Growth and Change
Vol. 38 No. 4 (December 2007), pp. 544–566

State Policies, Enterprise Dynamism, and Innovation System in Shanghai, China

WEIPING WU

ABSTRACT Today rapidly growing economies depend more on the creation, acquisition, distribution, and use of knowledge. As such, strategies for enhancing research and innovation capabilities have come to occupy a more important position in many developing nations, including China. Already the leading production center, and often seen as China's economic locomotive, Shanghai is striving aggressively to retain its national preeminence and has launched concerted efforts to increase local innovative output. The primary purpose of this paper is to understand how state-led efforts have fared in promoting technology innovation. By situating the city in the national and global context, the paper shows that Shanghai has gained a substantial lead in developing an innovation environment with extensive global linkages and leading research institutions. Recent efforts in building up the research and innovation capacity of the enterprise sector have begun to show progress. Although firms are enthusiastic about its future as an innovation center, Shanghai continues to face challenges of inadequate protection of intellectual property, lack of venture capital investment, and the tightening supply of highly qualified knowledge workers.

Introduction

The rise of the knowledge economy has underscored the essential role technological innovation plays in economic development. The pillars of such an economy include: an economic and institutional regime that provides incentives for the efficient use of existing knowledge, the creation of new knowledge, and entrepreneurship; an educated and skilled workforce that can create and use knowledge; a dynamic information infrastructure that can facilitate the effective communication, dissemination, and processing of information; and an effective innovation system that can tap into global knowledge, adapt it to local needs, and create new knowledge (Dahlman and Aubert 2001). While the national innovation system is important for understanding how innovations occur in nations, research shows there is a strong regional character associated with them (Cooke 2001; Simmie 2005; Storper 1997). Likely, there are regional innovation systems or regional learning networks

Weiping Wu is an associate professor of urban studies and planning at Virginia Commonwealth University, Richmond, Virgina. Her email address is wwu@vcu.edu. *The author is grateful for the comments of three anonymous reviewers. An earlier version of this paper was presented at the annual conference of the Association of American Geographers in Denver on April 5–9, 2005.*

Submitted October 2005; revised October 2006; accepted January 2007.

consisting of private- and public-sector actors interacting to create local institutions and relationships encouraging innovation and entrepreneurship (Chen and Kenney 2005; Doloreux 2003).

Since the 1980s, strategies for enhancing research and innovation capabilities have come to occupy a more important position in China's development. A series of ambitious initiatives have been launched to enhance the country's technological capabilities and reform the national innovation system. Perhaps one of the most significant measures is the dismissal of the Soviet model of functionally specialized organizations with minimal horizontal linkages between research and production. As reforms proceed, the positions of key actors in the national innovation system—public research institutes, universities, and enterprises undergo drastic change. The traditionally weak enterprise sector is expected to play a more significant role in technological innovation and to develop closer relationships with research institutes and universities. Within this national framework, regional entities (including the largest cities) have developed different strategies to augment innovation capacity and to take advantage of local resource endowment (Chen and Kenney 2005; Segal 2003).

Already the leading production center, and often seen as China's economic locomotive, Shanghai is attempting to increase its edge over other cities and regions through a "high road" based on efficiency enhancement and innovation. With increasing local autonomy and a rising cadre of younger technocrats, the new leaderships share in the vision of a market system. Together they showcase the rise of a new developmentalist state intent on being fully engaged in the global market. Following national directives, concerted efforts to establish a municipal innovation system began in Shanghai in the 1990s with policies to nurture research and development (R&D) institutions, increase investment in R&D, build a support infrastructure to facilitate research commercialization, develop an adequate regulatory and legal framework, and invest in human capital (Fan 2003). Municipal authorities hoped that a basic innovation system would take shape in the first decade of the twenty-first century and enable Shanghai to remain at the national forefront.

The primary purpose of this paper is to understand how state-led efforts (at both the national and municipal levels) in building a local innovation system may allow Shanghai to compete and prosper in the new knowledge-based economy. Specifically, the paper intends to show how these efforts have fared in improving the overall innovation environment and that for the enterprise sector in particular. The city's path is interesting to a wider audience because it offers a unique case to study the evolving institutional relationships while China's national innovation system continues to undergo drastic reforms. There is abundant evidence to show that places like the San Francisco Bay Area and Boston provide conducive environments for innovation. How this comes about in the first place or is maintained is not explained well in existing literature (Simmie 2005). In particular, more research is required to show how policy interventions can influence the formation of a local innovation system. This paper attempts to address this question, highlighting how innovation capacity can be enhanced locally, particularly through state-led policies and initiatives (e.g., financial incentives technology enterprises, cultivating spinoffs from R&D institutions, building support infrastructure, and investing in human capital).

What follows next is a brief overview of related research literature on the critical role and key elements of an innovation system. The third section examines how recent changes in China's national innovation system have affected Shanghai's policy options and how local outcomes compare to national patterns. Because a key reform goal is to make innovations more enterprise-based, the fourth section analyzes local policies and incentives targeted at the enterprise sector. This is accompanied by a case study of a small private technology enterprise based in the Fudan University Science Park. Last is a summary analysis of how high-tech manufacturing and knowledge-intensive service firms perceive the city's innovation environment and how future public investment and policy measures may address their needs.

Building an Innovation Environment—Research Context

The vitality of innovation in a location is undoubtedly shaped by the national innovation system—a complex network of agents, policies and institutions supporting the process of technical advance. It also includes a nation's intellectual property (IP) protection system. More broadly, it may include many other subsystems and processes, such as norms of competition and a nation's financial and monetary policies. Three key institutional actors—industry, research organizations, and government—occupy important positions in all national innovation systems (Crow and Bozeman 1998; Nelson and Rosenberg 1993; Porter and Stern 2001). The U.S. is characterized by extensive interactions between research institutes/universities and firms, particularly in the biotech, microelectronics, and computer industries (Mowery and Rosenberg 1993). On the other hand, the industrial sector in Japan tends to integrate the process of innovation—from basic or product research to commercialization—within one organizational framework (Fujita and Hill 2004). The importance of the national innovation system in shaping local competitiveness is showcased in Denmark and Finland. They have made major gains in wireless technology since the mid-1980s by substantially increasing their R&D workforce and investment, and emphasizing policies that support open competition and strong IP protection (Porter and Stern 2001). This has helped launch the city of Helsinki as a key node of technological innovation.

