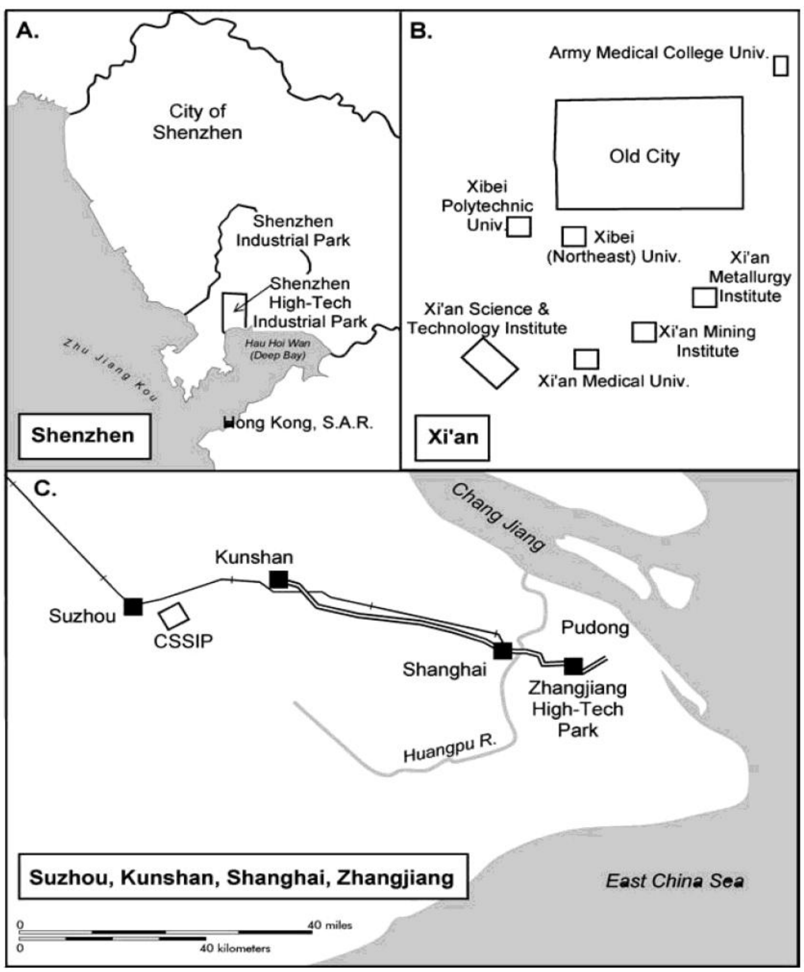

Figure 2 *New industrial districts: A) Shenzhen; B) Xi'an; C) Metro Shanghai.*

Science and technology park districts (Figure 2) were selected to reflect different stages in China's "opening and reform" since 1978 and different geographical settings. As illustrated in these maps, the government initially chose the location of these development districts for their attractiveness to foreign companies, not their proximity to research institutions. The companies contacted in each park focused on firms representative of China's four major high-technology targets: computers, information technology, pharmaceuticals, and new materials (Table 2). Table 3 provides the total number of companies interviewed by the author during three trips to China from 1999 to 2001 and their locations, along with the number and general position of individuals interviewed. A variety of complementary research methods guided the investigation into the nature and degree of spatial interaction and networks linking communication between entities in each cluster. A set of "Science Park Survey Questions" written in English and Chinese provided a framework for consistent inquiries. Table 4 displays the topics of inquiry and the responses. The use of both Chinese and English written questions aided respondents' understanding of the issues examined. Translations were checked for clarity with three native speakers of Chinese. Interviews were conducted in both spoken Chinese and English. This process reassured the interviewee that a set of identical questions was posed to all interviewees. Firms were selected from lists of occupants provided by development-park organizations, the *China Business Review*, and the American Chamber of Commerce in China.

