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De-centering 'spatial fix'—patterns of territorialization and regional technological dynamism of ICT hubs in China

Yu Zhou[*], *Yifei Sun*[†], *Y. H. Dennis Wei*[‡] *and George C. S. Lin*[§]

[*]Department of Earth Science and Geography, Vassar College, Poughkeepsie, NY 12604, *email* <yuzhou@vassar.edu>
[†]Department of Geography, California State University, Northridge, Northridge, CA 91330, *email* <yifei.sun@csun.edu>
[‡]Department of Geography and Institute of Public and International Affairs, University of Utah, 260 S. Central Campus Dr., Rm. 270, Salt Lake City, UT 84112-9155, *email* <wei@geog.utah.edu>
[§]Department of Geography, Hong Kong University, Hong Kong, *email* <gcslin@hkucc.hku.hk>

Abstract

This article critically assesses Harvey's 'spatial fix' thesis through systematically comparing the spatial patterns and dynamics of three key regions of China's information and communication industry. The divergent territorialization is analyzed by broadening the concepts of global pipelines and local buzz to the context of developing countries. The research is based on a large-scale survey conducted in 2006–2007 in three mega-city regions of China: Beijing, Shanghai-Suzhou and Shenzhen-Dongguan. The research found not only marked regional differences in industrial structure, ownership, export-orientation and technological investment, but also a surprising convergence of technological dynamism among foreign and domestic firms within each region. The data established an unmistakable negative association between transnational corporation–led export industry and technological investments. Beijing—the least foreign-oriented region—outperformed all others by a substantial margin in all measures of technological dynamism, highlighting the importance of indigenous R&D for domestic capital and for attracting technology intensive foreign capital.

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JEL classifications: R30, O10, O30
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1. Introduction

The mobility of capital and its territoriality has been a profound topic for geographers. The 'spatial fix' thesis introduced by David Harvey argues that the accumulation of capital inevitably engenders a fundamental contradiction 'between the rising power to overcome space and the immobile spatial structure required for such a purpose' (Harvey 1985, 150). While various reiterations of Harvey's 'spatial fix' thesis provide insight into the spatial logic of capital, they hinge upon the supremacy of western, specifically American, capital in expanding and annihilating global spaces. Much less attention has been paid to the multiple imperatives of capital and the multiple fields of power, some reside in developing countries, that shape spatial outcomes in peripheral regions. The rise of China and its forceful insertion into the global capital accumulation

process require careful assessment from this vantage point. Though China is a developing country starting with low standing in the global capital and technology hierarchy, its huge market size, a state-centered political structure, and fast capital accumulation present unique challenges to western centered analyses.

Harvey (2003) suggests that China offers the most promising spaces to absorb surplus western capital (p. 122). But do these Chinese spaces dance to the tone of 'spatial fix' from the west, or there are other significant forces to co-opt or shape the courses? Building on the grand capitalist narrative, the 'spatial fix' thesis proves helpful but ultimately deficient for analyzing the complex interplay between the multiple sources of capital and its local articulations in the global periphery.

We argue that the spatial outcome of the Chinese information communication industry (ICT) is a result of a contested and divergent process of territorialization with a significant role of indigenous capital and domestic market dynamics. Through a large scale firm-level survey that was conducted in 2006–2007, we systematically compared the state of the ICT industry in the three megacity regions in China, namely Beijing; Shanghai–Suzhou—the high-tech core of the Yangtze River Delta; and Shenzhen–Dongguan—the industrial core of the Pearl River Delta (Figure 1). Although they occupy a tiny portion of the total territory of China, together they accounted for half of China's ICT manufacturing employment and close to 60% of its ICT manufacturing output and export in 2004.

Our research found that while these regions have become indispensable sites for the territorial expansion of global capital since the 1990s, the injections of external capital are neither homogenous nor coordinated; rather, they are driven by conflicting motivations and come from disjointed sources. We found multiple rounds of 'spatial fix' are going on at once, each compelled by different interests and principally anchored at a different locality. These externally imposed 'spatial fixes' are further complicated by China's own accumulation of capital and developmental imperatives. The resultant industrial landscape is marked by a distinct territorialization in each of Chinese industrial hubs, determined by their respective positioning in the global production system and differentiated local abilities in mediating multiple conduits of power. These differences are evident not only among the three megacity regions, but within each region between the privileged metropolitan centers and their satellite high-tech suburbs. Foreign and Chinese domestic firms, though they behave differently in sector specialization and export tendencies, show striking convergence in technological dynamism within each region. This finding provides the strongest evidence yet of the power of territorialization that has channeled different capital into different locales, launching and sustaining regions on divergent technological trajectories. To address the diverse interfaces between global and local dynamics, we employ and broaden the concepts 'local buzz' and 'global pipelines' developed by Bathelt et al. (2004) while stressing the unequal power relations embedded in the 'spatial fix' thesis.

2. Spatial fix and cycles of territorialization

Harvey argues in his well-known 'spatial fix' thesis that a spatial solution is intrinsic to addressing the inevitable periodical crises in the capitalist accumulation process. On the one hand, crises that arise from the chronic tendency of capital to accumulate over and above what can be reinvested profitably in the production and exchange

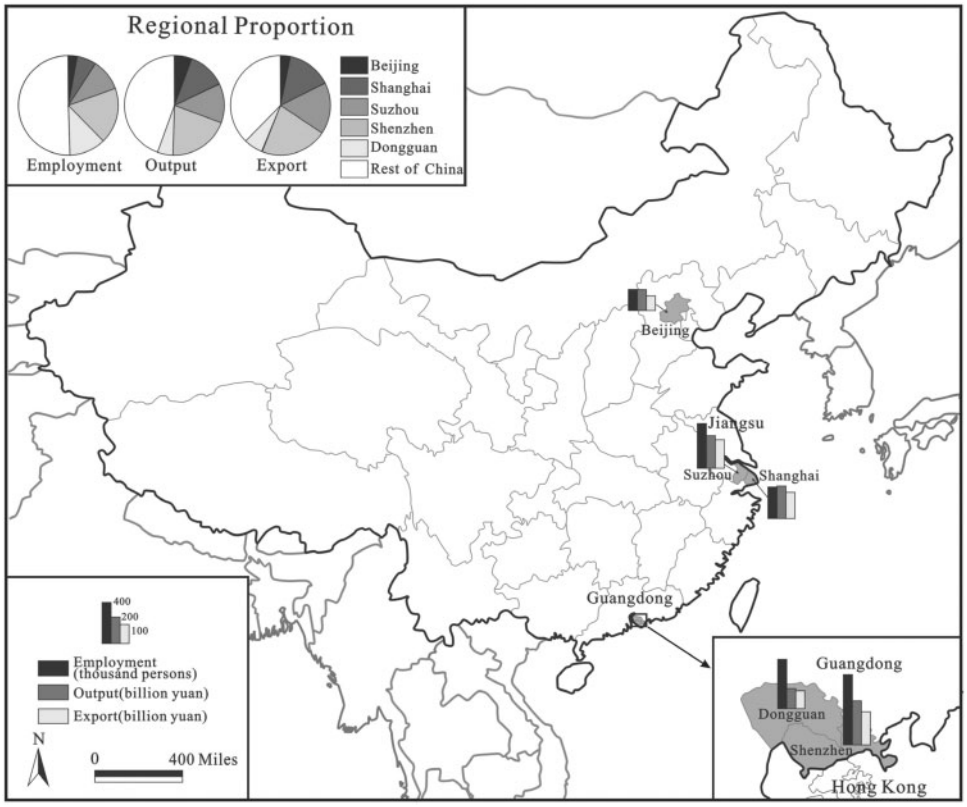


Figure 1. Three ICT hubs in China, the data show manufacturing sectors only.
Source: National Bureau of Statistics of China, Economic Census Office (2006). The database has annual updates from 2004 published yearbook.

of commodities propel expansions to incorporate new space (Harvey 2003, 109–112). On the other hand, the mobility of the capital is hindered by existing investment and infrastructure:

> A certain portion of the total capital is literally fixed in and on the land in some physical form for a relatively long period of time (depending on its economic and physical lifetime). Some social expenditures (such as public education or a health-care system) also become territorialized and rendered geographically immobile through state commitments (2003, 115).

In this formulation, territorialization refers a relative 'immobile spatial structure' created by capital, labor and state over a period of time. This term of territorialization has also been used by other scholars such as Storper (1997) and Brenner (1998) to describe the local embeddedness of regional production networks and unique regional institutions in fostering economic growth and technological changes. Territorialization is not a permanent state, however. It is a dynamic process shaped by the interaction between fixity and motion of capital. Specifically, capital act on its urge to expand and overcome geographical barriers and create territorial organizations, 'only to be torn

down, reconfigured and reterritorialized during each period systematic crisis' (Brenner, 1998, 462).

While 'spatial fix' is a powerful concept to explain the globalizing tendency of capital and its equally noted tendency of abandonment and decay of the previous industrial heartlands, this thesis tends to award primary agency to the western capital in its expansionary movements from the core into the global periphery, similar to many World System theorists do (Wallerstein, 1979). The peripheral regions are often viewed as passive participants. Its internal capital formation and accumulation acknowledged, but typically are not well analyzed. In the case of China, the role of central state is often stressed, but the dynamics of indigenous capital or internal market receive far less attention (Zhou, 2008b). Harvey, for example, regards China as the most promising site for spatial fix in the ongoing accumulation crisis that originated in the west (Harvey, 2003, 122–123; Arrighi, 2007, 219). Indeed, the twin drives of capturing the new and fast-growing market there and of tapping the world's largest ready supply of inexpensive labor have made China irresistible to western capital. Yet Harvey's account only provides limited understanding of the roles of non-western capital and China's internal dynamics in compelling or complicating the 'spatial fix'. To be sure, Harvey (2005) recognizes the relative independence of China's evolving capitalism. Yet he sees China moving to an eventual convergence with the global course of neoliberalism. Whether there is predetermined destiny of development in China has been a point of contentious debate (Arrighi, 2007), and is beyond the scope of this article. However, previous research has identified three complications for the territorialization of western capital in China. For one, capital from external sources has different access, motivations, and capacities to work within China. Overseas Chinese investments, for example, display different spatial and temporal dimensions from the western TNCs (Yeung, 2007). Second, all external capital has to deal with the Chinese central and local governments, which set different priorities in different time periods. Third and most importantly, as Arrighi argues (2007), China's development since the early 1980s was not a case of external imposition. Rather, '[F]oreign capital, ... jumped on the bandwagon of an economic expansion which it neither started nor led.' (p. 353) Instead of being a primary driver, external capital has to compete with the formidable logic of China's own capital accumulation and with local enterprises that are increasingly able to challenge the western corporations in the domestic and international markets (Zhou, 2008a, 2008b). This is bound to create complicated spatial dynamics beyond either TNCs-dominated or state-dominated model.