Innovation processes in different regions within the same nation, however, can operate differently. Saxenian (1994) shows that the institutions and entrepreneurship of the Silicon Valley and Boston differ markedly. What then drives innovation locally? Traditional thinking focuses more on internal factors, such as the capabilities and processes within firms. Central to local innovation systems are firms and research institutions, that are geographically distinctive and interlinked organizations, to support and conduct innovations (Simmie 2005). In particular, the presence of leading research universities and a high share of college graduates are essential for dynamic cities to leverage locational advantages, at least shown by the experience of U.S. cities (Glaeser and Saiz 2003). There are a number of notable instances where universities have supplied the crucial underpinnings of dynamic industrial innovations and clusters within city regions, as in the case of Boston, San Diego, and the San Francisco Bay Area in the U.S. But in other cities such as Portland, Seattle, and Tokyo, the innovative economy appears to be emerging by utilizing key high-tech firms that contribute to the creation of a skilled labor pool, knowledge, and entrepreneurship (Fujita and Hill 2004; Mayer 2003). In addition, research shows that investments in higher education infrastructure predict subsequent city and regional growth far better than investments in physical infrastructure like highways and railroads (cited in Florida 2002). Having a readily available and qualified workforce is one of the best investments cities can make and almost all centers of innovation are places with a high concentration of educated people.[1]

But innovation capacity alone is not sufficient, as generating new technologies locally may not be as important as having the ability to adapt them. Recent research shows that the external environment for innovation or a creative milieu is at least as important (Kresl and Singh 1999; Porter 1998; Porter and Stern 2001). Such an innovative milieu encompasses processes that can reduce uncertainty and benefit firms: collective information gathering, collective learning, and cooperative decision-making through local association (Hall 2000). The local community also needs to be able to absorb the innovation generated by research institutions and help develop the lifestyle amenities sought by firms and workers. The local culture needs to be supportive of experimentation, failure, and recovery so that entrepreneurship is more likely to occur (Walcott 2002). In addition, the role of institutions for collaboration or mediating organizations is important. Some such organizations are established prior to the takeoff of innovative activities while others emerge as part of the process. They facilitate the exchange of information and foster joint actions that can improve the overall business environment. Industrial associations also can function as political lobby groups to advance collective interests (Porter and Monitor Group 2001; Saxenian 1994; Scott 2000).

Good local infrastructure is important to the quality of local innovation environment, particularly critical to the direct operation of firms. For bio-tech laboratories, Internet-based companies and large facilities housing multiple servers, noninterruptible power is critical. So is access to backup power and telecommunication lines. New server hotels—large facilities constructed specifically to house servers of multiple firms—are becoming a significant factor in local electric demand (Sommers and Carlson 2000). In addition, a city's attraction to firms may be affected by how well it handles basic government services such as planning, permitting, and public services (Porter and Monitor Group 2001; Sommers and Carlson 2000). The real estate market also needs to provide space for companies from incubation to start-up and through established maturity, as well as an array of amenities for employees.

It is clear that in the new knowledge economy, costs or government-influenced low costs (e.g., lower taxes) and access to natural resources are less important. Rather, policies that influence the quality of local innovation environment are increasing in demand. The winning formula in Europe appears to have been a combination of a favorable business environment and technological acumen (Kelly 2003; Simmie 2001). Dynamic cities, such as Dublin, Amsterdam, and Helsinki, showcase local policies designed to build an infrastructure to support small and emerging businesses. Such policies range from establishing industry forums to identify sectoral needs, creating publicly supported venture capital funds, investing in digital labs, supporting art and technology studios, organizing trade missions around particular products, and to providing business development support and training (Tepper 2002). Municipal governments also can help young entrepreneurs develop viable business plans and start-up operations. Many entrepreneurs leave a university or lab with an idea for a product or service, but with little or no business experience. In addition, small businesses in general have a higher failure rate. City leaders can play a significant role in fostering organizations to provide business assistance and establishing industry associations (Sommers and Carlson 2000).

Research shows that localities in China have adopted markedly different methodologies for developing their technology and research capacity, given that they start with different endowments (Chen and Kenney 2005; Fan 2003; Segal 2003). Working out a development strategy that can stimulate growth is an essential goal for local governments. They have, to a certain extent, become local developmentalist states with their own policy preferences. At least two considerations motivate them to facilitate local growth: exhibiting achievements to the central government and promoting economic development to serve local interests (Zhang 2002; Zhu 2000). As a result, patterns of growth and development diverge markedly across the country. For instance, there is evidence showing that patents in China are highly clustered at the provincial level (Sun 2000). Regional resources and networks, particularly through research facilities, are critical in assisting local firms in learning technology, as shown in studies of the best-known innovative region in China—Zhongguancun Science Park in Beijing (Zhou 2004; Zhou and Tong 2003).

In summary, the lessons from industrialized countries will have significant relevance for Shanghai, as it will compete not only with other Chinese cities but also with well-established innovative hubs of the world. Specifically, the aggregate level of R&D spending, the effectiveness of IP protection, openness to competition, and the intensity of spending on higher education are particularly important determinants of innovative output (Porter and Stern 2001). To leverage the advantages conferred by a particular national innovation system, cities need to build institutional and political mechanisms that nurture creativity and channel innovation. Effective institutions for collaboration, quality business services and infrastructure, and efficient basic government services are all important elements of a supportive local environment. Small enterprises, in particular, need services beyond physical infrastructure, and can benefit from consultation on financing, licensing and patenting, marketing, and management. Dynamic cities also leverage locational advantages by attracting and retaining talent, and by adapting their economies to new technologies. However, this list is by no means exhaustive; there is also no conclusive evidence in the literature to suggest that any of the factors is more important than the others.

Shaping a Local Innovation System under National Reforms

Recent changes in China's national innovation system have affected Shanghai's policy options. For nearly three decades (1949–1979), China followed the Soviet Union's model of establishing functionally specialized organizations whose activities and interactions would be managed by a central government agency. There was clear division of labor—public research institutes responsible for conducting the majority of research activities; universities responsible for science and technology (S&T) training with limited involvement in R&D; and enterprise R&D units responsible for production, prototyping, and other downstream innovation activities (Gu 2003; Liu and White 2000; Sun 2002; Xue 2004). Since 1979 this system has been undergoing drastic reforms. The central government has been decentralizing responsibility, and the necessary authority to make decisions parallel to new levels of responsibility has moved down. Another measure is to encourage a closer relationship between research and production by breaking the vertical coordinating functions of the old planning system and encouraging horizontal, market-based ties between research institutes/universities and enterprises (Liu and White 2000; Suttmeier and Cao 1999). A new legal framework has been put in place at the national level to enable such ties. In April 1999, the State Council gave its approval to the "Several Provisions on Promoting the Transformation of Scientific and Technological Achievements" (Suttmeier and Cao 1999). The central government also has paid more attention to IP protection, creating the Chinese Patent Office in 1980 and enacting its patent law in 1985 and copyright law in 1990 (Hu and Jefferson 2004; Liu and White 2000; Suttmeier and Cao 1999). The patent law was substantially revised in 1992 with expanded scope of patent protection, leading to a sharply rising number of patents granted afterward.

Accompanying efforts to encourage research commercialization and horizontal linkages, a major shift has occurred in the national distribution of the three major sectors performing S&T activities. Whereas industrial enterprises performed less than 40 percent of the nation's R&D as recently as mid-1990s, they now perform about two-thirds. By 1999, over half of China's scientists and engineers worked in enterprises, representing a considerable change from the early 1990's when state institutes employed most S&T workers. The change reflects steps taken to eliminate some state-owned research institutes by merging them into existing industrial enterprises or university-affiliated enterprises (Hsiung 2002; Hu and Jefferson 2004). Research institutes also are encouraged to launch commercial spin-offs based on successful applied research in their laboratories. There are now a variety of spin-off enterprises—some state-owned, some collectively owned, and others privately owned, and they have become a lucrative and increasingly important source of revenue for many research institutes.