Table 2 *Types of Industries in Parks*

Park Location	Types of Industries	Multinational Corporations/Countries
Shenzhen	Electrical information (92%), new materials, biotechnology	Japan, U.S., Holland, England, France
Zhangjiang	Pharmaceutical, electronics, information technologies (IT), silicon-chip manufacturers	40 out of 100 companies; U.S., Japan, Germany, 12 other countries
Suzhou	Electrical/electronics (45%), light industrial and food (30%), biopharmaceuticals (14%), chemicals, new material (10%)	U.S. (30%), Northeast Asia (15%), Southeast Asia (29%), Europe (15%), Oceania (11%)
Xi'an	Electronics-IT, optomechanic, new materials, biomedical, engineering, software	Coca-Cola, Siemens, Mitsubishi, IBM

Source: Development park and company booklets (Becton Dickinson 1999; XIBI 1999; Suzhou Industrial Park Administrative Committee [SIPAC] 2000; Shanghai Zhangjiang Hi-Tech Park 2000).

The initial approach involved mailing a survey sheet to 115 companies several months prior to the field research. The explanatory cover letter gave the purpose of the survey as examining "what role location plays in the conduct and success of your business." To encourage responses, a check-off area was provided for companies wishing to receive a copy of the full report of the overall results. The number of surveys sent to each location varied according to the number of high-technology firms in the park.

Table 3 *Interviews*

Location	Company Representative	Technology Park Official	University-Connected	Total
Shenzhen	8	3	2	13
Zhangjiang	7	4	2	13
Suzhou	4	1	0	5
Xi'an	1	4	3	8
Total	20	12	7	39

Source: Author's field research.

The primary data source consisted of on-site personal interviews by the author with company executives and development-park officials, arranged in advance over a period of three months by fax or email contact or through intermediaries. Questions covered the same areas as those in the survey form.

Historical Setting

The proclamation of a "Reform and Openness" policy by the 11th Chinese Communist Party Congress in December 1978 marked an historic shift in emphasis from class struggle to economic development as China's central ordering principle. Premier Deng Xiaoping's statement that "science and technology are the primary productive forces" signaled major policy realignments with broad spatial ramifications. The establishment of special zones for accelerated industrial modernization dates from this time forward, beginning with the eastern coastal areas. Historically, these sections of the country possessed the most potential, due to their long-standing ties with more advanced world regions.

Table 4 *Interview Responses*

Question	Response Categories	Number/Place of Positive Responses
1. Major reasons company chose to be in present location?	Assigned by government	6
	Transportation access	11
	Labor base available	All
	Attractive environment	SH, CSSIP
	Other companies in park	All
	Desirable city	All
2. Linkages with local entities?	Other contiguous companies	SH, CSSIP, XIBI
	Organizations	All
	Tacit information access	All
3. Basis of mediating organizations working to promote company success?	Park	All
	Government	All
	Occupation	XIBI, SZ, SH
	Background (education)	XIBI, SZ, SH
	Industry	XIBI, SZ, SH
4. Special infrastructure available?	Computer access	All (but slow)
	Transportation (incl. vans)	XIBI, SZ
5. Business focus	IT	All
	Pharmaceutical	SZ, SH, CSSIP
6. Quality of life consideration attracting you/company to this location?	Cultural	Shanghai
	Commute	XIBI
	Education	SZ, SH
	Affordability	All
7. Technology transfer	By specific university	All
	Within company	All
	Between companies	SZ, SH

Source: Author's field research.
Note: SH = Shanghai (Pudong-Zhangjiang); CSSIP = Suzhou; XIBI = Xi'an; SZ = Shenzhen (SHIP).

In July 1985, the municipal government and the Chinese Academy of Sciences founded the Shenzhen Science and Technology Industrial Park (Yang 2000). Four years later the municipal government established Shenzhen Hi-tech Industrial Park (SHIP), subsuming the original industrial park into one of twenty-seven state science and technology industrial parks. SHIP's creation as the first district combining research from institutions affiliated with the Chinese Academy of Science and foreign company technology transfers (Gu 1996) marks the beginning of the "bridge high technology" stage.

The first national-level government program specifically providing capital for technologically promising businesses was the "863" plan, named for the date (March 1986) of a speech launching the idea. The impetus resembles Vannevar Bush's post–World War II efforts culminating in the establishment of the U.S. National Science Foundation in 1950 to support applied research. Fueled by concern over a perceived collusion between the U.S. and Taiwan against mainland China, the plan focused on military projects as well as those intended to improve the people's livelihood. Launched by the Chinese Academy of Science and Peking University, 863 advocated government preparation of a large fund to assist high-technology project research.