Instead of sequential waves of industrial diffusion from one region of China to another based on movement of external capital, we see several cycles of capital territorialization occurring simultaneously, each with a distinct regional articulation of industrial processes and involving different parts of the world or specializations of the industry. We argue that one way to capture these complex global–local interplays is to use and expand the conceptual framework of 'local buzz' and 'global pipelines' developed by Bathelt et al. (2004). If we also recognize the unequal power relations embedded in the global networks of the 'spatial fix', employing this framework can provide productive imagery for understanding how different regional endowments and institutions and different cycles of global and local capital accumulation combine to produce divergent outcomes in industrial territorialization.

3. 'Local buzz' and 'global pipelines' in the developing regions

Economic geography has paid great attention to the process of territorialization in technological dynamic regions. The scholarship has moved beyond simply looking at major factors such as human resources, universities, corporate R&D facilities and conventional economic agglomeration effects. Rather, it has examined the roles of social, cultural and organizational synergies and the unique institutional culture created by spatial agglomeration (Amin and Thrift, 1992; Henry 1995, Gertler 1995; Storper, 1997; Amin, 2000; Scott and Storper, 2003; Kenney and Patton, 2005; Porter, 2000;). Various terms have been used to capture the importance of regional characters: industrial districts, innovative milieu, regional systems of innovation, technopoles, and learning regions. While each term has a somewhat different conceptual twist, all stress how regional institutions and local technology and knowledge bases are critical in producing distinct trajectories (Andersson, 1985; Scott, 1988; Camagni, 1991; Malecki, 1991; Amin and Thrift, 1992; Scott, 1993; Gertler, 1995; Markusen, 1996; Amin and Cohendet, 1999; Rigby, 2000; Porter, 2000; Bunnell and Coe, 2002; Oinas and Malecki, 2002).

While these studies have generally emphasized endogenous networks, recent scholarly work also points to the importance of external agents in creating technological dynamism (Saxenian and Hsu, 2001; Bathelt et al., 2004; Simmie, 2004; Wolfe and Gertler, 2004; Moodysson, 2008). The interaction between external and internal actors is particularly important for developing countries, where it is often the external agents—either the TNCs or external markets—that drive the technology changes. Fromhold-Eisebith's work (2002) shows the importance of these interactions. She compared the patterns of interaction among TNCs, indigenous firms and local research institutions in Bangalore, India and Bandung, Indonesia. She concluded that although both regions were well endowed with universities and research institutions, the active participation of TNCs in Bangalore generated a superior regional cycle of learning compared to Bandung, where technological development is based on domestic actors and markets. Zhou and Tong (2003) also emphasize the interdependent nature of TNCs and local firms. However, they argue that the reliance on external technology does not necessarily diminish the importance of local networks and institutions in promoting technological change. Vang and Asheim (2006) suggest that the most fruitful approach is to build a balanced and flexible coupling between TNCs and regional components of innovative industries (41).

One particularly useful framework for capturing both the endogenous and exogenous dynamics is the idea of 'local buzz' and 'global pipelines' (Bathelt et al., 2004; Moodysson 2008). While the local–global dichotomy has been debated (Faulconbridge, 2007), Bathelt et al. (2004) argue that 'successful clusters are the ones that are able to build and maintain a variety of channels for low-cost exchange of knowledge with relevant hot-spots around the global' (33). They recognize the importance of 'local buzz', whereby 'in some crucial sense knowledge is created, stored and utilized locally in a decisive manner'. Yet, they argue, there is also a 'need to go beyond the borders of the cluster and build pipelines to bodies of knowledge residing elsewhere' (33). Their argument is based on the knowledge creation process, but we found it useful to expand the framework to the formation of regional production networks in developing countries. Substantial research has shown that knowledge networks differ significantly from business networks regarding core industrial knowledge. Giuliani (2007), for

example, shows that innovation-related knowledge is diffused in highly selective ways, favoring firms with similarly strong knowledge base and capacity of reciprocity. However, the knowledge we consider here is not only limited to innovative knowledge, but also the knowledge involved in the production organization, product specification and delivery, which can be carried through assembly type of subcontracting networks. We argue that different types of business networks involve transmission of different types of knowledge; some are more valuable than others regarding innovation, but all are useful in the context of industrializing countries. All can be described by a combination of external pipelines and local buzz. Pinch et al. (2003) similarly point to the link between localized knowledge and industrial agglomeration. We have no intention to equalize the value of different types of knowledge. Rather, we use the idea of global pipeline and local buzz to represent how these different types of knowledge become territorialized, which in turn, lead to divergence in regional industrial complexes.

The theory of local buzz and global pipelines expects diverse pathways of at the regional level rather than a uniform trajectory of technological progress typified by the 'Flying geese' model (Ozawa, 2005; Chiang, 2008). The 'Flying geese' model is based on Japanese experience in technology development, which is characterized by five succeeding stages: 'labor-driven, scale-driven, assembly-driven, knowledge-based and IT-driven.' (Chiang, 2008, 228) The model has been applied to other leading developing economies in Southeast Asia. But the 'fly geese formation' does not mean to account for the divergence existed at the regional scale. Given the size and complexity of Chinese economy, it is crucial to scrutinize these regional differences, not simply as interesting details, but as fundamental features on how Chinese regions have developed different couplings with the global economy and technological processes. According to Bathelt et al. (2004, 31), '[t]he co-existence of high levels of buzz and many pipelines may provide firms located in outward-looking and lively clusters with a string of particular advantages not available to outsiders.' Given the interdependence of external connections and local cluster development, a global pipeline linked with venture capitalists in Silicon Valley, California, for example, would carry innovative knowledge to push firms into a more innovative direction. A region deeply embedded with trade/manufacture-oriented networks may generate an active knowledge network on lowing cost and improving quality and delivery of products, but not necessarily in introducing innovation. There is not necessarily a smooth upgrading progression between two types of industrial and knowledge networks.

Bathelt et al. (2004) largely situate their study in the context of developed economies. While considerable differences exist among developed economies in specific industrial sectors, these differences pale in comparison with industrial and institutional gaps between developed and developing countries. We need to expand the framework to accommodate the realities of developing regions where the formation of pipelines is inevitably ingrained with unequal power relations. In the global system, TNCs are generally considered the most powerful players compared to local firms or even the local governments (Sklair, 2001). The interactions between TNCs and local regions in developing countries depend not so much on the opportunities of reciprocity but on matters of leverage, i.e. whether the developing regions have the bargaining power to attract and make better use of the flow. China is often seen as a developing country with the highest bargaining power due to its large market and rapid development. Yet, when it comes to each locality within China, their individual

bargaining position is much less assured, and is determined by the positions of this locality in the global and national hierarchy.

We argue that the global pipeline should be conceptualized not just as a channel of knowledge and expertise, but also as a conduit of power between places occupying different positions in the global hierarchy. And the local buzz is not just vibrant communication or information exchanges at the local level, but also the ability of localities to mediate and leverage the interests of capital from different sources and to create synergies from them. In fact, an earlier paper by (Bathelt and Taylor, 2002) recognized that inequality is a built-in condition of cluster development. This article will examines these ideas using empirical data in China.

We chose to focus on the ICT industry because it is one of the most dynamic and globalized industries in the world and in China—the best example of global pipelines and local buzz. China is one of the world's largest and fastest-growing producers and consumers of ICT products (OECD, 2006), and in recent years it has also emerged as a significant R&D site, attracting a diverse range of capital (Walsh, 2007). We compared the three most important high-tech city-regions of China: Beijing, Shanghai–Suzhou and Shenzhen–Dongguan. Not only do these three regions constitute roughly half of the entire ICT industry in China in the mid 2000's (Figure 1), they also host China's most affluent and educated population and its most sophisticated technology customers (Lin, 1997; Wei, 2000; Zhou and Tong, 2003). In a 2003 study of the strength of the new economy based on a compound index of professional occupations, the presence of global firms, economic dynamism, the information technology industry, and innovation capacity, Beijing, Shanghai and Guangdong province[1] where Shenzhen–Dongguan is located ranked as the top three regions among all Chinese provinces and provincial-level cities; they ranked respectively 97, 73 and 64 on a scale of 0–100 (Ji, 2003). Though the index is not updated, there is little sign of a major shift since then. Figure 1 shows their regional shares in employment, revenue, and exports based on the 2004 Economic Census. In 2007, their collective shares in China had dipped somewhat as industrial activities had dispersed more widely in the country, although these three regions are in no danger of losing their leads. According to *China's Electronic & Information Industry Statistical Yearbook*, Beijing, Shanghai and Guangdong province together produced 43.4% of national electronic output and 43.1% of national sales in 2007. They also generated 48.9% of national income from software services the same year, and hosted 45.1% of internet domain names in China in 2008 (CNNIC 2008). Most TNCs' investment in hardware, software and venture capital continues to gravitate to these three regions.

These elite regions have distinct features and developmental histories that we will discuss in more detail later. In selecting these regions, we attempt to identify whether and how the local articulations of global pipelines and local buzz differ under the most successful and comparable circumstances within a single country. We offer two hypotheses, each with three subhypothesis.

1 Much of Guangdong's industrial power is located in the Pearl River Delta, with its core in the Shenzhen–Dongguan axis nicknamed 'the factory of the world'.

4. Regional divergence

We hypothesize that each of these three regions has significantly different relationships with domestic and global capital. Industrial and technological dynamics in each individual region could not be projected to others, but together they set a range of possibilities of China's engagement with the global industry. (Hypothesis 1):

1. We expect significant differences in industrial structure, capital sources, capital intensity, market orientation and technological capacities in these regions.
2. These regions are not engaged in zero-sum competition for external resources. Instead, they perform complementary roles in global and Chinese capital accumulation in a divergent process of territorialization. We expect a concurrent rather substituting pattern of growth in these regions.
3. National-level metropolitan areas, due to their privileged positions in China's capital accumulation cycle and better human resources, have a greater mediating capacity regarding different sources of capital, which allow them to gain better bargaining position to leverage the global capital. This is reflected in their more diverse and robust economic structures, heavier presences of domestic enterprises and higher levels of technological dynamism.