Shanghai's efforts to establish a local innovation system began in full force in the 1990s and followed the national lead. More specifically, efforts to cultivate the local innovation system fall into five broad categories (Fan 2003):

1. *Nurturing R&D institutions*—two key emphases are the development of private technology enterprises and high-tech/science parks, through a broad array of incentives in financing, taxation, IP protection, commercialization of innovation, and support services. The high-tech/science parks are used as incubators to promote commercialization of innovation.

2. *Increasing investment in R&D*—particularly to increase the ratio of R&D funding as percentage of GDP. The rise of R&D expenditure can be mostly attributed to large- and medium-sized industrial enterprises.
3. *Building a support infrastructure to facilitate commercialization of innovation*—municipal authorities have established a network of service centers to facilitate the technology transfer and commercialization of product or process innovations. They share the goals of expediting information exchange among R&D facilities, reducing costs and risks of innovation, and facilitating commercialization of new R&D outcome.
4. *Developing an adequate regulatory and legal framework*—the enactment of laws governing commercialization of high-tech innovations, IP protection, and development of small and medium-sized technological enterprises.
5. *Investing in human capital*—launching programs to cultivate young scientists and engineers through funding incentives and to attract talent returning from overseas. Shanghai's leaders are providing a small pot of money that local scientists can use to attract larger sums from other sources and compete on a national level. For instance, the Shanghai Science and Technology Commission (STC) administers a series of high-profile grant programs. The peer-reviewed grants favor young scientists and those with well-established research teams.

Spearheading these efforts is the STC, formulating and implementing policies related to the city's S&T development. Equivalent of a municipal department, STC oversees a number of service centers that are key players of the newly established support infrastructure. Chief among them are a technology exchange center, a high-tech commercialization service center, and high-tech enterprise incubators. The Shanghai Technology Transfer Exchange, cosponsored by the central Ministry of Science and Technology, is the first state-level permanent technomart in China (retrieved on January 9, 2007 from http://www.stte.sh.cn/). It allows for technology transfer transactions and high-tech product trade among different regions, business entities and organizations from both inside and outside of China. Operating on a membership basis, it also provides business services in such areas as feasibility study, market research, technology transfer certification, and venture capital financing (Fan 2003). The Shanghai Technology Innovation Center is primarily responsible for promoting new technology enterprises and entrepreneurs (retrieved on January 9, 2007, from http://www.incubator.sh.cn/). Under the center there is the Shanghai International Business Incubator that has operations in nearly all of the city's science parks, including Caohejing High-Tech Park, Zhangjiang Science Park, Shanghai University Science Park, and Yangpu Science Park. The Shanghai Hi-Tech Commercialization Service Center, on the other hand, focuses on providing one-stop style services for projects turning technology into actual products. These services include business and tax registration, licensing, and overseeing the implementation of financial incentives (Fan 2003).

Accompanying the creation of this support infrastructure is a steady rise of investment in S&T. For instance, expenditure in R&D has increased significantly, reaching over RMB 17 billion in 2004. This was equivalent to 2.29 percent of the municipal GDP (see Table 1), a

TABLE 1. KEY INDICATORS OF SHANGHAI AND CHINA, 1995–2004.

	Shanghai			China		
	1995	2000	2004	1995	2000	2004
R&D expenditure as % of GDP	1.32	1.69	2.29	0.60	0.90	1.23
Exports of high-tech products as % of total exports	5.6	18.9	39.3	6.8	14.9	27.9
% of R&D expenditure in						
Basic research	—	6.5	6.1	5.7	5.2	6.0
Applied research	—	23.7	26.1	27.2	17	20.4
Product/process development	—	69.8	67.8	67.1	77.8	73.6
% R&D expenditure in	—					
Universities	—	9.7	11.1	12.1	8.6	10.2
Research institutes	—	33.3	25.4	42.9	28.8	22.0
Enterprises	—	54.0	61.8	42.9	60.3	66.8
Other institutions	—	3.0	1.7	2.1	2.3	1.0
% of patents granted to						
Universities	7.5	7.2	9.7	19.2	23.1	28.6
Research institutes	11.8	8.5	7.2	28.9	32.2	19.8
Enterprises	35.7	82.9	82.2	36.3	36.0	50.3
Other institutions	45.0	1.4	0.9	15.6	8.7	1.3
% of patents in						
Inventions	5.0	7.5	15.9	3.5	6.5	12.1
Utility models	71.4	51.4	38.0	67.0	57.1	46.3
Designs	23.6	41.1	46.1	29.6	36.4	41.7

Note: Data for China on patents by type are for 1996 and on detailed R&D expenditure are for 1997.
Source: *Shanghai S&T Statistical Yearbook*, various years (http://www.stcsm.gov.cn); *China S&T Statistical Databook*, various years (http://www.most.gov.cn).
—, data not available.

level much higher than the rising national average.[2] In fact, Shanghai has consistently invested a higher share of its GDP in R&D than the nation as a whole since the 1990s. Closely following the national trend, Shanghai's R&D expenditure is concentrated in product or process development (about two-thirds) while basic research constitutes about 6 percent and applied research about 26 percent (in 2004). Both show continued neglect of basic research, a problem that can hinder the long-term capacity for innovation. Patterns of granted patents in the city also are similar to the national distribution. Patents in inventions and designs have increased steadily while those in utility models have declined (see Table 1).[3] But Shanghai appears to experience faster growth in invention patents. Because inventions, and to a lesser degree new utility models, are the most fundamental and beneficial paths for technology development in the long run, this is an encouraging development for the city.

A number of national S&T programs launched since the mid-1980s have had significant imprints on the city. In particular, the designation of high-tech/science parks in Shanghai followed the launching of the national "863" and "Torch" programs, to promote the development of high-tech industries (Shanghai Municipal Government 2004; Wei and Leung 2005).[4] Science parks are used as incubators for cultivating such industries and promoting research spin-offs—including Caohejing High-Tech Park, Zhangjiang Science Park, Jinqiao Science Park, Shanghai University Science Parks, China International Textile Technology Development Zone and Jiading High-Tech Park. Specifically, the development of high-tech industry has been spearheaded by the Zhangjiang Science Park in the Pudong New Area. The park's two leading industries are information technology and modern biotechnology and pharmaceuticals, which are supported by four national-level bases: the National Shanghai Biotech & Pharmaceutical Industry Base, the National IT (information technology) Industry Base, the National 863 Information Security Industry Base, and the National Technology Innovation Base.