Initial funds for successful projects solicited from major university scientists showing some "fruits" of their ideas went to well-known and established experts. The "Torch Program," launched by the Ministry of Science and Technology in 1988, focuses on small and medium-sized businesses. With a lower requirement for demonstrated success of an idea than 863 had had, but still involving initial screening by a panel of scientists, Torch encouraged a broader base of applicants. Most funds are distributed for high-technology projects throughout the country, combining with other venture funding to sustain small but worthy efforts. Torch investments particularly target the second stage of company capital needs following some preliminary product launch. Constructing a viable business plan in order to attract foreign investors forms a key goal of Torch awardees.

Technology Transfer through Foreign Direct Investment

Four factors distinguish the current Chinese development district model from previous patterns in developing countries. The first is China's size, both its land mass and, more importantly, its large population. A huge pool of hard-working, low-pay-scale, semieducated workers supply an enormous workforce by migrating into job opportunity regions from the interior. This situation distinguishes China from the less populous Asian Tigers.

The labor base in China includes a highly educated segment capable of innovating but hampered by a shortage of both investment capital and trained management.

China's access to models of development to study and choose from constitutes the second distinct factor. Like Japan at the initial stage of Western influence a century and a half ago, China actively sends agents abroad to acquire knowledge about such models to construct its own path for modernization. At the same time, a third distinction from other Asian models emerges: China's lack of a strong, wealthy international mentor country due to confining political allegiances in the communist bloc. The fourth factor is the unfolding of a transitioning state from economic centralization to localization of control, within a framework of controlled stability. As in other developing countries, government entities play major roles in the development of targeted localities.

Shenzhen Hi-tech Industrial Park

Investments in Shenzhen in the early 1980s, received from electrical industries headquartered in Hong Kong, signaled the first multinational company activity permitted in China. Provided that they were technologically advanced, companies with non-Chinese headquarters operating in China that held promise for generating foreign currency through export and filled an area of national need (Weidenbaum and Hughes 1996) received priority assistance. These requirements have been relaxed in the last several years. Joint ventures now constitute 64 percent of Shenzhen's high-technology enterprises, accounting in 1996 for 70 percent of Shenzhen's total product value. However, this form of organization remains a tricky, initial-entry strategy based on the premise that partners can deliver on their promises and profitably coexist (Lan 1996). Shenzhen's high-technology products increased from a 1992 value of U.S.$100 million to 1998's figure of U.S.$264.4 million (CSB 2000a). Most corporate arrangements remain at the stage-1 level of satellite multinational corporations in this locale.

A follow-up to 863, the "973" plan (advanced in March 1997) highlights nine technology projects in "six key pillar" areas, including telecommunication, electronics, biotechnology, and the environment. By 1998, SHIP supplied 35.4 percent of Shenzhen's total high-technology products, such as computers, software and pharmaceutical products. The three pillar industries of information technologies (IT), biotechnology, and new materials represent almost 90 percent of the increase in gross industrial value of products in Shenzhen (CSB 2000a). Development bursts (1979–1984, 1988–1994) were largely fueled by a tremendous inflow of capital from outside the country, particularly from Hong Kong. By 1999, Shenzhen commanded the sixth highest gross domestic product (GDP) of all Chinese cities; per-capita GDP placed it number one, as did the value of its total exports and imports, due primarily to Hong Kong's proximity. The shifting proportion of jobs in the primary, secondary, and tertiary sectors, from 37%:20%:42% in 1979 to 1%:51%:48% in 1999, suggests a maturing economy and rising labor force skill level (CSB 2000a; Yang 2000)—fruits of the government's policy encouraging foreign corporate presence for technology transfer.

SHIP inhabits a relatively small section (11.5 square km) within the larger and better-known 327.5-square-km industrial park. The central part of SHIP is the older core area, while most of the multinational corporations have located in the northern section since it opened in the early 1980s. While they comprise only 4.5 percent of the total companies located in SHIP, multinationals—principally in IT and opticalelectronics—include major global players such as IBM (U.S.), Olympus (Japan), Lucent (U.S.), Harris (U.S.), Compaq (Japan), Epson (Japan), Philips (Holland), and Thomson (France). IBM, Compaq, and Epson brought other supplier companies with them. The top ten multinational corporations in China include three from Shenzhen; fifteen firms fall in *Fortune* magazine's list of the top "Global 500" (CSB 2000a). Though over 90 percent of the companies in Shenzhen report exporting their products, many actually reroute their shipments, as evidenced by lines of trucks stretching from Shenzhen in and out of Hong Kong, looping back across the border to sell their cargo in the domestic market.