We are certainly not the first people to study regional differences in China's ICT industry, but we may be among the first to systematically measure the differences among China's most successful regions in the leading industrial sectors. Studies of China cannot help but note regional industrial bases of growth. Yet, it is still a common practice among scholars and industrial journalists to use certain regions of China to project a national image. In particular, the Shenzhen-Dongguan region with its fame of 'factory of the world', is often assumed to represent the main thrust of China's model which is export-driven technological growth. Naughton's volume, *China Circle* (1997), for example, examines the shift of the export-oriented manufacturing segments of the industry from Hong Kong and Taiwan to the southeast coast of China in the 1990s. The enterprises discussed in the volume largely locate in export-oriented regions with scant reference to Beijing and Shanghai where different technological dynamics were emerging (Chung, 1997; Huchet, 1997). Steinfeld (2004)'s study on China's integration with global manufacturing industry draws on a World Bank survey data in 2001 in five major Chinese cities, but it again focuses on the role of export with little attempt to discern regional difference. In addition, many national level studies on China depend on international trade or foreign direct investment data to digest domestic technology capacity. While these indicators are important, they have the similar effect of privileging export-oriented processes or regions to understand technological changes (Chiang, 2008; Lemoine and Unal-Kesenci, 2004). These works shed little light on how indigenous capital formation and domestic market, in combination with the export industry, might create transformative implication for the dynamics of industry, as Zhou shows in her work in Beijing (2005, 2008a, 2008b). Segal's (2003) comparative research on nongovernmental (minying民营) high-tech firms in Beijing, Shanghai, Xian and Guangzhou has clearly shown very different technological dynamics at the regional level. He attributed these differences to local governance and found that Beijing has a local governance structure that is highly supportive of high-tech enterprises. His research touches little on the varied interface between TNCs and local firms in these regions, which has grown in importance. We argue that by systematically comparing

China's three major technological hubs, we are able to capture key regional differences not only in how much they are integrated in the global economy, but also in different ways they are integrated. Furthermore, we are able to examine the consequences of such different couplings.

Recent developments have made it apparent that China's role in the global ICT industry is not limited to low-value-added activities. The growth of China's technological market and the increasing sophistication of its domestic companies are making it necessary for TNCs to locate significant higher-value-added activities in China, whether or not they fit with their original intention. While labor-intensive manufacturing has been taking place in China throughout the 1990s and 2000s, capital-intensive and R&D-intensive activities have also moved to China at an accelerating pace in the 2000s. At least two explanations have been offered. First, the shift of capital-intensive manufacturing in the semiconductor areas has to do with the prominent role of overseas Chinese manufacturers in the global ICT industry and their cultural and linguistic affiliations with the mainland. In order to secure their positions amid heated global competition, Taiwanese notebook computer and semiconductor makers moved en masse to the Yangtze River delta since the late 1990s, anchoring in Shanghai–Suzhou region. In Harvey's term, it is the 'spatial fix' initiated from Taiwan that makes Shanghai–Suzhou the ICT hub. Taiwanese firms were later joined by global semiconductor giants in the USA, Japan, Korea and Europe (PwC, 2008; SHIC and SHICA, 2008). Secondly, the growth of R&D activities by TNCs in China since the 2000s is a response to the formation of China's skilled labor force and the expanding domestic market (Sun et al., 2008). The growing global competition on R&D since the 1990s made low-cost engineers in developing countries an attractive resource to tap into. More importantly, as China's domestic companies move aggressively to make products for domestic consumption, it is no longer safe for TNCs to assume that demand in China can be met by products designed for the west (Walsh, 2007; Altenburg et al., 2008). Localized R&D became inevitable despite continued misgivings about China's lack of protection of intellectual property rights. Walsh (2007) cites international surveys showing that China ranks first among both developed and developing economies in likely future R&D sites (EIU, 2004; UNCTAD, 2005). She also asserts that the most difficult decision confronting chief executive officers these days is not whether to do R&D in China, but where and how (321). More TNCs are also building R&D establishments in China in anticipation of the emergence of new technologically innovative directions there (Sun, 2003; Sun et al., 2006). 'Spatial fix' in the R&D activities follow the similar capitalistic logic of incorporating new spaces, but the locations patterns are different from labor intensive activities.

Since external capital is driven to China from multiple sources and by multiple imperatives—from seeking lower labor costs to seeking future markets or innovations—regions with better innovative resources or better national market access such as Beijing and Shanghai are in more favorable positions to leverage and harness the external capital. Regions dominated by labor-intensive export assembly are in far less powerful positions despite their evident growth. These differences may be found both between megacity regions and within each city region. Metropolitan centers have a more educated workforce, a more diverse economic structure, more access to local, national or international markets, and more competition from the domestic technological players. They also are more influential with Chinese policy makers and therefore able to extract disproportionate public resources and political preferences. Since 2003,

the Chinese central state has shifted its policy priorities from rewarding labor-intensive export to rewarding indigenous innovation. Those enterprises within the national metropolitan areas are in a better position to take advantage of the changing policy framework. With the robust indigenous R&D investment, the metropolitan areas have more leverage to attract high-tech foreign investment.

Given the diversity of their industrial structure and global pipelines, these three regions are not competitors in a zero-sum game for external resources. Together they provide complementary services for domestic and international firms. We should expect a more or less concurrent rather than a substituting pattern of growth among them.

5. Territorialization and technological dynamism

If each region is territorialized in a unique way, questions are raised on which pathway is more technologically dynamic. Here we need to look at the roles and relationship between foreign and domestic firms and their behavior in technological investment. Past research has shown that foreign firms have established marketing networks and they are different from domestic firms in market orientation, business strategies and technological capacity. Yet, territorialization implies a local articulation process that may induce a certain forms of convergence within a region among firms from different origins. Our second hypothesis is made by the following subhypotheses.

1. Base on existing literature, we expect that foreign-affiliated companies are more capital intensive and more involved in exporting than domestic Chinese firms regardless of where they are. But they are not necessarily more technologically dynamic.
2. Depending on locations, domestic and foreign-owned firms may display some forms of convergence in technology investment as both foreign and domestic capital choose similar locations for comparable high- or low-tech activities.
3. Regions specialized in low-end assembly may have limited potential to upgrade their technological activities. China's expanding role in the global ICT industry is achieved through better endowed regions participating in global ICT system rather than by *in situ* upgrade.

The differences between foreign-owned and domestic companies in developing countries have been commonly noted. Foreign enterprises are generally associated with better capital provision, higher labor productivity, technological superiority and greater export competitiveness. They may or may not have close interactions with domestic capital. Research on China's trade and export sectors has identified a dualistic model wherein highly competitive industry in China is dominated by imported technology and foreign affiliates. Some observe that the foreign affiliates are segregated from other domestic sectors and thus have a limited impact on local production and the diffusion of technology in China (Huchet, 1997; Lemoine and Unal-Kesenci, 2004; Wang, 2006). Zhou (2008b) has debunked the dualistic model by pointing out that China's most successful high-tech enterprises have extensive links with foreign-affiliated companies even if they target exclusively the domestic market. In this research, we examine the extent of differences between domestic and foreign-affiliated companies and how such differences hold across regions.

The literature has little to say on a regional convergence between foreign and domestic companies in developing countries. If we envision a powerful territorialization process in which different types of external capital deliberately select locations within China to accomplish their objectives, convergences among foreign and domestic firms are conceivable. After all, local production networks and institutional environments condition both the formation of global pipelines and the development of local buzz. More R&D intensive foreign capital is more interested in locales with better human resources and R&D infrastructure. Export-oriented capital sought out places with existing supply networks to lower the costs and ensure timely delivery.

Let us consider the relationships between technological dynamism and regional reliance on TNCs or export. Here the links are also ambiguous. On the one hand, TNCs are typically thought to be the technological leaders in developing countries (Pack, 2000; Fromhold-Eisebith, 2002), so regions with extensive TNC involvement should enjoy technological advantages. On the other hand, it has been also widely acknowledged that TNCs' investment in developing countries is driven primarily by their search for cheaper, both skilled or unskilled, labor and fresh markets, not by the desire of transferring of core knowledge (Malecki, 1991). Unless the localities have the leverage or human resources to induce high-tech R&D investment from TNCs, there is little reason for TNCs to do so. For developing regions, it had been thought that the key to attract more high-tech investment from TNCs is the promise of market access. China has practiced since the 1980s the strategy of 'technology in exchange to market access', which entails promises of market access through technology transfer to mandatory local partners in joint ventures, but with poor results (Wang, 2006). It turns out that TNCs could easily avoid transfer core technology if the local partners in joint ventures are not competent. What really has set in motion for the TNCs technological spending in China, in addition to attraction of low cost engineers, was the emergence of credible competition from both local firms and other TNCs. TNCs will increase their R&D spending in China if they realize that unless they do so, they risk of losing market share to others (Walsh, 2007; Chen, 2008b). In short, the presence of others, including indigenous enterprises with strong R&D investment is the most important leverage to attract foreign R&D. Conversely, if the region lack indigenous firms with heavy R&D focus, it would be hard to convince external firms to invest R&D in the region.

A related question is the relationship between technological dynamism and export. Here the literature is plentiful, though without consensus. The well-known East Asian development model argues that export industry is the driving force for technological upgrade and economic growth in South Korea, Taiwan, Hong Kong and Singapore (Haggard, 1990; Hobday, 1995). The fly geese model expects the similar sequence. Yet, others question whether export alone explains the economic achievements of these economies (Webber and Rigby, 1996). Research has shown that indigenous and sometimes state-sponsored R&D efforts have also played key roles in fueling industrial upgrade in Taiwan and South Korea (Johnson, 1987; Kim, 1997; Hsu, 1997; Fields, 1990). Similarly, studies on the widespread practice of building export-processing zones in developing countries have found that in some cases the zones have had extremely limited technological benefits for the local economies, as the main purpose of these zones has been to exploit cheap labor or land (Malecki, 1991, 231). Unfortunately, studies of successful 'dragon' economies typically are conducted at the national level and concerned mainly with national policies; they hardly ever pay attention to regional knowledge bases. In the case of China, however, we have the opportunity and indeed

the obligation to examine these questions at the regional scale. If the regions specializing in export are found to exhibit the greatest technological dynamism, it is reasonable to argue that industrial upgrade led by export is the driving force behind China's technological progress, as suggested by the East Asia model. But if this is not the case, it would suggest that other processes are more important. We may conclude that China's increasingly sophisticated roles in the global ICT industry are not driven primarily by *in situ* upgrade, but by the participation of technological regions with a higher technological capacity.

Please note that we used the term technological dynamism, rather than innovation in this study. There is a vibrant debate since 2004 on whether Chinese firms are innovative (Gilboy, 2004; Steinfeld,2004; Ramo, 2004; Alcorta et al., 2008). In our view the evaluation is premature as Chinese manufacturing industry is not only highly dynamic, but also regionally differentiated. We largely agree with the conclusion reached by Alterburg et al. (2008). They suggest that China has yet to be involved in cutting-edge innovation, but is rapidly building innovative capacity and has a good prospect in making the transition from production to innovation. Given that China has started from a low technology base as recently as in the 1980s (Zhou, 2008a), it is in a stage of capacity building, which by definition involves mounting effort and investment with only limited visible results. Other scholars or industrial observers have noted that China's leading manufacturing firms are enthusiastically invested in innovative efforts that have the prospect to challenge global leaders (Zeng and Williamson, 2003; Fan, 2006; Boston Consulting Group, 2009). Our data are based on random samples, and are better at showing average regional dynamics than they are at evaluating performance of individual leading firms. The real question for us is the technological dynamism at the regional scale, i.e. whether enterprises in a region are motivated to, and capable of sustained investment into technology. These differences will generate an accumulative effect on regional innovation capacity even if at present time, the evident technology breakthrough is still limited.