In addition to policy initiatives directly targeted at the building of a local innovation system, other measures have improved local communications and education. For instance, a five-year key project has been launched to integrate all the circuits and pipelines for telecom services into an underground broadband pipeline (Yusuf and Wu 2002). This project offers a strong backbone for the city's development as an Internet-smart metropolis. Rapidly increasing Internet usage also relates to the export orientation of Shanghai-based enterprises and the steadily improving quality of the telecom facilities is helping integrate Shanghai with the world economy. Shanghai also has begun to emphasize higher education, and two measures have been taken to attract new, young talent into the city. Annual enrollment for local students in higher education has been increased substantially—for universities from 19,000 in 1991–1995 to 30,000 in 1996–2000 and for adult continuing education from 10,000 to 18,000, and for vocational schools from 22,000 to 35,000 (Shanghai Academy of Social Sciences 1997). Municipal authorities also have relaxed restrictions on enterprises in hiring personnel with college or graduate education from other parts of China by allowing them more quotas for urban household registration. In particular, the city welcomes students who are returning from overseas, either temporarily or permanently, to open new businesses.

Cultivating Innovation Capacity in the Enterprise Sector

For a long time, the enterprise sector had been a weaker actor in China's national innovation system, particularly in comparison to public research institutes. In-house capacity in basic and applied research was absent in most enterprises. Industry-specific research institutes within different ministries were responsible for solving specific applied problems as well as for introducing new technology into enterprises (Gu 2003; Liu and White 2000; Xue 2004). The lack of in-house R&D capability in most Chinese industrial enterprises means that they could not rely on themselves for solving more complex technical problems in their production (Xue 2004).

To make the national innovation system more enterprise-based, at least two measures have been implemented nationally. First, since the late 1980s, a large number of public research institutes have been merged into existing industrial enterprises. A key rationale is to enhance the connection between research and production, as public research institutes remained insulated from the technology market after early reform efforts (Gu 1999; Sun 2002). The second approach is to encourage the creation of enterprises' in-house R&D facilities. Despite mixed results, the enterprise sector is experiencing growth in R&D capacity. Hu and Jefferson (2004) report that between 1995 and 2001, R&D performers among large- and medium-sized enterprises rose from 19.7 to 28.7 percent. Enterprises also are the most active participants in patenting activity nationally, counting for about 50 percent of granted patents in 2004 (see Table 1).

To further promote links between research and industry, the central government has encouraged the growth of enterprises affiliated with universities or research institutes. This is accompanied by measures providing financial and legal services for faculty and student startups, strengthening patent laws, encouraging the establishment of university-based science parks (more than forty nationwide), and building high-tech development zones near major universities (Walcott 2003; Wei and Leung 2005; Zhang 2003). In the computer industry, for instance, some of the leading Chinese companies have been affiliated with universities or public research institutes (at least in the early stage) and benefited from close relationships with academic researchers (Lu 2000). The overall impact of university enterprises, however, remains limited. In 2001, for instance, only about 40 percent of university enterprises were involved in S&T-related activities and their sales revenue made up a mere 2.3 percent of high-tech enterprises nationwide (Ma 2004). Much of academic technology transfer is not the commercialization of research results, but rather the transfer of personnel from universities to the enterprise sector.

Shanghai has been making great stride in cultivating innovation capacity in the enterprise sector, although its path is dotted with marked progress and some missed opportunities. For instance, the rise in the number of patents registered by enterprises is rapid (see Table 1). Shanghai's enterprise sector now receives more than 80 percent of granted patents, compared to the national average of about 50 percent. Enterprises now perform a little more than 60 percent of the R&D in the city (see Table 1). But unlike Beijing, Shanghai fell behind in cultivating the nonstate enterprise sector. Early on, municipal officials funneled the majority of local and foreign direct investment to large state-owned corporate groups or firms. Such large groups tended to dominate the local economy, a legacy of Shanghai's historical role as the "industrial workhorse" of the planned economy (Segal and Thun 2001; Segal 2003). The emphasis on large enterprises, in particular, helped launch the city's successful automobile sector, with several champion firms such as Shanghai Volkswagen and General Motors' joint venture.

It was not until the early 1990s that the development of private technology enterprises came into focus, after such enterprises in other cities (particularly Beijing) had achieved critical fame. Municipal authorities begun to offer a broad array of incentives in financing, taxation, IP protection, commercialization, and support services (Fan 2003). Public service centers also were set up to promote new technology enterprises and entrepreneurs (Shanghai Technology Innovation Center in 1988), and later to facilitate the commercialization of technology (Shanghai Hi-Tech Commercialization Service Center in 1998). These efforts have been particularly welcoming to private and small technology enterprises, which have to compete in an urban economy dominated by large firms and state-owned groups.

The mushrooming of private technology enterprises since the mid-1990s is apparent (see Table 2). The number of such enterprises nearly tripled between 1995 and 2003. Most of them are small in size, averaging twenty-one employees each (Shanghai Science and Technology Commission 2004). However, the magnitude of local funding to them is much more limited, compared to that received by large firms and corporate groups. Related to this funding shortfall, R&D expenditure in the enterprise sector (share) remains lagging behind the national average—by about 5 percentage points in 2004 (see Table 1). Large- and medium-sized enterprise have continued to be the dominant players, counting for about 80 percent of total enterprise R&D expenditures throughout the period of 2000 to 2005 (see Table 2).

Most of private technology enterprises are in electronics, information technology (IT), software, communications, and bio-tech industries. They tend to invest more in R&D (averaging 5 to 10 percent of corporate investment) than other types of enterprises (Fan 2003). Because the IT and software sectors house a large number of private technology firms, policy incentives offered in these sectors provide an illustrating example. Municipal authorities offer preferential treatment in four areas: enterprise income tax, product circulation, export, and human resources (Shanghai Information Commission 2006). The most significant incentive is the reduction in corporate income taxes—firms are exempted from such taxes in the first two years after becoming profitable and pay at half of the regular rate (30 percent) in the third to fifth years. If an enterprise achieves annual sales revenue above RMB 5 million, it can seek a high-tech designation and this allows for a flat rate of corporate income tax at 15 percent. This rate drops further down to 10 percent if the enterprise is designated as a national key enterprise.

The experience of a small, private IT firm based in the Fudan University Science Park showcases how policy incentives have helped and where the shortfall is. Shanghai Fudan Microelectronics Company Limited was established in July 1998 by a former Fudan graduate student. Unlike most of enterprises affiliated with Fudan University, it drew cash investment from an IC (integrated circuit) research lab in Fudan, an outside investment firm, and several entrepreneurial employees, forming one of the smallest shareholding companies in China at the time (*Chinese University Technology Transfer*, December 2004,

TABLE 2. ENTERPRISE SECTOR IN SHANGHAI'S INNOVATION SYSTEM, 1995–2005.

Shanghai	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number of private technological enterprises	6,787	6,902	7,381	8,638	9,707	12,316	15,462	18,441	21,516	16,373	16,128
Share of large- and medium-sized enterprises in enterprise R&D expenditure (%)	—	—	—	—	—	74.76	81.92	81.78	84.76	78.04	77.52
Number of high-tech enterprises	411	496	587	761	905	1,136	1,398	1,743	1,916	2,161	2,303
Value of high-tech products as % of total industrial output value	13.9	14.78	15.4	16.5	18.2	20.6	21.8	23.4	26.5	28.2	28.6

Source: *Shanghai S&T Statistical Yearbook*, various years (http://www.stcsm.gov.cn).
—, data not available.

p. 28). The company has concentrated its limited funding on product development and sales, in five broad categories of ICs for industrial applications—telecommunication products, smart cards, motor vehicle electronic products, power supply electronic products, and consumer electronic products (*Business Wire*, June 15, 2004). Although research innovation by the Fudan research lab provided the foundation for the company, most of the products have been developed in-house with proprietary technologies. It went public on the Hong Kong Stock Exchange within two years of creation and set up a Hong Kong subsidiary in 2002. It is now considered one of the most advanced IC firms in China.