Multinational companies rely heavily on government intermediaries for local information and on their headquarters for funds. The national government's Foreign Enterprise Association in Shenzhen informs multinational corporations of new directives that affect them and in turn solicits questions and advice. The government also provides tax reduction (up to 50 percent) for high-technology companies.

The North American Harris Company, which supplies medium- and low-wave digital microwave systems and telephone and data transmission capacity throughout China, is the example of a multinational studied in SHIP. Harris entered China in 1993 as a joint venture with a Chinese partner in order to be quickly ingratiated into a *guanxi* (personal connections) network. The company eventually made the transition to being a wholly foreign-owned enterprise—the most common route for a multinational—and relocated in SHIP. Most of Harris's supplies and technical parts for products originate in North America. Some local suppliers are used, despite the common complaint that the search for local producers often flounders for lack of sufficient quality standards. Within Harris, technology primarily flows from the Canadian corporate side, and top employees go there to train for 4–8 weeks. Most technology transfer takes place through such labor exchanges. One product was developed locally for the Chinese market. Chinese universities in other cities provide 95 percent of Harris's college-educated employees—85 percent of the company's total number of employees. Harris operates at the stage-2 "advanced hub and spoke" level of the Asian development model, as do many of the multinationals that predominate in the next example.

China-Singapore Suzhou Industrial Park (CSSIP)

Geographically within the orbit of metropolitan Shanghai, but lying eighty kilometers to the west, CSSIP began in 1994 as a project between the government of Singapore and the People's Republic of China (PRC). Utilizing Singapore's strategy of development based on attracting multinationals, the park's management attracted global corporations that currently comprise over 95 percent of its occupants. Samsung, Hitachi, AMD, Fairchild, and Philips, as well as companies from Taiwan, handle semiconductor assembly projects. In general, many foreign companies seeking to enter China first set up manufacturing facilities, followed by R&D centers to modify product lines for the domestic Chinese market rather than to invent new goods. The fluency in English of Singaporean managers located in the CSSIP appeals to many companies seeking a learning location in China (interviews).

During CSSIP's first three years, it primarily attracted American and European companies. The next three years brought more activity from Taiwanese and overseas Chinese operations due to seismic movements of both earthquakes and politics (interviews). A series of earthquakes in Taiwan the late 1990s—the last registering over 7.5 on the Richter scale— damaged factories and caused shipment delays of vital computer silicon chips from Taiwan, the world leader in exporting this item. In addition, President Chen Shuibian's policies are seen as both pro-"green" and antibusiness, prompting some major Taiwanese manufacturers to look at other locations—such as Suzhou. The metropolitan area of Suzhou supports two other industrial parks, with the Suzhou New District containing more than twice the number of companies in CSSIP: 400, compared to 190. Kunshan, to the east of Suzhou, holds 1,000 companies, mostly small and medium-sized enterprises from Taiwan, ranging from foundries to semiconductor manufacturers (SIPAC 2000).

The CSSIP framework reflects policies pursued in Singapore: support for multinational corporations rather than smaller local companies in a branch-plant economy (Yeung 2000). The development corporation acts as a matchmaker, seeking private partners and suppliers for park companies and locating them on the outskirts of the park to keep the interior for larger, clean corporations. Metropolitan Suzhou supports more than half of Jiangsu Province's economy. There are also Singapore-sponsored industrial districts located in the cities of Wuxi (primarily pharmaceutical), Xi'an and Chengdu, but CSSIP is the only complex with government-to-government status to approve large projects on its own authority. Difficulties in managing the "triangular nexus" of firm/host-state/origin-state relations (Stopford and Strange 1991) surfaced with the Chinese government's refusal to accede to BurroughsWellcome's demand for a monopoly on domestic trade in a particular product line as a precondition for completing its U.S.$1 billion investment. Prior to the switch to majority Chinese control, administrative employees went to Singapore for training, and then worked as assistants to chief executive officers. Technology transfer came from the practice of training Chinese employees at overseas sites so that they could see operations of the integrated foreign system.