6. Methodology

The research for this article was conducted by a team of researchers employing both qualitative and quantitative methods. The quantitative data came from a multiregion firm survey conducted in 2006–2007. The sample was drawn from the database maintained by the National Bureau of Statistics of China (2006) from their 2004 economic census, with an annual update. This census is by far the most comprehensive survey of economic units in China. Most significantly, it incorporates service sectors for the first time. The census also attempted to include many smaller companies, which are traditionally overlooked as well. Our survey was conducted by a national survey company affiliated with the Bureau of Statistics. The survey of Shenzhen and Dongguan was conducted between October and November 2006, and the surveys of Beijing, Shanghai and Suzhou were conducted in the spring of 2007. We proportioned the sample size based on sector and regional information provided by the Bureau of Statistics database, and made adjustments to make sure the sample size was larger than 30[2] in all

2 In Suzhou, the software sample is only 20 because of the small number of software companies there. All other sample sizes are larger than 30.

Table 1. Sample firm distribution

Region	Hardware sector				Software sector	Total sample
	Hardware total	Computer/comm. equipment manufacturing	Electronic parts	Semi-conductor		
Beijing	100	40	30	30	180	280
Shanghai	110	30	50	30	120	230
Suzhou	157	47	80	30	20	177
Shenzhen	151	55	96	0	70	221
Dongguan	115	40	75	0	0	115
Total	633	212	331	90	390	1023

but one subcategory. The survey questionnaires were separated into hardware manufacturing including manufacturing of computer/communication equipment (Chinese SIC 401 and 404), semiconductors (SIC 4052 and 4053), electronic parts manufacturing excluding semiconductors (4051, 406) and software (SIC 62). Altogether, 1,023 companies were surveyed, including 633 hardware companies and 390 software companies. Table 1 shows the sample size distribution of sectors and regions.

The survey followed a standard procedure. The surveyors contacted senior executives in each individual firm in the Bureau of Statistics database to ask for an interview. As an incentive, the survey company provided for free an unpublished research report for the ICT industry based on the 2004 national census. If rejected, the surveyors moved on to the next firm until the required sample size was reached. In Shenzhen and Dongguan, the survey was conducted through on-site visits by trained surveyors. For the other regions, it was conducted by a mix of phone calls and on-site visits. The individual questionnaire usually took 1–1.5 hours to complete. After the survey was finished, a supervisor made contact with 95% of those surveyed to verify the procedure. We also had our team members accompany the surveyors on some sites to ensure quality. Overall, we are highly satisfied with the professionalism of the survey company and the resulting quality and consistency of this difficult firm-level survey.

Each researcher also conducted follow-up interviews with executives of selected companies and interviewed local government officials in the regions to explore the firms' or regional histories and rationales for their actions and performances. We have each conducted research in our respective regions for years, and the considerable expertise and local contacts that we accumulated made our interview contacts easier. The interviews took place in the three summers of 2006–2008.

We tested the survey respondents against the distribution of foreign-affiliated and domestic firms in the national database (Table 2). We found that in the hardware sector there was an oversampling of domestic firms at the 0.05 significance level (z-score 2.55) only in Shenzhen. In the software sector, there was an oversampling of domestic firms at the 0.05 significance level (z-score 2.25) in Beijing and at the 0.10 significance level (z-score 1.85) in Shenzhen. Otherwise, there were no significant statistical differences between the samples and the database.

Table 2. Sample representative test for ownership

	National database			Survey sample data			
	No. of firms in the database	Domestic firm (%)	Foreign-affiliated firms (%)	Sample size	Domestic firm (%)	Foreign-affiliated firms (%)	*Z*-score (domestic)
Region (hardware)							
Beijing	1516	79.13	20.88	100	82.00	18.00	0.75
Shanghai	1733	57.37	42.62	110	50.00	50.00	−1.55
Shenzhen	2992	57.13	42.82	151	66.89	33.11	2.55
Dongguan	1992	21.63	78.37	115	21.74	78.26	0.03
Suzhou	1734	34.21	65.79	157	30.57	69.43	−0.99
Region (software)							
Beijing	6224	80.96	19.04	180	86.67	13.33	2.252
Shanghai	3448	62.79	37.21	120	66.67	33.33	0.901
Suzhou	297	66.33	33.67	20	65.00	35.00	−0.125
Shenzhen	1441	71.13	28.87	70	80.00	20.00	1.855

Foreign-affiliated firms include wholly foreign-owned firms, joint-ventures and subsidaries.

7. Research settings: historical and geographical contexts

Before we launch into statistical analysis, it is essential to put these regions in their historical and geographical contexts. The Pearl River Delta where Shenzhen–Dongguan is located was the first to be brought into the global orbit of capital accumulation. Its geographical proximity to Hong Kong and extensive social connections with the capitalist enclave made it an attractive choice in 1979 for special autonomy status designed to move it 'one step ahead' of other regions in the country through foreign capital investment, promotion of exports and development of an open market economy. It was in this special context that Pearl River Delta developed its local buzz and positioned itself in the global pipeline of the ICT industry. In the early period of the 1980s, much of the foreign investment that flowed into the Shenzhen came from Hong Kong and then spilled to nearby Dongguan; its purpose was primarily to develop the area as an outlet to accommodate small-scale and labor-intensive manufacturing facilities outsourced from Hong Kong. The relocated manufacturing activities included the production of garments, shoes and toys and other export-processing activities. Since the mid-1990s, however, both the sources and types of foreign investment have become increasingly diversified (Zhao and Zhang, 2007). Although Hong Kong has remained the leading source of capital overseas, its share has declined significantly, and the balance has been picked up by other countries and regions. In Dongguan, for instance, the share of Hong Kong investment has dropped from 84% in 1996 to less than 50% in 2002, and the balance has been picked up by Taiwan, Japan, Singapore, USA and South Korea. This shift in sources of foreign investment has been accompanied by a structural change in industrial production characterized by the dramatic growth of the electronics industry. By 2000, Dongguan had become one of the largest electronic industry production sites of the world, producing over 40% of the world's computer cases and computer magnetic heads, 30% of computer disk drivers, 20% of

scanners and mini-motors, 16% of keyboards and 15% of computer motherboards (McGee et al., 2007, 101). In a similar manner, Shenzhen has actively pursued the development of the electronics industry since the mid-1990s, originally focusing on export processing and more recently turning toward the development of innovation and research and development capacity. By 2007, Shenzhen was producing 15.8% of China's electronic industrial output and 17% of the country's software, which ranked first and second respectively among all Chinese cities. Shenzhen now harbors some of the leading and largest ICT industrial enterprises in the country, including Huawei, ZTE, Skyworth, China Vanke, Konka and TCL (Wang and Lin, 2008).

Shanghai–Suzhou is the core of the larger Yangtze River Delta which has been China's traditional economic center in the modern era, extended from Shanghai to southern Jiangsu and north Zhejiang provinces. Shanghai enjoyed greater human resources and capital investment than the rest of China during the colonial period and socialist China. Before the Chinese reforms in the late 1970s, Shanghai was China's largest economic center and particularly strong in state-owned enterprises (SOEs) in manufacturing. After a brief slowdown following the reforms, Shanghai regained its leading status after 1992 by shifting its focus from SOEs to attracting foreign investment, particularly for capital-intensive projects (Wei and Leung, 2005). Foreign capital flooded into Shanghai due to its earlier colonial reputation as China's most westernized city and its extensive linkages with China's domestic economy (Zhao and Zhang, 2007). Shanghai was able to develop diverse and dynamic ICT sectors. It hosts some of China's most technically advanced large companies such as Shanghai Alcatel, Huahong-NEC, and has the fastest growth in the mid-2000s. The global pipeline in Shanghai is more connected with capital-intensive operations in Taiwan and elsewhere. For example, Shanghai boasts China's largest semiconductor manufacturing capabilities with Semiconductor Manufacturing International Corporation (SMIC) and Huahong-NEC, and almost all of the firms in the semiconductor sector there have strong connections with Taiwan such as SMIC, Shanghai Grace Semiconductor Manufacturing Co. Ltd, Taiwan Semiconductor Manufacturing Company Ltd (TSMC Shanghai). Most of such manufacturing facilities rely on imported technologies (SHIC and SHICA, 2008).

Suzhou had been an ancient capital of China and one of the pre-industrial world's great cities; it was known for its silk industry and historic landscape. The city has a long history of indigenous light industry development. Since the reforms in 1978, its development has been characterized by local state-directed township and village enterprises (TVEs). Its success is credited to local state corporatism and urbanization/development from below (Ma and Fan, 1994; Oi 1999). However, since the early 1990s, Suzhou has moved from domestic-centered development toward externally driven development through attracting foreign investment, spearheaded by the China–Singapore Suzhou Industrial Park, Suzhou High-Tech Zone and Kunshan Economic and Technological Development Zone (Wei, 2002). Given its proximity to Shanghai and business-friendly and competent local states, Suzhou has become a major destination of foreign investment, especially Taiwanese investment in information technology (Zhao and Zhang, 2007), including BenQ, Samsung, Solectron, Philips and AUO. The megaregion of Shanghai–Suzhou has enjoyed the most spectacular growth in high-tech industry during the 1990s and 2000s was a cause for national admiration. A number of local cadres in Suzhou were appointed by the Chinese central government to

go elsewhere in the hope of replicating Suzhou's success. The peril of external dependency, though recognized early, was put on the backburner.

Beijing is China's political capital and center for national decision making. The city is not a favored site for manufacturing activities due to its chronic water shortages and the strictest migration controls within China. Its economy, although diverse and strong, is compared unfavorably to either Shanghai–Suzhou or Shenzhen–Dongguan. Yet Beijing has an unparalleled advantage in human resources, as it hosts the largest number of premier universities and research institutes in China (Zhou, 2005, 2008a; Chen, 2008a). Its edge in human resources sparked China's earliest wave of indigenous, competitive high-tech companies in China's first and largest high-tech park—Zhongguancun, northeast of Beijing (Zhou, 2008a). Zhongguancun was China's birthplace for nongovernmental high-tech companies in the 1980s. It became known as China's 'Silicon Valley' given its culture of entrepreneurial startups and intense interactions among enterprises, universities, and research institutes. After producing China's first group of personal computer manufacturing companies such as Lenovo and Founder in the mid-1990s, Beijing also became the birthplace of China's internet startups in the late 1990s and early 2000s, with companies such as Baidu, Sina, Sohu, among the top internet companies in China. Other large state-owned technology companies such as China Mobile, China Telecom, Datang are also the national or international heavy weights in telecommunication sector. Foreign capital came to Beijing particularly for the political access and human resources it offered. Top technological giants, such as Microsoft, IBM, Intel and Google, all chose Beijing as the site of their largest R&D operations in China (Chen, 2008b). Beijing is particularly strong in the new economy. An internet survey released in July 2008 found that Beijing hosts 20.4% of internet domain names in China, with Shanghai a distant second at 12.7% (CNNIC, 2008). What is truly amazing is that Beijing's percentage declined only slightly from 2004 (24.3%) even though the total number of domain names in China leaped from 0.38 to 14.8 million during the same period.