The fund-raising mechanism used by the company is not an uncommon one for private technology enterprises. A number of other enterprises founded by Fudan University professors had to rely on personal and informal funds to finance initial operations (Segal 2003). For Fudan Microelectronics, social connections also have made the difference. The company founder, while going through graduate school, had long been interested in the research conducted by the Fudan research lab on IC technology. But it was not until after he joined the Shanghai Commercial Investment Corporation was he able to persuade his employer to chip in a 38 percent share in the company. Fudan's research innovation was converted into knowledge capital—an equivalent of a 37 percent share. The founder and several other employees contributed personal funds for the rest of the company share—25 percent (Shanghai Private Economy Development and Promotion Center 2006).

In many ways, private technology enterprises such as Fudan Microelectronics have not been the prime target for local and foreign investment. Particularly in the early reform period, the municipal government had a limited number of financial tools available to support the growth of these enterprises. Bank lending had to be directed to foundering state enterprises and lending to private firms was believed to be more risky (Segal and Thun 2001). More recently, municipal authorities have begun to acknowledge the importance of attracting foreign venture capital to link Chinese start-ups with international talent. State-backed venture capital firms also are being restructured in order to compete. For instance, Shanghai Venture Capital Corporation now enjoys considerable autonomy to operate according to market principles (Leng 2002).

Fudan Microelectronics has benefited a great deal from the amenities and assistance provided by the Fudan University Science Park. Established in 2000, the park now houses over one hundred enterprises created by both Fudan researchers and other entrepreneurs. It is a joint effort between Fudan and several local entities. The management of the park is undertaken by a holding company, which also helps enterprises raise investment through establishing various venture-capital funds. The municipal and district governments have provided significant in-kind assistance, including free land allocation and updated computers (personal interview with a park official). There is a small, one-year incubator grant program for startup enterprises by Fudan's own graduates and selected faculty, with funding from the city (RMB 12 million a year), the Yangpu district government (5 million) and the university (5 million). Business services provided by the incubator includes training and assistance in obtaining local or national innovation grants and applying for licenses and high-tech designation as well as relevant incentives (personal interview with a Fudan University official). In addition, Fudan University's enterprise office acts as a venture capitalist to finance the surviving small enterprises for another two to three years through its investment company. When these enterprises become mature businesses, some are sold to larger firms and some even go public, as in the case of Fudan Microelectronics.

Fudan Microelectronics' rise sheds some light on the critical role of small technology firms, particularly those that connect with universities and their science parks. In fact, there is evidence that a higher incidence of firms in Shanghai are located in industrial or science parks—higher than in other large Chinese cities such as Beijing, Guangzhou, and Tianjin (Jefferson and Zhong 2004). Another important new trend in the development of industrial R&D is the growing interest by multinational corporations (MNCs) in doing R&D in Shanghai. The city is now home to dozens of R&D centers of multinationals—in such industries as automobiles, machinery, biotechnology, pharmaceuticals, and software. These MNCs include General Electric, Bayer, Bell Labs, and Lucent Technologies ("Asia's New R&D Center," *FDI Magazine*, April 5, 2004). Although some of these R&D activities are not cutting edge and involve adaptations to suit local markets, MNCs are clearly taking advantage of Shanghai's skilled labor force, quality university labs, and local production clusters. In the process they also help restructure the municipal innovation system through demonstration effects in joint-research labs and market competition in mobilizing local firms to set up R&D facilities (Chen 2004). Today, about half of the large- and medium-sized enterprises engaging in S&T activities involve some foreign investment (Shanghai Science and Technology Commission 2004).

The in-house R&D capacity of Shanghai's enterprise sector, however, remains uneven. Unlike many foreign firms, most domestic firms do not plan ahead new product lines or technology. When research innovations are ideas still far from maturity into commercial products, these firms are unwilling or unable to take them over for further development (personal interview with a Fudan University official). For this reason, elite research universities in Shanghai have encountered difficulty in licensing patents with more basic research content. According to a manager of Shanghai Jiaotong University's National Technology Transfer Center, only about 10 percent of all patents registered by the university have been marketed out (personal interview). Some universities even discourage faculty to collaborate with small- and medium-sized enterprises because of their low-technology content and the large amount of time needed to train their staff in order to do collaborative R&D (personal interview with a Fudan University official).

Enterprise Perspectives on Shanghai's Innovation Environment

To gauge how Shanghai's innovation environment is perceived, a small survey of fifty high-tech manufacturing and knowledge-intensive service firms was conducted. This was done in both Shanghai and Beijing in 2003–2004 by two Chinese researchers involved in a collaborative research project with several U.S.-based researchers including myself. Using a semistructured questionnaire and purposive sampling methods, the survey covered a reasonable range of sectors, firm size, and ownership. Surveyed firms in Shanghai include fifteen in electronics/IT manufacturing, six in life sciences, six in consultancy services, three in marketing and financial services, two in printing, seventeen in software/multimedia, and one in TV/film. Most of these firms have received foreign investment and some are actually foreign controlled (Wang and Tong 2005). Although Shanghai's innovation system is of a very recent origin, the firm perspectives provide some useful insights. The discussions further on draws from some tabulation by Wang and Tong (2005) and my own analysis of the original questionnaires.

One of the key results from the survey pertains to how these firms assess the various aspects of Shanghai's innovation environment. Global linkages appear to be the city's strongest asset, followed by the supply of knowledge professionals and quality of research institutes (Wang and Tong 2005). This reflects the progress Shanghai has made in the last decade or so. After the opening of the new international airport in Pudong in 1999, Shanghai is becoming an aviation hub in the Asia and Pacific region with nonstop flights reaching most of the world's important urban centers. Foreign airlines have responded to the city's rising significance as a business center and the growth in airport capacity by increasing the volume of services. This in fact speaks to a broad trend that availability of direct flights may be the number one priority in the location decisions of high-tech firms with above-average innovation (Echeverri-Carroll 1999). Shanghai also ranks among the top five busiest container ports in the world and, with the starting of operation of the new Yangshan port in late 2005, will have the capacity to absorb traffic from Southeast Asia currently channeled through Hong Kong (Yusuf and Wu 2002). The large number of universities and colleges in the city provides a steady supply of trained professionals. As the place where China's first modern institutions of higher learning were established, Shanghai has nearly sixty universities and colleges, twenty of which offer graduate education. But the university sector is yet to become the key driver of local innovation and has consistently spent less than other R&D institutions. For instance, university expenditures in S&T-related activities (a much broader category of spending than R&D expenditure) reached RMB 2.76 billion in 2003, a mere 1.2 percent of the city total (Shanghai Science and Technology Commission 2004).[5]