This research's examination of a typical CSSIP company focuses on Becton Dickinson, a 103- year-old life-science giant headquartered in Franklin Lakes, New Jersey. As of 1999, Becton Dickinson's global employees topped 20,000, and its capital exceeded U.S. $3.4 billion (Becton Dickinson 1999). The company's Suzhou employees number over 180. Its three key worldwide foci are in medication, pre-analytical devices, and bioscience. Becton Dickinson's Asia Pacific headquarters have operated in Singapore since 1989—the primary reason for locating their China headquarters in the Singapore government-sponsored CSSIP since late 1996.

Becton's experiences illustrate some problems for high-technology companies seeking to transition to stage 3 of the development model. The development of pharmaceutical and medical device products in China is limited due to control of the field by the State Drug Administration and the Ministry of Health. All raw materials are imported, with only cartons and packaging produced locally. Due to international standards for consistently high quality, products have to be sent to U.S. headquarters for testing. Lots of education is needed all along the supply chain in order to do more subcontracting in China. Only one out of five Chinese labs visited by the Becton team met the industry's "Good Laboratory Practices" regulations.

Top personnel are sent throughout the world for training at various Becton locations (interviews). Skilled labor for firms is recruited from Shanghai's top ten universities. College grads without experience are available, but all are difficult to retain due to the lure of Shanghai's nearby "bright lights." The goal is to have a local R&D facility in Suzhou. Becton Dickinson provides advice to some neighbors and new firms in the park. No sectoral leadership or networking group exists, despite attempts in that direction. A university in Nanjing sends students for an internship program, which the company uses as a recruitment tool.

Interactions: Bridge-Building

Fragmentary university-multinational corporation interactions occur at the stage-3 level, wherein advanced satellites construct enhanced local linkages to more innovative local entities. Recent individual examples include a partnership between the combined laboratories of pharmaceutical giants Burroughs Wellcome and SmithKline Beecham and the Shanghai Institute of Material Medica, one of China's oldest medical research institutes, in the interests of exploring combinatorial chemistry possibilities. Roche Pharmaceutical (Zhangjiang) recently arranged to fund a laboratory at Fudan University in exchange for receiving test results on a project of interest to the company. On the other hand, some companies consider exporting their products to China from another Asian production base such as the Philippines, rather than enduring the hardships of manufacturing locally.

Both Motorola and Coca-Cola introduced new products tailored for the China market, manufactured and handled by a subsidiary under a brand name unrelated to the parent company. While a wholly foreign-owned enterprise makes the beverage concentrate in Shanghai, Coca-Cola's technology transfer in supply and distribution links upgraded the beverage industry in China. Additionally, Coca-Cola offers university scholarships and school-building funds to attract future well-trained local talent (Cong 2001). Much more systematic and structured activity currently occurs between Chinese companies and research institutions at the stage-3A level of "bridge high technology," advancing interactions tentatively attempted by stage 3 enterprises.

"Bridge High Technology": The Role of Research Institutions

In 1956, Shanghai's Jiaotong University established a branch campus in Xi'an, following Mao Zedong's defensive opening of the Third Front, seeking to build up missile capabilities via university technology transfer to the military-industrial complex in the face of U.S. support for China's outpost in Taiwan (Naughton 1988). Deng Xiaoping's shift to use coastal cities for an economic offensive boosted the fortunes of Beijing and Shenzhen in the 1980s and Shanghai in the 1990s. Today, university-affiliated companies receive enhanced attention as high-technology enterprises in China. Universities provide technology-transfer opportunities for their students, professors, and alumni. In some cases, students are allowed to take a year off to experiment with setting up and running a company within the supportive confines of their university's business incubator.

Where a local outstanding research university is not present, as in Shenzhen, Beijing-based universities such as Peking University and Qinghua University become directly involved in nurturing companies. The perception of Shenzhen as a hotbed of computer-related high technology and an export center, as well as the predominance there of small and medium-sized Chinese firms, compared to multinationals with a base in Shanghai or Beijing, attracts Chinese companies. However, Shenzhen's lack of a significant university or research center remains a major drawback, since potential employees of high-technology firms prefer to stay close to their alma maters and home provinces. Approximately 10,000 workers with graduate-school-level education find employment in SHIP, which promotes the prominence of Mandarin (as opposed to the local Cantonese dialect) with a sign at the park entrance, advertising linguistic compatibility for nationwide migrant technology workers. The average age of workers in SHIP is 27 years. Information exchange arises in part from frequent employee churning—employees average a job change every two to three years (interviews).