Since the mid-2000s Beijing has attracted a large number of overseas returnees, many of whom were educated in Zhongguancun (Chen, 2008a; Zhou, 2008a). These returning entrepreneurs have created vital technological and venture capital links between Beijing and other innovative hotpots such as Silicon Valley in California (Saxenian, 2007). The strength of Zhongguancun's US connections is highlighted by a 2008 American study that the top undergraduate alma maters of US Ph.D. degree earners in 2006 were not American or European universities but Tsinghua followed by neighboring Peking University in Zhongguancun! The University of California at Berkeley had to settle for third in this ranking (Mervis, 2008). Of course, if only a small percentage of these bi-culturally educated Chinese returned to Zhongguancun, it would be quite significant for China's high-tech industry. Companies started by returnees include most major internet companies, and a number of semiconductor design companies such as Vimicro, a leading global supplier of multi-media chips used in computer cameras.

While companies in Beijing are better positioned in R&D than are companies in Shanghai–Suzhou and Shenzhen–Dongguan, they have a much less developed manufacturing base, so they have to engage with firms in above places for production. Beijing is also reputed to be the most bureaucratic of all three city regions. In addition, Beijing companies tend to rely more on governmental relationships and purchasing than do their counterparts elsewhere. Beijing's ICT industry is decisively domestic oriented.

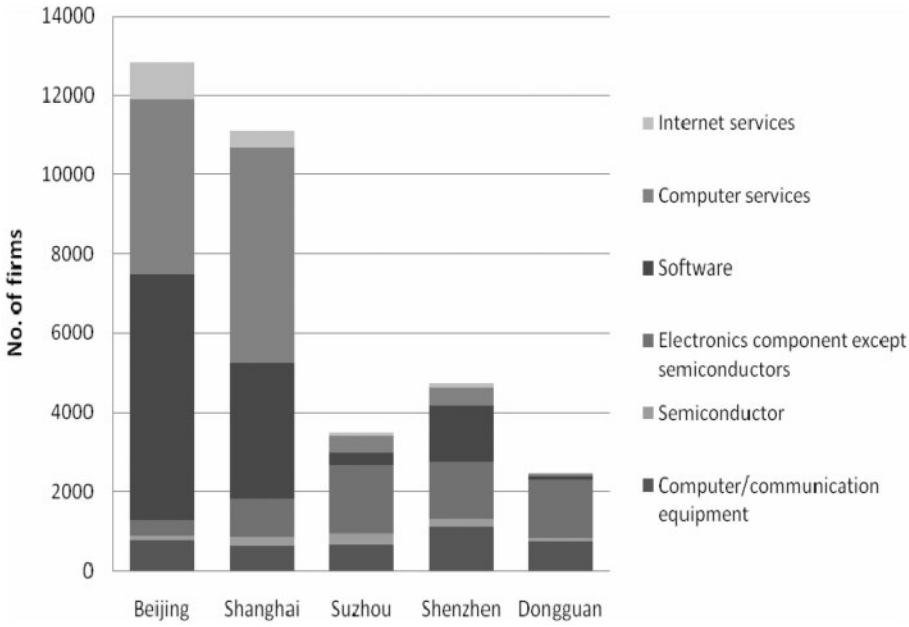


Figure 2. ICT sector structure in five regions.
Source: Bureau of Statistics enterprises database (unpublished).

8. Regional industrial structure and ownership

Figure 2 is based on the Chinese economic census database and presents the number of firms in each ICT subsector across five regions.

The figure shows that Beijing and Shanghai are in a class of their own: they host the largest clusters of ICT firms in most diversified sectors. Beijing is dominated by software and computer service companies, and it is also the center of internet services. Shanghai is less software heavy, but it has a larger number of computer service companies. Shenzhen—another national-level metropolitan area—has significantly fewer firms, though still considerable sector diversity. In contrast, both Suzhou and Dongguan, as satellite industrial clusters, are heavily dominated by hardware firms.

Within the hardware sector, the national-level metropolitan locations (Beijing, Shanghai and Shenzhen) are stronger in semiconductors and computer/communication equipment manufacturing—which is likely to be more capital intensive—than in electronic parts, which dominates Suzhou and Dongguan. Suzhou and Dongguan's strength in electronic parts indicates that they have more extensive manufacturing supply networks. Shanghai and Suzhou have more firms engaged in capital-intensive semiconductor manufacturing than do other places, reflecting regional specialization. As stated in hypothesis 1(a), vast sector diversity exists among China's ICT industrial hubs. Such diversity is also apparent in the ownership structures of the regions.

9. Ownership and global connections

Figure 3 shows the ownership distribution in these five regions. Beijing is dominated by domestic companies in both the hardware and software sectors. Shanghai and

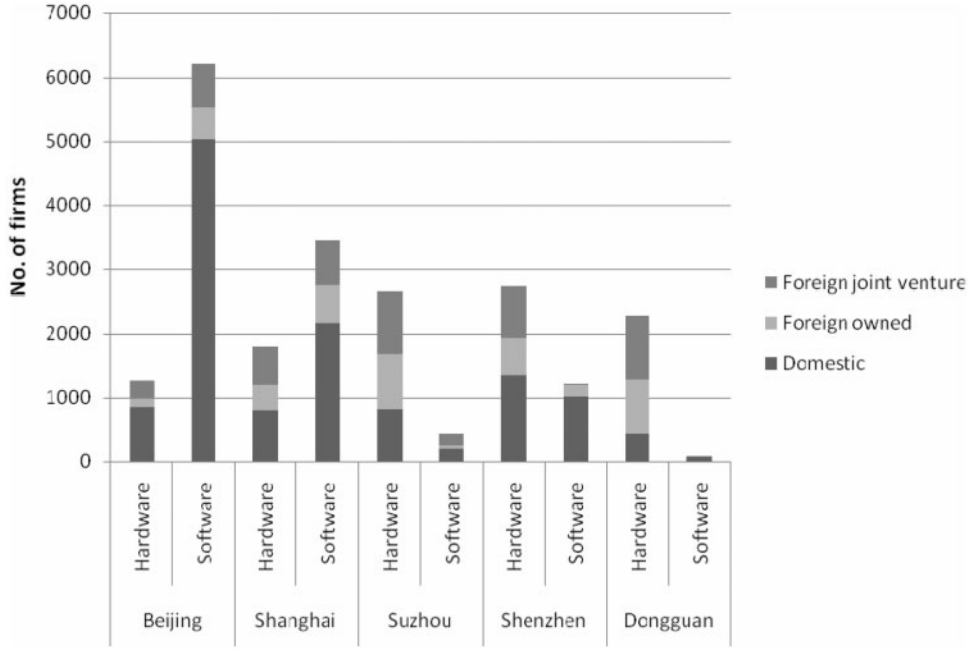


Figure 3. Ownership distribution in hardware and software sectors (service firms are excluded since survey was not conducted on these firms).
Source: Bureau of Statistics enterprises database (unpublished).

Shenzhen's hardware sectors are almost evenly split between domestic and foreign-owned or joint-venture firms, though domestic firms are more important in the software sector. Suzhou and Dongguan have very few software firms, and their hardware sectors are dominated by foreign-owned or joint-venture companies. As foreign-owned or joint-venture firms are a lot larger than domestic firms in the hardward sector—they average 1116 employees, while domestic firms average 510, based on our survey—it is likely that foreign-affiliated enterprises are the majority employers in the hardware sector both in Shanghai–Suzhou and Shenzhen–Dongguan.

The figure also shows that the large metropolitan centers—Beijing, Shanghai and Shenzhen—have better resources or conditions for domestic companies than their satellite suburbs Suzhou and Dongguan. And Suzhou has better such conditions than Dongguan. Although Suzhou is a satellite of Shanghai, it has considerably better urban/industrial infrastructure and a more educated labor force than Dongguan, and consequently more local firms. Since all these areas have a large number of foreign firms, the size of the locally owned firms indicates the strength of local capital accumulation. In her survey of Malaysian manufacturing companies, Leslie O'Brien (1993) suggested that locally owned or controlled companies were more likely than their foreign counterparts to forge links with their national economies and to modify their products to suit local conditions. Alterburg et al. (2008) also note that national chain can be more conducive to develop innovative capacity because the power relationship with customers tends to be more symmetrical and more intimate (329). We argue that domestic enterprises constitute a vital part of local buzz to synthesize and generate knowledge from foreign and local sources. As stated in hypothesis 1 (a and c),

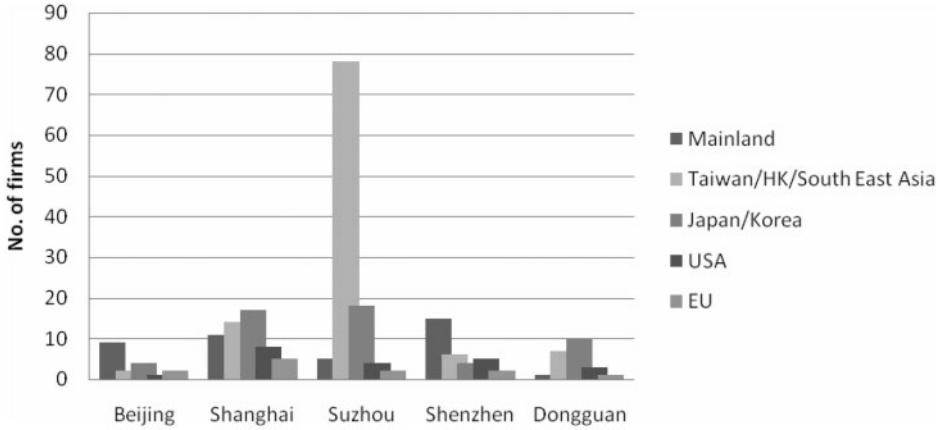


Figure 4. Headquarters of foreign-owned firms.
Source: Firm survey sample.

metropolitan locations offer better resources and are more able to mediate the power relations between foreign and domestic capital and harness these resources; hence they have more resilient and diverse presence of domestic firms.