An impressive finding from the survey is that Shanghai scores better than Beijing in the overall local innovation environment and how well it handles basic government services such as planning, permitting, and public services (Wang and Tong 2005). This is consistent with findings from research done by Jefferson and Zhong (2004). Using a composite index of R&D capabilities (including such indicators as international exposure, human capital resources, the R&D network, and the policy setting), they rank Shanghai above four other major Chinese cities (Beijing, Guangzhou, Chengdu, and Tianjin) along all dimensions. Shanghai's R&D capabilities are in fact close to those in Seoul, South Korea. They continue to argue that Shanghai has begun to create the institutional attributes that boost the productivity of R&D. According to another study ranking ten Chinese cities by the Management School of China Southeast University, Shanghai ranks first in aggregate competitiveness (cited in Jefferson and Zhong 2004). It enjoys the most advantageous location and best infrastructure. Shanghai also ranks first in the competitiveness of capital, technology, location, social order, and management, and it ranks second in the competitiveness of human capital and culture.

Not surprisingly, the lowest-ranking aspects of Shanghai's innovation environment pertain to the availability of venture capital, transparency and IP protection (Wang and Tong 2005). True venture investments or funds, particularly those with a pure focus on technology, are still rare in Shanghai and China in general. Worldwide experience shows that continuing investment in product development is essential in the growth of innovation. Startup firms, particularly those in cutting-edge R&D, depend on venture capital to underwrite their initial costs. But venture capital tends to have a strong tendency toward localization. It flows not only to a few centers of innovation, but also to a specific set of technologies within those areas.[6] However, the availability of venture capital is contingent in part on the presence of local venture capital firms. Shanghai municipal authorities have began to use tax incentives, preferential loans, and risk compensation to encourage venture financing at the local level, which in turn can help cultivate a more long-term-driven investment culture.

Problems with IP protection are much more far-reaching and national in scope, as China's legal system is still inadequate for supporting innovative activities and promoting interorganizational linkages. Most generally, the major difficulty arises from an incomplete system for assigning, exercising, and protecting property rights (Liu and White 2000). Inadequacies in contract law and its enforcement also reduce the willingness of innovators to transfer technology to other organizations. Since the mid-1980s, China has been gradually building a legal infrastructure, training lawyers, assimilating laws, and instituting legal procedures that are increasingly a common currency worldwide. But the nature of Chinese legal and regulatory practices, as well as the approach to enforcing regulations, still differs markedly from that of more open industrialized countries.

When given the opportunity to respond to questions about the future of Shanghai, the firms have expressed overwhelming optimism. About half of them (48 percent) believe that the city has a very high chance to become a center for knowledge-based firms and industries in the near future. Another 32 percent see this chance as being high. Only 20 percent of the firms have some uncertainty about the city's prospect. The firms, on the other hand, point to a number of areas worthy of additional public investment and attention in the city. Foremost among them relates to human resources and their training (identified by about one-third of the firms), while several firms call for more attention to financing mechanisms and particularly venture capital. With a growing number of foreign firms and local startups, it has become increasingly difficult to recruit and retain quality domestic talent. The looming shortage appears particularly severe for the service sector (e.g., engineers, finance workers, accountants, quantitative analysts, life science researchers, and doctors), according to a recent study by the McKinsey Global Institute (Farrell and Grant 2005). This can be largely attributed to the disconnect between the higher education system and practice. Although nearly one-third of college students in China study engineering, they get little experience working on projects or in team while at school to prepare for actual employment.

To make the city more attractive to domestic as well as foreign talent, the firms emphasize two key opportunities for enhancement: quality of life and services (identified by ten firms), and investment and entrepreneural environment (eight firms). Quality of life may refer to such important issues as quality public education, reliable health care, assured public safety, and a clean and attractive natural environment. Surveys in the U.S. also find that knowledge workers, in particular, want urban amenities such as outdoor dining, walking streets, a vibrant night life, and outdoor recreation activities (CEOs for Cities 2000; IntelliQuest 1999). The call by some firms for a better environment for investment and entrepreneurship again emphasizes that the external environment for innovation is as important as the capacity within firms. It also appears to echo the recent attention paid to how diversity and tolerance may make places more attractive to knowledge workers (Florida 2002).

Shanghai in some ways may be the victim of its own success in becoming China's business hub. As an increasing number of MNCs establish R&D centers in the city, they compete with local firms for talent, but often with promises of better pay and work environment. This can put small startups at a particular disadvantage in recruitment. In addition, horizontal mobility for knowledge workers has increased as a result of the growing demand, creating difficulty in retention for many firms (personal interview with an overseas Chinese manager of an IT firm).[7] By comparison, Shanghai's close neighbor—Hangzhou—is rapidly catching up as a new center for knowledge-based firms and industries. With a top-ranked university (Zhejiang University) that produces graduates of no lesser quality than those from universities in Shanghai, Hangzhou is a city of an equally efficient municipal government and beautiful environment anchored by the West Lake. More importantly to firms, it remains feasible to retain quality knowledge workers, for at least several years (personal interview with an overseas Chinese manager of an IT firm).

Conclusion

The experience of Shanghai shows that the vitality of local innovation is shaped by the national innovation system, just as its continued competitiveness in the global market is intertwined with China's prosperity. In particular, the critical policies determining the nation's IP protection system and the coordination mechanism among various actors of innovation are largely decided by the central government. Yet despite national as well as municipal efforts to enact the necessary laws, ineffective IP protection remains to be a key concern for firms about Shanghai's innovation environment. The major shift in the national distribution of R&D effort among the three major sectors performing R&D has had a profound effect on localities. Mirroring a national trend, Shanghai has seen the rise of industrial enterprises and, recently, of private technology enterprises as the key agent in R&D. This accounts for a large part of the increase in local R&D expenditures and a continued focus on product or process innovation (hence the continued neglect of basic research). However, an encouraging development for the city is a faster growth pattern in invention patents, in comparison with national trends.

Echoing another national trend, Shanghai has relied significantly on science parks as the main incubator for R&D. Among the half dozen such parks, Zhangjiang Science Park in the Pudong New Area has been instrumental in spearheading the development of high-tech industries. Launching these parks to support key high-tech sectors appears to be the most ardent local response to nationwide 863 and Torch programs aimed at commercialization of new technologies. These parks, as result, have become homes to many knowledge-based firms and industries. Among them are an increasing number of R&D centers affiliated with MNCs.

Efforts to promote private technology enterprises in the city have materialized at a slower pace than in Beijing—the city's main domestic competitor. The early focus on large state enterprises and groups stemmed from Shanghai's historical legacy. Since the mid-1990s, the number of private technology enterprise has increased steadily, although large- and medium-sized enterprises continue to be the dominant players of industrial R&D. The case study of Fudan Microelectronics shows that, despite preferential treatments offered by municipal authorities, private technology enterprises continue to experience substantial difficulty in raising funds at their initial stages of development. Having a formal relationship with a science park offers some advantages for them, because various forms of in-kind public investment and services are channeled through the city's science and high-tech industrial parks. The enterprise sector's in-house R&D capacity, however, remains low. This has frustrated elite universities in the city in their efforts to commercialize academic research.