While the national government serves as a major capital source, the problem is how to choose the best recipients of that capital. Funneling funds through universities such as Peking University is one route (Wang 1999). Professor Wang Xuan of Peking University, the scientist-founder of the leading Chinese computer typesetter, proved to be both a technical and business talent. His investments in other promising technology start-ups (in the manner of his American computer-tycoon counterparts) magnified the impacts of his company's success and modeled successful university-based technology transfer. The affiliated Founders Group passes funds through Peking University's Research Group, which also transfers research university-affiliated ventures. Corporate profits then flow back in part to the university through the Peking University Education Foundation. The Founders Group currently sponsors more than twenty companies, from golf courses to a science and technology district in Dongguan, due to the company's access to information from proximate international companies also involved in computer parts and assembly operations. Peking University's "Industrial Department" supervises venture capital affairs, going to Shanghai—among other places—to learn how to raise capital (interviews). Legend Computer, a spin-off from the Chinese Academy of Science and the leading Chinese domestic computer brand, also channels profits through Peking University.

Human networks affiliated with Peking University include groups of students studying technology parks from Shenzhen to Xi'an for summer projects. Alumni linked through past service as elected representatives to the Student Union form webs of reference and assistance beyond graduation. Peking University– connected entities in SHIP include Kexing (biotechnology), Jadebird (IT), and Vanguard (fingerprint identification). While the government provides land and the Torch Program awards grants, a university-affiliated mediating organization such as Founders shortens the learning curve for fledgling ventures. Venture capitalists, largely from Taiwan, Hong Kong, and the U.S., tend to provide financing but offer little management advice and involvement, despite the urgent and apparent need for such "software." Therefore, Peking University and Beijing's Qinghua University are establishing a "University Park" and increasing their investment in linked firms. Other primary R&D links are with Hong Kong universities. A joint MBA program offered by Peking University and HK Technology University seeks to meet the needs of local companies, providing a profit stream to the universities at the same time. The following sections illustrate the presence and functions of "bridge high technology" university-corporate networks in the profiled geographic areas.

SHIP

The featured company in SHIP is Kexing, a university-affiliated entity associated with the China (Peking University) Weiming Biotechnology Group since 1989. This company relies largely on research, personnel, and assistance from Peking University's Founders Group investment arm, exemplifying the "bridge high technology" stage proposed in this research. Occupying 200,000 square kilometers, Kexing is the largest biopharmaceutical and genomic manufacturing plant in China (Weiming 2000). Kexing is currently adding high-quality manufacturing facilities to expand into an anchor of the anticipated SHIP "Medical Valley." A major new investor is a U.S. company, seeking to ensure the addition will meet FDA standards for export to global markets. Peking University also founded a "Peking University Biocity" and plans a "Bio Park" in Xiamen (due to the proximity of a local venture capitalist).

Incubators furnish subsidized surroundings for fledgling companies. Qinghua University recently opened its own facility in striking new surroundings designed by its School of Architecture. Over 300 people occupy the incubator at present, with an average degree higher than the master's level. Setting up this institute complied with SHIP's requirement that technology developed there must be quickly usable by industry. While incubating some industries, training at the institute also serves SHIP college graduates. Major fields include computers, telecommunications, economics, environmental studies, architecture, and master's of business administration classes. Other universities, from Harbin to Hong Kong, are considering setting up branches in the Information Park.