The sources of foreign ownership also differ among regions. We focused on the hardware sector where foreign ownership is more pronounced. Based on our survey (we do not have access to country ownership information from the national database), Figure 4 shows the locations of the headquarters of foreign-owned or joint-venture companies. About 20% of these companies have their headquarters in mainland China. These tend to be joint venture companies or companies that register abroad to take advantages of the tax and other benefits for foreign direct investment, but confine most of their business to China. Most of these firms are found in Beijing, Shanghai and Shenzhen. Shanghai has the strongest and most diverse presence of foreign-affiliated firms. Suzhou is dominated by Asian capital, particularly from Taiwan. Asian capital also dominates Dongguan, to a less extent. Other metropolitan regions do not feature the dominance of a single foreign source. Japanese and Korean investments favor Shanghai–Suzhou, so do American and European investments. Diversity of external capital sources is important since it enhances the bargaining position of the region to attract more desirable investment. By this score, Shanghai clearly has the most favored location. While the absolute number of firms headquartered in the USA or Europe is relatively low, most Southeast Asian companies are subcontractors for these firms, so the total capital presence from the West is not low. The relationships between foreign capital from different origin and technological changes are complex and will be analyzed by different papers.

10. Patterns of growth among regions

Given their diverse industrial structures and ownership compositions, it would be reasonable to expect temporal differences in the growth patterns of the five regions. But this is not the case. Figures 5 and 6 show the years of the establishment of hardware and software companies based on our survey. Both figures show striking consistency in the

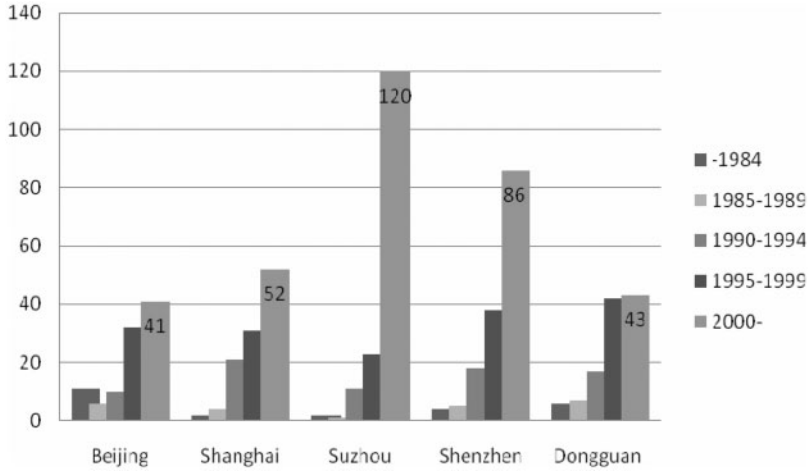


Figure 5. Years of establishment in hardware sector among surveyed firms.
Source: Firm sample survey.

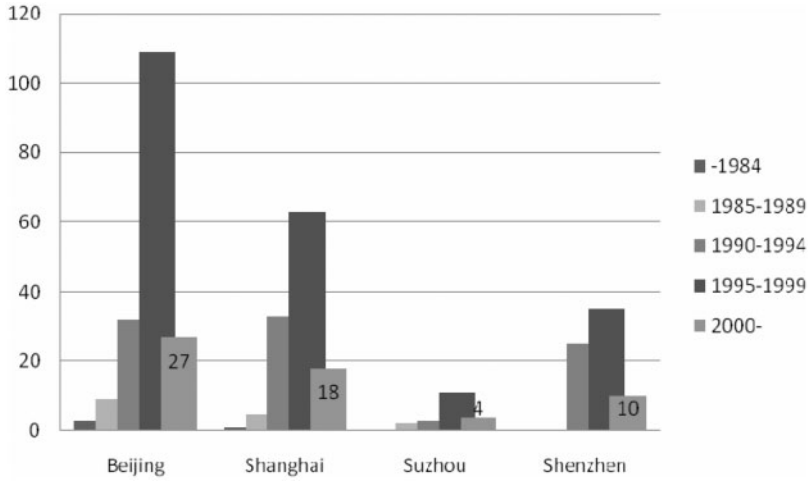


Figure 6. Years of establishment in software sector among surveyed firms.
Source: Firm sample survey. (side-by-side with Figure 5, if possible).

growth patterns across all five regions. As outlined by hypothesis 1(b), this concurrent growth is a result of different types of foreign capital arriving in China simultaneously to address different aspects of accumulation needs. Very few companies that exist today in these regions can be traced back to the 1980s—the ground zero of China's ICT industry. Except the extremely small number of state-owned enterprises, China's earliest competitive ICT companies were born after the mid-1980s, and few of them survived to this day (Zhou 2005, 2008a). The growth started in the early 1990s and accelerated with exceptional growth periods in the late 1990s–2000s, especially for hardware manufacturing in the Shanghai–Suzhou and software in Beijing. Beijing's hardware development has largely been steady given that Beijing is not a favored location for

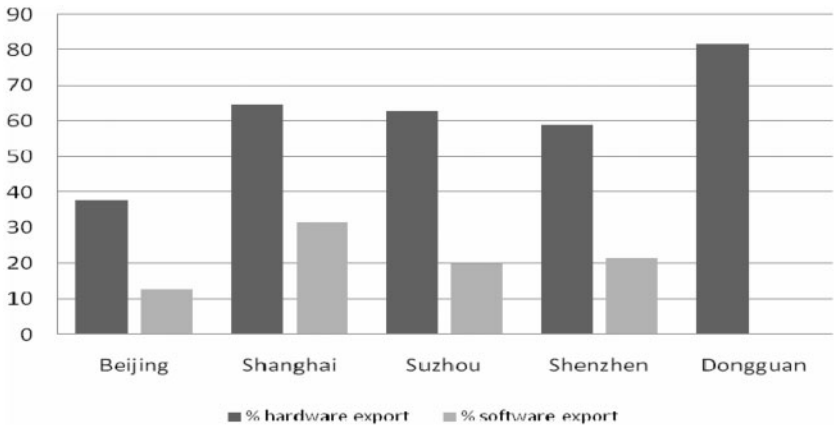


Figure 7. Percentage of companies with export businesses.
Source: Firm sample survey.

hardware production as mentioned above. For software companies, the biggest across-the-board gains were in the late 1990s, especially in Beijing; then new company creation slowed down in all regions in the 2000s. While the number of firms cannot tell us much about changes in revenue or profits, it does tell us whether the climate is favorable or unfavorable for start-up. Overall, Figures 5 and 6 suggest that a favorable climate emerged in the latter half of the 1990s to the time of the survey. It was in this decade that China became a desired place for diverse ICT capital, from manufacturing to R&D. Our survey also shows that in 2006–2007 the average annual growth rate among all hardware firms was 14.4%. All regions enjoyed double-digit growth. In Shanghai, the growth rate reached 20%. This was clearly the golden period for growth. Figures 5 and 6 suggest that it is unlikely that the three regions are engaging in zero-sum competition for external resources. Their relationship is likely more complementary than supplementary, since their growth periods more or less corresponded with each other.

11. Export and domestic market orientation

China has been the world's leading exporter of ICT products since 2006. Figure 7 shows the unmistakable prominence of export among hardware firms. Beijing is the least export-oriented of all five regions, but even in Beijing, close to 40% of hardware firms are involved in export. In Dongguan over 80% of companies engage in export. In Shanghai–Suzhou and Shenzhen about 60% of companies do. In contrast, the software sector remains largely domestically bound. Only in Shanghai are more than 20% of software companies involved in export. This is not surprising given the fact that China's software industry has developed largely along with China's domestic hardware industry. Sizable software export only emerged in the 2000s. It is decades later and less competitive globally than its Indian counterpart in the English-speaking markets (Zhou, 2008a).

Table 3 summarizes the number of firms engaged in export and the share of revenue generated by export for these firms. The firms are divided into foreign-affiliated and

Table 3. Export involvement among foreign and domestic firms.

Region	Total firms			Foreign-affiliated firms			Domestic firms		
	Percentage of firms has export business	No. of exporting firms	Average share of revenue from export[a]	Percentage of firms has export business	No. of exporting firms	Average share of revenue from export[a]	Percentage of firms has export business	No. of exporting firms	Average share of revenue from export[a]
Beijing	38.0	38	31.3	66.7	12	48.3	31.7	26	23.4
Shanghai	64.5	71	53.9	80	44	65.1	49.1	27	35.7
Suzhou	63.1	99	55.7	76.9	83	56.6	32.7	16	50.8
Shenzhen	58.9	89	53.5	84.4	27	70.2	52.1	62	46.3
Dongguan	81.7	94	70.9	90.9	20	74	79.6	74	70.1
Total	61.8	391	56.1	79.1	186	61.9	51.5	205	50.9

[a]The average is limited to firms reporting that they have export business.

domestic-owned companies. Foreign-affilated firms include wholly foreign-owned companies, joint-ventures and subsidaries. Domestic companies include state-owned enterprises, private or minying firms and others. We can draw several conclusions from this table.

First, exporting companies derive slightly over half of their revenue from exporting. Foreign-affiliated companies are far more likely to engage in exporting than their domestic counterparts (79.1% vs. 51.5%). They also derive a higher share of their revenue from exporting (61.9% vs. 50.9%). This is not surprising since low labor costs have been China's primary attraction for foreign investment. In other words, the chief logic of 'spatial fix' for TNCs in China is to compete in export. Foreign firms also have more established channals for export than do domestic firms. As a result, foreign affiliated firms are more oriented to export businesses.

Second, Beijing is the least dependent on export of all the regions, as measured either by the number of exporting firms or by revenue. Dongguan is almost exclusively dependent on export. Shanghai–Suzhou and Shenzhen are in the middle. On average, more than half of the revenue of all exporting firms in Shanghai–Suzhou and Shenzen is generated by export.

Third, with the exception of Dongguan, export activities are by no means the exclusive concerns of ICT companies. Most of Beijing's companies are domestic oriented, and so are many companies in Shanghai, Suzhou and Shenzhen. This suggests that firms in these regions, while deeply emmeshed in the global division of labor, are also highly concerned with the dynamics of China's internal market. Our interviews confirmed that companies in Shenzhen–Dongguan and Shanghai–Suzhou were increasingly interested in expanding their domestic market shares even before the financial crisis of 2008. Local governments in Suzhou and Dongguan are moving in the same direction. This suggests that these industrial hubs are not only the spatial frontiers of global capital, but also the key and growing players in China's accumulation of capital.

Fourth, the most interesting finding of Table 3 is the level of regional convergence among domestic and foreign firms. The foreign firms in Beijing are twice as likely as their domestic counterparts to engage in exporting, and a higher share of their revenue

comes from export. But they are also less likely to engage in exporting than are foreign firms in other regions. Foreign firms in Dongguan, on the other hand, are exclusively involved in exporting, just like the domestic firms there. Other regions are in the middle. The exception is Suzhou, where we found a smaller percentage of firms engaged in export. This has to do with the highly developed regional supply chain. Firms in Suzhou are selling intermediate goods domestically for eventual export. Overall, Table 3 reveals that foreign-affiliated firms strongly favor export, as stated in hypothesis 2(a), but that they show a subtle but noticable convengence with their Chinese counterparts in the same region, as indicated in hypothesis 2(b).