What appears to be highly appreciated by firms is Shanghai's recent efforts to increase global linkages. Its outstanding combination of air, port, and communications infrastructure is clearly a highlight of its innovation environment. Shanghai is becoming an aviation hub in the Asia and Pacific region with nonstop flights reaching most of the world's important urban centers. Shanghai also scores well in the efficiency of local infrastructure that is critical to firms' direct operations, with the exception of the urban transport network. Municipal authorities handle well basic government services such as planning, permitting, and public services, confirming a reputation for being well organized and efficient.

By in large, Shanghai's experience shows that the building of a local innovation system in China remains a process primarily dictated by national directives and programs. Yet equally important are municipal policies that advance private technology enterprises, business services, transport and communications facilities, and availability of skills. In an economy with accelerating technological innovations and rising specialized service functions, the labor force needs good basic education and skills, and market institutions should permit a high degree of flexibility. Shanghai is clearly moving in that direction, having already made significant headways in enhancing its research institutions and support infrastructure. Although there is a high level of enthusiasm among enterprises regarding its prospect in becoming a center for knowledge-based firms and industries, measures to ensure an adequate supply of skills are likely Shanghai's biggest challenges. Sustaining the supply of knowledge workers calls for more attention to the quality of life and services, as well as the investment and entrepreneural environment.

NOTES

1. Research has shown that increasing the average level of education in a metropolitan area by one grade increases total factor productivity by 2.8 percent (cited in Appleseed, Inc. 2003).
2. Although most developed countries' R&D/GDP ratios range between 2 and 2.5 percent, China now stands out as a heavy spender among developing countries with the largest R&D expenditures. Mexico's R&D spending, for example, was 0.4 percent in 1999, while India's score was 0.86 percent in the same year. Despite growth in China's R&D funding, China remains far behind most of the developed world (Hsiung 2002).
3. By official definitions, patents in China are divided into three groups: inventions, utility models, and designs. Inventions "refer to new technical proposals [on] products, methods, or both." New utility models "refer to new technical proposals on shape, structure of a product or the combination of both." New designs "refer to aesthetics and industry-applicable new designs for shape, design or color of a product, or their combination" (Sun 2000:443).
4. The "863" Program aims to catch up with the West in fundamental and frontier research, while the Torch Program promotes commercialization of new technologies (Hu and Jefferson 2004). All provinces have begun operating science parks with the help of the Torch Program. Besides those in Beijing, Shanghai's science parks are the most developed (Hsiung 2002; Suttmeier and Cao 1999).
5. The enterprise sector, on the other hand, counted for 86 percent of Shanghai's S&T-related expenditures in 2003.
6. In the U.S., for instance, more than 60 percent of all venture capital flowed to just five cities—San Francisco, Boston, New York, Los Angeles, and Washington, DC (Cortright and Mayer 2001).
7. A notable feature of knowledge workers is horizontal hypermobility. Instead of moving up through the ranks of one firm, employees move laterally from company to company in search of what they really want. See Florida (2002).

REFERENCES

Appleseed, Inc. 2003. *Engines of economic growth: The impact of Boston's eight research universities on the metropolitan Boston area*. Boston, MA: Appleseed, Inc.

CEOs for Cities and Progressive Policy Institute. 2000. *Urban economic prospects in the knowledge economy*. Boston: CEOs for Cities. http://www.ceosforcities.org/research/2000/urban_economic_prospects/index.html (accessed November 2004).

Chen, K., and M. Kenney. 2005. Universities/research institutes and regional innovation systems: The cases of Beijing and Shenzhen. Paper presented at the workshop, *Universities as Drivers of Urban Economies in Asia*, sponsored by the Development Economics Research Group of the World Bank and the Social Science Research Council, Washington, November 17–18.

Chen, Y.-C. 2004. Restructuring the Shanghai innovation systems: The role of multinational corporations' R&D centers in Shanghai. Paper presented at the First *ASIANLICS International Conference: Innovation Systems and Clusters in Asia—Challenges and Regional Integration*, Bangkok, Thailand, April 1–2.

Cooke, P. 2001. Regional innovation systems, clusters, and the knowledge economy. *Industrial and Corporate Change* 10: 945–974.

Cortright, J., and H. Mayer. 2001. High tech specialization: A comparison high technology centers. In *Survey series*. Washington, DC: The Brookings Institution Center on Urban and Metropolitan Affairs.

Crow, M., and B. Bozeman. 1998. *Limited by design: R&D laboratories in the U.S. National Innovation System*. New York: Columbia University Press.

Dahlman, C.J., and J.-E. Aubert. 2001. *China and the knowledge economy: Seizing the 21st. century*. Washington, DC: The World Bank.

Doloreux, D. 2003. Regional innovation systems in the periphery: The case of the Beauce in Quebec (Canada). *International Journal of Innovation Management* 7(1): 67–94.

Echeverri-Carroll, E. 1999. The regional economic impact of new airport construction: The case of Austin-Bergstrom International Airport. *Texas Business Review* (June): 5–7.

Fan, B. 2003. *Research on City Technological Innovation* [chengshi jishu chuangxin toushi]. Beijing, China: China Machine Press.

Farrell, D., and A.J. Grant. 2005. China's looming talent shortage. McKinsey Global Institute. http://www.mckinsey.com/mgi/publications/Chinatalent.asp (accessed October 27, 2006).

Florida, R. 2002. *The Rise of the creative class: And how it's transforming work, leisure and community*. New York: Basic Books.

Fujita, K., and R.C. Hill. 2004. Innovative Tokyo. Paper presented at the *World Bank Workshop on Creative Industries in East Asia*, Bangkok, Thailand, February 22–23, 2004.

Glaeser, E.L., and A. Saiz. 2003. *The rise of the skilled city*. Harvard Institute of Economic Research Discussion Paper No. 2025, December.

Gu, S. 1999. *China's industrial technology: Market reform and organizational changes*. New York: Routledge.

———. 2003. Science and technology policy in China. In *Encyclopedia of life support systems (EOLSS)*. Developed under the auspices of the UNESCO. Oxford, UK: EOLSS Publishers.

Hall, P. 2000. Creative cities and economic development. *Urban Studies* 37(4): 639–649.

Hsiung, D.-I. 2002. An evaluation of China's science and technology system and its impact on the research community. A Special Report for the Environment, Science and Technology Section of US Embassy, Beijing, China.

Hu, A.G.Z., and G.H. Jefferson. 2004. Science and technology in China. Paper presented at Conference 2—China's Economic Transition: Origins, Mechanisms, and Consequences, Pittsburgh, PA, November 5–7.

IntelliQuest. 1999. High tech communities quality of life study. http://www.intelliquest.com (accessed November 2004).

Jefferson, G.H., and K. Zhong. 2004. An investigation of firm-level R&D capabilities in Asia. In *Global production networking and technological change in East Asia*, ed. S. Yusuf, M.A. Altaf, and K. Nabeshima, 435–475. New York: Oxford University Press, for the World Bank.