Shanghai-Pudong

Metropolitan Shanghai currently contains one-third of China's scientific research projects and forty-seven industrial parks, including two national-level science and high-technology parks (Fung et al. 1992; Chesterton, Blumenauer, and Binswanger, Industrial Services Division 1998; CSB 2000b). Opened in 1992, Zhangjiang Hi-Tech Park occupies over three square kilometers on rapidly developing Pudong, a formerly agricultural area located on the eastern margins of Shanghai. A variety of incubators sponsored by several government entities intermix with numerous large multinational companies, from Revlon to Roche (Walcott and Xiao 2000). The number of foreign-invested companies tripled from twenty-three in 1999 to seventy a year later; by 2 00 1, around one hundred companies occupied the district (Shanghai Zhangjiang Hi-Tech Park 2000). Formerly vacant spaces between buildings, resulting from the Asian economic slowdown in the early 1990s, are now largely full of new companies, incubators, and service facilities.

The only bus routes between Shanghai and Zhangjiang run to research universities, encouraging exchange of personnel and undercutting the pull of technology parks on the periphery of these relatively land-locked universities. Signs outside structures indicate the scale of their sponsoring entities, from the nationally funded Torch Program and Chinese Academy of Science to Shanghai affiliation, Pudong, and Zhangjiang-level government interests (Figure 3). Old company quarters such as Revlon's are reused as new incubator space for fledgling startups, while Revlon occupies larger quarters within the park.

Figure 3 *Zhangjiang incubators: A) software park; B) start-ups, subsidiaries.*

Xi'an: The Interior West

High-technology development in China's interior region concentrates on technology transfers from the universities and research centers of Xi'an in northwest central China, the focus of a "Go West" campaign to broaden foreign investment away from the eastern coast (Smith 2000). The integration of Xi'an into high-technology-driven growth operates as an important regional balancing strategy, attracting domestic labor migration and foreign investment to enterprising inland regions away from the huge clusters on the east coast (Fan 1998; Wei 1999). Heavily rural inland provinces lose hundreds of thousands of migrants to prosperous coastal provinces. In 1990 alone, Sichuan lost 846,000 residents, while Guangdong gained over one million (Smith 2000). The government increasingly finds this a worrisome economic and spatial divide.

Xi'an sports two out of fifty-seven National High and Technology Industry Development Zones. Singaporeans now play a large role as potential company funders in Xi'an, along with the popular Torch program. The Xi'an International Business Incubator (XIBI) is in one of the four technology districts of this ancient city anchoring the China end of the Silk Road. The incubator occupies 475,000 square meters and has housed 248 science and technology enterprises since its inception. According to a plaque posted in the entrance lobby, the range of incubating businesses covers plastics, various metal products, aviation development companies, law firms, electronics, imagery companies, telecommunications, computer-related concerns, and biomedical instrument firms. In 1999, ten "foreign specialists" worked at the Center for two- to three-week periods. Training offered ranges from English language programs to team building (XIBI 1999). A fifth industrial district will locate by Jiaotong University, the main engineering school in the area. Functions of the university's technology-transfer office include bridging university research and companies, designing projects, acting as a technology incubator representing the university to get small and medium-sized investors (including funds to improve for global venture capital-standards), and intellectual property, patent, financial, and human-resource requirements.

Pioneering High-Tech: Trans-Pacific Ties

The realization of Park's (1996) prediction of stage 4 companies utilizing pioneering high technology along with extensive local supplier and market ties and a global network is just beginning to emerge in Chinese new industrial districts. This stage marks an advance over the incubator level of "bridge high technology," continuing the characteristic university ties but at the level of a stand-alone firm. These companies often arise from technology transfers due to domestic universities and Chinese students returning following graduation and work experience abroad.

Interviews in each park were conducted with these young entrepreneurs, who form a much sought after "reverse brain drain" contingent (Gilley 1999). In some cases, they leave their family in the U.S. and keep investment ties with classmates who are not yet ready to return but provide other forms of information and financial support. A SHIP automation-design lab facility, for example, cooperates with a Silicon Valley lab started by Qinghua University graduates in the mid-1980s, transferring technology to China via production orders. While equipment is largely imported, most of the material comes from China.

Major Chinese companies specializing in computers, telecommunications, medical devices, and biopharmaceuticals locate their research and development facilities in Shenzhen, maintain R&D relations with firms in more developed countries such as the U.S., and draw upon university ties in China and abroad. Kexing extends R&D operations from American Silicon Valley contacts to small firms in western China. Given the long time it takes to develop a biotechnology breakthrough into a market-ready product, Kexing also purchases U.S. biotechnology companies to acquire their expertise.