By now it should be clear that the three Chinese high-tech regions—Beijing, Shanghai–Suzhou and Shenzhen–Dongguan—are situated at different positions in the global production system and perform different functions for the domestic market. Among them, Beijing, Shanghai and Shenzhen as top national metropolis have robust and diverse industrial structures, with particularly strong presences of domestic firms and orientation to the domestic market. Their satellite hubs, in contrast, are highly dependent on global industry in terms of capital and markets. Marked differences also exist among the three metropolitan centers. Beijing is least tied to foreign capital and markets, but nevertheless has one of China's largest number of ICT companies, with an emphasis on software and computer services. Shanghai and Shenzhen feature a mixed ICT economy, with a solid blend of domestic and foreign-affiliated companies.

12. Regional technological dynamism

Let us now look at how regional technological dynamism relates to industrial structure, ownership composition and market orientation. We will use three conventional measures of technological dynamism: labor productivity, R&D investment and new products[3]. Together they should measure the technological level of the firm, and their commitment to technology changes.

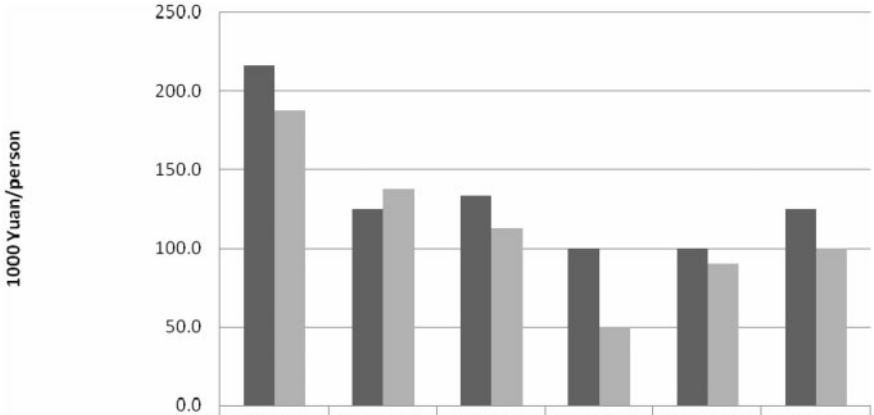
12.1. Labor productivity

Labor productivity is often used to indicate the technological level of an operation. The more labor-intensive regions have lower labor productivity than capital-intensive or technology-intensive regions. Figure 8 shows the median productivity of the five regions.

We used median productivity instead of mean productivity because there are a couple of outliers that caused dramatically large standard derivations in Shanghai and Suzhou. Figure 8 shows that Beijing has the highest median labor productivity. Shanghai and Suzhou are in the middle, and Shenzhen and Dongguan are at the bottom. Shenzhen is lowest, because it has more small companies than Dongguan, which is dominated by large factories.

We found that foreign-affiliated firms have substantially higher mean labor productivity than domestic firms (729.4 vs. 184.8 thousand yuan per person). But if

3 We decided against using patent statistics as an index of technological innovation because the vast majority of patents registered in China are by foreign-affiliated companies from existing patents registerered elsewhere. Patent registration is thus a poor indicator of original technological capacity.



	Beijing	Shanghai	Suzhou	Shenzhen	Dongguan	Total
foreign affliated firms	215.9	125.0	133.3	100.0	100.0	125.0
domestic firms	187.5	137.5	112.5	50.0	90.0	100.0

Figure 8. Median labor productivity among regions.
Source: Firm sample survey.

we use the median to eliminate the influence of outliers, the differences shrink sharply (125 vs. 100 thousand yuan per person). Within each region (with the exception of Shanghai), foreign-affiliated firms have slightly higher median labor productivity than their domestic counterparts. But across regions, median labor productivity is negatively associated with the portion of foreign ownership and the intensity of export. Beijing, the least foreign-oriented region, has the highest median labor productivity, and Dongguan and Shenzhen, the most foreign-oriented places, have the lowest. The regional convergences among foreign and domestic firms in median labor productivities are quite evident in Figure 8. Only in Shenzhen is there a major difference between domestic and foreign companies.

12.2. R&D input

We also examine R&D investment at the firm level. Chinese companies are known to invest little in R&D. Less than 1% of their revenue is invested in R&D on a national average (MOST, 2006). We found that ICT firms in the five regions invest a much higher percentage of their revenue in R&D, especially for the software companies (Table 4).

In hardware, the average R&D input is the highest in Beijing as measured by the percentages of employees and revenue in R&D. The two most export-dependent regions, Suzhou and Dongguan, have the least R&D investment. Shanghai and Shenzhen are in the middle; they have high expenditures in R&D but relatively low shares of employees in R&D. Among software firms, most companies have over one-third of their employees or expenditures in R&D, with the exception of Suzhou, which spent the least. Metropolitan areas are far more engaged in R&D activities than their satellites. Their greater R&D investments would mean higher levels of local buzz—the ability of firms to generate knowledge.

Table 4. R&D investment by region

Region	Hardware			Software		
	Mean % of employees	Mean % R&D expenditure in revenue	*N*	Mean % of employees	Mean % R&D expenditure in revenue	*N*
Beijing	29.67	32.05	100	53.05	44.37	180
Shanghai	13.55	19.59	110	52.42	35.92	120
Suzhou	5.31	6.86	157	35.05	8.78	20
Shenzhen	5.91	14.99	151	43.1	34.16	70
Dongguan	2.67	6.74	115			
Total	10.25	14.88	633	50.15	37.76	390

Source: Firm sample survey.

Table 5. R&D investments in foreign-affiliated and domestic hardware firms

	Foreign-affiliated firms				Domestic firms			
	Percentage of employees in R&D	No. of responses	Percentage R&D of total expenditures	No. of responses	Percentage of employees in R&D	No. of responses	Percentage R&D of total expenditures	No. of responses
Beijing	28.44	18	31	16	29.93	82	32.28	76
Shanghai	12.90	22	18.00	21	14.16	55	21.07	54
Suzhou	3.31	55	6.87	51	9.68	49	6.84	49
Shenzhen	3.45	108	14.00	108	5.56	119	15.23	112
Dongguan	1.46	32	4.19	28	2.95	93	7.4	81
Total	7.34	235	11.77	224	11.97	398	16.75	372

Source: Firm sample survey.

In comparing R&D investment between domestic and foreign-affiliated companies (Table 5), we concentrated on the hardware sector, which is China's specialization. Contrary to the conventional wisdom that foreign-affiliated firms have stronger R&D investment, we found that foreign firms overall invest slightly less than their domestic counterparts in R&D, as measured either by share of employees in R&D (7.34 vs. 11.97%) or by R&D expenditure (11.77 vs. 16.75%) among all surveyed companies (Table 5). The result is not surprising since TNCs are more likely to rely on global headquarters and R&D centers outside China for their product development. In contrast, Chinese firms have to rely on internal R&D, so they have to devote more resources to R&D (Sun, 2002).

The most interesting finding in Table 5 is the virtually identical pattern of R&D investment among foreign and domestic firms in each region. This echoes the earlier finding on labor productivity. We conclude that both foreign and domestic companies assess locations based on their environments for technology investment. R&D-intensive companies choose a certain environment and assembly companies choose others,

regardless of firm origins [Hypothesis 2(b)]. We found that China's most R&D-intensive region is Beijing. Shanghai and Shenzhen are in the middle, and the export-oriented regions have the least R&D investment. Only in Shenzhen, there is a major discrepancy between domestic and foreign firms. Domestic firms view Shenzhen as a good environment for R&D, but foreign firms view it more like an assembly site, as they do Dongguan. This finding contradicts the notion that foreign firms are the leading technological investors in China. While individual foreign affiliated firms can clearly be technology leaders, as a group, they show no stronger propensity for technology investment in China than their Chinese counterparts in the same region.

12.3. Revenue from new products

R&D investment *per se* does not tell us whether such investment is effective. Our survey asked the companies to report whether they had any new products during the last year and the share of their revenue that came from new products. We again concentrated on hardware companies, since the definition of new products can be ambiguous with software companies. We found the rate at which new products are introduced in the five regions to be remarkable: over 40% of firms are producing new products the previous year. What's more, over 40% of their revenues are derived from these new products (Table 6). Beijing tops both measures by a substantial margin. We see less variation among other regions than we did with the R&D measures. Dongguan, for example, is only slightly less active in introducing new products than Shanghai, and its share of revenue from new products is virtually the same as other regions except Beijing. We conclude that to be competitive in export, firms must be able to introduce new products rapidly, even though their R&D activities may take place elsewhere.

We also found that domestic-owned firms are just as active as foreign-affiliated ones at introducing new products. Table 6 shows that the percentages of foreign and domestic firms that introduced new products in the previous year were almost identical (42.6 vs. 43.7%), so are the revenue generated by new products (41.22 vs. 42.46%). Regional pictures are somewhat complex. With the exception of Shenzhen, all foreign

Table 6. Development of new products and revenue from new products among hardware firms

Region	Total firms			Foreign-affiliated firms			Domestic firms		
	No. of valid responses[a]	Percentage of firms with new products[b]	Percentage of revenue from new products	No. of valid responses	Percentage of firms with new products	Percentage of revenue from new products	No. of valid responses	Percentage of firms with new products	Percentage of revenue from new products
Beijing	62	62	58.62	12	66.7	61.99	50	60.98	57.81
Shanghai	41	37.27	37.71	18	32.7	41.93	23	41.82	34.42
Suzhou	75	48.41	35.94	53	49.1	37.86	22	44.90	31.34
Shenzhen	62	41.06	36.67	11	34.4	27.62	51	42.86	38.61
Dongguan	34	29.57	39.99	6	27.3	52.08	28	30.11	37.42
Total	274	43.6	42.00	100	42.6	41.22	174	43.72	42.46

[a]Firms providing valid entries in reporting share of revenue from new products, including those reporting zero.
[b]The number of firms reported have new products divided by total number of firms.

affiliated firms have higher share of revenue generated by new products than domestic firms, though no clear pattern exist regarding the percentage of firms producing new products. In Shenzhen, domestic firms are far more active in generating new products and derived higher share of revenue from new products than foreign firms. Again, this provides further evidence that Shenzhen is seen as a place for innovation for domestic firms, but not for foreign firms.

We can draw several conclusions from all three measures of technological dynamism. First, Beijing is consistently the most technologically intensive region, with substantially higher median labor productivity, R&D investment and new products than the other regions. This can be attributed to Beijing's human resources and especially to Zhongguancun as China's 'Silicon Valley', with its intensive R&D activities. Second, regions dominated by export and foreign-affiliated companies achieved no advantages in technological performance among the three elite hubs. In fact, high dependency both on export and on foreign capital at the regional level is associated with lower R&D investment and median labor productivity. The negative association is less pronounced on producing new product, but it does not disappear. These results strongly suggest that, contrary to the model of export-led technological upgrade, China's exporting region is dominated by low-skill, labor-intensive activities, which do not lend themselves easily to high-tech investment. Companies in the labor-intensive sector have limited incentives or few resources to move up the value chain even if they offer competitive prices. Foreign or domestic firms interested in higher technology shun exporting regions. They choose to locate in Beijing or Shanghai, and for domestic firms only, Shenzhen, for better human resources and more technology-intensive production networks. Third, foreign-affiliated firms in their operation in China do not have higher propensity for R&D investment. Indeed, they achieved only slightly better median labor productivity than their Chinese counterparts, and they are hardly distinguished from their counterparts within the same regions on any measure of technological dynamism. The territorial convergences in technological behavior are highly consistent for all three measures.