Kelly, J. 2003. *World winning cities in an era of change*. Chicago: Jones Lang LaSalle. http://www.rakli.fi/uutisia/Lehdisto/JLLProperty_Futures_6_1.pdf (accessed November 2004).

Kresl, P.K., and B. Singh. 1999. Competitiveness and the urban economy: Twenty-four large U.S. metropolitan areas. *Urban Studies* 36(5-6): 1017–1027.

Leng, T.-K. 2002. Economic globalization and IT talent flows across the Taiwan strait: The Taipei/Shanghai/Silicon Valley triangle. *Asian Survey* 42(2, March/April): 230–250 (243).

Liu, X., and S. White. 2000. China's national innovation system in transition: An activity-based analysis. Paper presented at the *Sino–US Conference on Technological Innovation*, Beijing, April 24–26.

Lu, Q. 2000. *China's leap into the information age*. Oxford: Oxford University Press.

Ma, W. 2004. *From Berkeley to Beida and Tsinghua: The development and governance of public research universities in the US and China* [cong Berkeley dao beida qinghua: zhong mei gongli yanjiuxing daxue jianshe yu yunxing]. Beijing, China: Educational Science Press.

Mayer, H. 2003. A clarification of the role of the university in economic development. Paper presented at the Joint Conference of the Association of Collegiate Schools of Planning and the Association of European Schools of Planning, Leuven, Belgium, July 8–13.

Mowery, D.C., and N. Rosenberg. 1993. The U.S. National Innovation System. In *National innovation systems: A comparative analysis*, ed. R.R. Nelson, 29–75. Oxford and New York: Oxford University Press.

Nelson, R.R., and N. Rosenberg. 1993. Technical innovation and national systems. In *National innovation systems: A comparative analysis*, ed. R.R. Nelson, 3–21. Oxford and New York: Oxford University Press.

Porter, M.E. 1998. Clusters and the new economics of competition. *Harvard Business Review* (November–December): 77–87.

Porter, M.E., and Monitor Group. 2001. *Clusters of innovation initiative—San Diego*. Washington, DC: Council on Competitiveness.

Porter, M.E., and S. Stern. 2001. Innovation: Location matters. *MIT Sloan Management Review* (Summer) 28–36.

Saxenian, A. 1994. *Regional advantage: Culture and competition in Silicon Valley and Route 128*. Cambridge, MA: Harvard University Press.

Scott, A.J. 2000. *The cultural economy of cities: Essays on the geography of image-producing industries*. London: Sage Publication.

Segal, A. 2003. *Digital dragon: High-technology enterprises in China*. Ithaca, NY: Cornell University Press.

Segal, A., and E. Thun. 2001. Thinking globally, acting locally: Local governments, industrial sectors, and development in China. *Politics & Society* 29(4, December): 557–588.

Shanghai Academy of Social Sciences. 1997. *Shanghai entering the new century: Issues in social development* [Shanghai kuashiji shehui fazhan wenti yanjiu]. Shanghai, China: Shanghai Academy of Social Sciences Press.

Shanghai Information Commission. 2006. *Atlas of Shanghai's software industry 2006* [Shanghai ruanjian chanye ditu]. Beijing, China: Social Sciences Academic Press.

Shanghai Municipal Government. 2004. *Reforms and innovations in Shanghai's science and technology system* [Shanghai keji tizhi gaige yu chuangxin]. Shanghai, China: Shanghai People's Press.

Shanghai Private Economy Development and Promotion Center. 2006. *Entrepreneurship, innovation and creation: Experience of Shanghai's private enterprises* [chuangye chuangxin chuangzao:

Shanghai minying qiye zizhu chuangxin jishi]. Shanghai, China: Shanghai Science and Technology Academic Press.

Shanghai Science and Technology Commission. 2004. *Shanghai statistical yearbook on science and technology* [Shanghai keji tongji nianjian]. Shanghai, China: Shanghai Science Press.

Simmie, J. 2005. Innovation and space: A critical review of the literature. *Regional Studies* 39(6, August): 789–804.

———. ed. 2001. *Innovative cities*. London: Spon Press.

Sommers, P., and D. Carlson. 2000. *Ten steps to a high tech future: The new economy in metropolitan Seattle*. Discussion Paper for the Brooking Institution Center on Urban and Metropolitan Affairs (Washington DC), CEOs For Cities (Cambridge, MA), City of Seattle Office of Economic Development (Seattle, WA).

Storper, M. 1997. *The regional world: Territorial development in a global economy*. New York: The Guilford Press.

Sun, Y. 2000. Spatial distribution of patents in China. *Regional Studies* 34 (5, July): 441–454.

———. 2002. China's national innovation system in transition. *Eurasian Geography and Economics* 43(6): 476–492.

Suttmeier, R.P., and C. Cao. 1999. China faces the new industrial revolution: Achievement and uncertainty in the search for research and innovation strategies. *Asian Perspective* 23(3): 153–200.

Tepper, S.J. 2002. Creative assets and the changing economy. *Journal of Arts Management, Law, and Society* 32(2, Summer): 159–168.

Walcott, S. 2002. Analyzing an innovative environment: San Diego as a bioscience beachhead. *Economic Development Quarterly* 16(2, May): 99–114.

———. 2003. *Chinese science and technology industrial parks*. Burlington, VT: Ashgate Publishing Limited.

Wang, J., and X. Tong. 2005. *Sustaining urban growth through innovative capacity: Beijing Shanghai in Comparison*. World Bank Policy Research Working Papers WPS 3545, Washington, DC: The World Bank.

Wei, Y., and C.K. Leung. 2005. Development zones, foreign investment, and global city formation in Shanghai. *Growth and Change* 36(1, Winter): 16–40.

Xue, L. 2004. University-market linkages in China: The case of university-affiliated enterprises. Paper presented at the symposium on University, Research Institute and Industry Relations in the U.S., Taiwan and Mainland China, Stanford Project on Regions of Innovation and Entrepreneurship. Palo Alto, CA, September 7–8.

Yusuf, S., and W. Wu. 2002. Pathway to a world city: Shanghai rising in an era of globalization. *Urban Studies* 39(7, June): 1213–1240.

Zhang, J. 2003. *The development of high-tech enterprises in China's universities* [zhongguo gaixiao gaoxin jishu chanye de fazhan yanjiu]. Wuhan, China: Huazhong Science and Technology University Press.

Zhang, T. 2002. Urban development and a socialist pro-growth coalition in Shanghai. *Urban Affairs Review* 37(4): 475–499.

Zhou, Y. 2004. The making of an innovative region from a centrally planned economy: Institutional evolution in Zhongguancun science park in Beijing. *Environment and Planning A* 37: 1113–1134.

Zhou, Y., and X. Tong. 2003. An innovative region in China: Interaction between multinational corporations and local firms in a high-tech cluster in Beijing. *Economic Geography* 79(2): 129–152.

Zhu, J. 2000. Urban physical development in transition to market: The case of China as a transitional economy. *Urban Affairs Review* 36(2): 178–196.