Technology-transfer infusions come from personal ties to university professors in the U.S. who come to an affiliated company for visits, student exchanges with Chinese universities, and consultations with local professors. Several Chinese universities have cooperative arrangements with foreign universities offering MBAs, such as Wuhan's with Toronto and Fudan's (Shanghai) with MIT's Sloan School. Networking associations sponsored by the government in Shanghai include the Returned American Students Club (*Mei Tong Xue Huei*) and an MBA association, as well as localized industry-level groups for software and dot-coms. A returned Overseas Student Center is a particular feature in XIBI; many participants are local natives.

Discussion and Conclusion

China's race to raise the level of its industrial output and join the world economic system as a key player has advanced through the five stages of the proposed model. The country initially relied on transfer of knowledge and capital from foreign firms in the first stage; grouping them together in industrial parks sought to promote local supplier relationships and subsidiary formation in the second stage. The effectiveness of the Chinese science and high-technology park model lies in its mix of local and foreign forms of investment and in the role of universities in nurturing native companies through information networks and entrepreneurship training, in the "bridge high technology" stage (3A). The incubators of all four parks examined show evidence of new companies forming based on domestic efforts, as predicted in the fourth stage.

Interviews and surveys particularly explored the function and effectiveness of grouping multinational and domestic corporations in industrial and high-tech parks. Table 4 displays results from the interviews and surveys. Association with a technology park was generally felt to be advantageous due to a prestigious address, well-maintained attractive surroundings, and good-quality buildings and infrastructure, all at a reasonable rate. Many managers lived nearby in the abundant supply of new apartment complexes. The government and park authorities provided affordable apartment facilities close by for workers, rented by local companies. Vans also furnished worker transport. Government support through infrastructure provision and policies supporting startup companies received positive reviews. Chinese control of the local rules and resources of market and regulation particularly attracts investments from Chinese living outside the People's Republic (Hayter and Han 1998). Government-established high-technology parks create a privileged space in which product development and manufacture occur in more favorable conditions than would otherwise be possible. In this sense, they do constitute "learning districts" as originally designed. Basically, however, representatives of multinational corporations interact with their foreign counterparts, and representatives of Chinese firms with their Chinese counterparts.

Bridging High Technology

While most foreign companies concentrated their efforts on manufacturing, with primary R&D done elsewhere, their utilization of some industry-focused university research signals future cooperative potential. Something new is occurring on an experimental level, as China encourages the development of endogenous innovative industries capable of competing at all levels within the global economy. The addition of a "bridge high technology" category to the Asian development model highlights this stage of emerging enterprises less linked to foreign companies than previous stages. Local companies learn from each other by utilizing ties to Chinese alumni and overseas and offsite students from Berkeley to Beijing. Interviews demonstrated the variety of ties to technology among Chinese contacts: between returned-student associations in each of the cities examined and professors and classmates in former universities, to Beijing universities in Shenzhen and local universities in Shanghai and Xi'an, and through Taiwanese employers hiring top Chinese university graduates to work in their mainland China companies. The final stage of the development model, "pioneering high technology," can be realized based on lessons learned from these networks with universities and other companies, domestic and overseas.

The four factors cited earlier explain the variety of corporate forms emerging: China's size, the transitioning economy, a lack of a strong mentor state, and the multiplicity of types of learning districts in different locations. Networks and supplier-market relations utilized by multinational corporations are largely separate from those utilized by domestic Chinese high-technology companies. Hopes held by government planners for technology transfer from foreign to native companies fell short of the pace and quality anticipated, as evidenced by the rapid swing of support to local incubators and research institutes since 1988. Multinational corporations are welcome for their affect on the balance of trade and positive externalities, but these are recognized now as a partial solution. Fledgling Chinese companies, on the other hand, are being assisted in a variety of new ways. Chinese entrepreneurs cite an open and free attitude toward business as critical for innovative enterprises. Universities sprout their own incubators and nourish nearby businesses at each of the case studies. Locations vary in the source of foreign capital they attract, with the Pearl River Delta supplied by overseas Chinese and Hong Kong, Shanghai by the most developed countries, CSSIP shifting from the latter to the former, and Xi'an looking to Singapore and the central government. Given the pace of China's development over the last decade, and the its potential impact on global business, the evolution of China's technology parks bears continued examination.

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