While our findings do suggest that technological upgrades are underway in all the regions, since they all have higher R&D investment than the national average and are all producing new products, China's rapid expansion into more sophisticated ICT products clearly has more to do with the better-endowed regions becoming part of the global system than with *in situ* upgrade in export-driven regions. It is the Shanghai-Suzhou that provides the most capital-intensive production for the global ICT industry, and it is Beijing that boasts China's leading R&D capacity.

13. Conclusion

We began this article by asking whether Chinese industrial spaces are dancing to the tone of 'spatial fix' from the west. What we found is that the 'music' being played in China's most important high-tech regions is a more complex and fairly local version of 'symphony'. Three most elite Chinese high-tech hubs feature distinct territorialization in domestic and foreign capital. While western capital is certainly indispensable, its supremacy over domestic capital is hardly a given at the regional level. In Dongguan and Suzhou, western capital is arguably dominant, but it acts with or through the proxy of overseas Chinese capital. In Shanghai and Shenzhen, the supremacy of western

capital is challenged by diverse capital sources and the growth of local enterprises. In Beijing—the leading technological region of China—foreign capital can best be described as a participant in a decisively domestically driven environment. China's high-tech hubs are meeting places of several sources of capital to address their different needs, and the resulting territorialities are shaped by the positions of each region in the global technological hierarchy and local capacities to mediate and harness the multiple conduits of power.

We developed two hypotheses on the divergent development of regions and convergences in technological dynamism within regions. Our data largely supported these two hypotheses. Against the conventional view that TNCs play leading roles in technological development in developing countries and that export-led growth is most conducive to technological learning, we found a strong and persistent negative spatial association between technological investment and regional specialization in TNC-led export. ICT firms in Beijing—the most domestic-oriented region—outperform others by a substantial margin on all three measures of technological dynamism. This suggests that indigenous investment in R&D is not only essential for technological performance of domestic companies. It also makes a region attractive for high-level technological investment by foreign firms. The better human resource base and competitive pressure created by technology intensive local firms provide the leverage and incentives for R&D commitment from TNCs, subverting the power of external players. The national-level metropolitan centers are better equipped to generating local buzz and achieving dynamism and resilience in the face of global volatility.

Our findings also raise serious questions about how export-oriented regions such as Dongguan and, to a lesser degree, Suzhou and Shenzhen can move up the technological ladder if they invest relatively little in R&D. As the global financial crisis hits China, these regions suffer from the full force of the financial tsunami; the impact has been most acutely felt in Dongguan, as thousands of companies closed down there in 2008. Actually, external dependency has long been recognized as a problem before 2008. With the appreciation of Chinese currency and the increase in wages since 2003, the provincial and municipal governments in Shanghai–Suzhou and Shenzhen–Dongguan have made a major effort to filter out labor-intensive manufacturing and attract high-value-added and innovative ICT industry (Lin, 2006, 48–49; Smart and Lin, 2007, 297–298). Yet moving from export to the domestic market or moving up the technological hierarchy is easier said than done. As we have shown, they require transforming the fixity of local industrial and institutional structures made for export. The generally subordinate positions of Dongguan and Suzhou in relation to TNCs give them limited leverage to counteract these capital tendencies to look for next cheapest place to move.

That is not to say that Suzhou and Dongguan cannot get out of the labor-intensive assembly trap. But they have to change the regional power equation by expanding their global pipelines. Their best hope is to collaborate more actively with the nearby metropolitan centers and expand their engagements with diverse types of capital, especially innovative domestic capital and market. Both Shanghai and Shenzhen have indigenous companies with high R&D investment. Dongguan and Suzhou have in the past neglected this engagement in favor of attracting FDI from abroad. In the economic downturn, the advantages of engaging in multiple pipelines globally and nationally have become more apparent.

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References

Alcorta, L., Urem, B., An, T. (2008) Do manufacturing firms in China innovate? *Journal of Contemporary Asia*, 38: 4560–4590.

Altenburg, T., Schmitz, H., Stamm, A. (2008) Breakthrough? China's and India's transition from production to innovation. *World development*, 36: 325–344.

Amin, A. (2000) Industry districts. In E. Sheppard, T. Barnes (eds) *A Companion to Economic Geography*, pp. 149–168. Malden, MA: Blackwell.

Amin, A., Cohendet, P. (1999) Learning and adaptation in decentralized business networks. *Environment and Planning, D: Society and Space*, 17: 87–104.

Amin, A., Thrift, N. (1992) Neo-Marshallian nodes in global networks. *International Journal of Urban and Regional Research*, 16: 571–587.

Andersson, A. E. (1985) Creativity and regional development. *Papers of the Regional Science Association*, 56: 5–20.

Arrighi, G. (2007) *Adam Smith in Beijing: Lineages of the Twenty-first Century*. New York: Verso.

Bathelt, H., Malmberg, A., Maskell, P. (2004) Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*, 28: 31–56.

Bathelt, H., Taylor, M. (2002) Clusters, power and place: inequality and local growth in time-space. *Geografiska Annaler, Series B: Human Geography*, 84: 93–109.

Boston Consulting Group. (2009) *The 2009 BCG 100 New Global Challengers: How companies from rapidly developing economies are contending for global leadership*. BCG Report. Jan. 2009, available at: http://www.bcg.com.cn/export/sites/default/en/files/publications/reports_pdf/The_2009_BCG_100_New_Global_Challengers_Jan_2009.pdf.

Brenner, N. (1998) Between fixity and motion: accumulation, territorial organization and the historical geography of spatial scales. *Environment and Planning D: Society and Space*, 16: 459–481.

Bunnell, T. G., Coe, N. M. (2002) Space and scales of innovation. *Progress in Human Geography*, 25: 569–589.

Camagni, R. (1991) Introduction: from the local 'milieu' to innovation through cooperation networks. In R. Camagni (ed.) *Innovation Networks: Spatial Perspectives*, pp. 1–9. London: Belhaven Press.

Chen, Y. C. (2008a) The limits of brain circulation: Chinese returnees and technological development in Beijing. *Pacific Affairs*, 81: 195–215.

Chen, Y. C. (2008b) Why do multinational corporations locate their advanced R and D centres in Beijing? *Journal of Development Studies*, 44: 622–644.

Chiang, H. H. (2008) The 'Flying Geese Development' model of the IT industry in East Asia. *Journal of the Asia Pacific Economy*, 13: 227–242.

Chung, C. (1997) Division of labor across the Taiwan Strait: macro overviews and analysis of the electronics industry. In B. Naughton., D. C. Washington (eds) *China Circle: Economics and Electronics in the PRC, Taiwan and Hong Kong*, pp. 164–209. Washington, D.C.: Brooking Institution Press.

CNNIC (China Internet Network Information Center). (1997–2008) *Survey Report of China's Internet Development 1997-2004*.
EIU (Economist Intelligence Unit). (2004) *China is #1 for R&D Investment*. Economist Intelligence Unit.
Fan, P. (2006) Catching up through developing innovation capability: evidence from China's Telecom-equipment industry. *Technovation*, 26: 359–368.
Faulconbridge, J. R. (2007) London's and New York's advertising and law clusters and their networks of learning. *Urban Studies*, 44: 1635–1656.
Fields, K. J. (1990) Developmental capitalism and industrial organization: business groups and the state in Korea and Taiwan. Ph.D. diss. Berkeley: University of California Editor.
Fromhold-Eisebith, M. (2002) Regional cycles of learning: foreign multinationals as agents of technological upgrading in less developed countries. *Environment and Planning A*, 34: 2155–2173.
Gertler, M. S. (1995) Being there: proximity, organization and culture in the development and adoption of advanced manufacturing technologies. *Economic Geography*, 71: 1–26.
Gilboy, G. J. (2004) The myth behind China's miracle. *Foreign affairs*, 83: 33–48.
Giuliani, E. (2007) The selective nature of knowledge networks in clusters: evidence from the wine industry. *Journal of Economic Geography*, 7: 139–168.
Haggard, S. (1990) *Pathways from the Periphery: The Politics of Growth in the Newly Industrializing Countries*. Ithaca, NY: Cornell University Press.
Harvey, D. (1985) The geopolitics of capitalism. In Gregory, J. David, Urry (eds) *Social Relations and spatial structures*, pp. 128–163. London: Macmillan.
Harvey, D. (2003) *The New Imperialism*. New York: Oxford University Press.
Harvey, D. (2005) *A Brief History of Neoliberalism*. New York: Oxford University Press.
Henry, N. (1995) The new industrial spaces: locational logic of a new production era? *International Journal of Urban and Regional Research*, 16: 375–396.
Hobday, M. (1995) *Innovation in East Asia: The Challenge to Japan*. Brookfield, VM: Edward Elgar.
Hsu, J. (1997) The historical study of Taiwan's integrated circuit industry – high technology, state intervention, and returnee entrepreneurism. *Journal of Geographical Science*, 23: 2333–2348.
Huchet, J. (1997) The China circle and technological development in the Chinese electronics industry. In B. Naughton (ed.) *China circle: Economics and Electronics in the PRC, Taiwan and Hong Kong*, pp. 254–289. Washington D.C.: Brookings Institution Press.
Ji, Lin. (2003) Jiedu woguo shoubu quyu xinjinji zhishu baogao解读我国首部新经济指数报告(Reading China's first regional new economy indices report). Jingji ribao经济日报(Economic Daily) [cited 6/20 2003]. Available frin http://curdr.pku.edu.cn/xcinwenzhang/list.asp?id=32.
Johnson, C. (1987) Political institutions and economic performance: the government-business relationship in Japan, South Korea and Taiwan. In F. C. Deyo (ed.) *Political Economy of the New Asian Industrialism*, pp. 136–164. Ithaca, NY: Cornell University Press.
Kenney, M, Patton, D. (2005) Entrepreneurial geographies: support networks in three high-technology industries. *Economic Geography*, 81: 201–228.
Kim, L. (1997) *Imitation to Innovation: The Dynamism of Korea's Technological Learning*. Boston, MA: Harvard business School Press.
Lemoine, F., Deniz, U.-K. (2004) Assembly trade and technology transfer: the case of China. *World development*, 32: 829–850.
Lin, G. C. S. (1997) *Red Capitalism in South China*. Vancouver, BC: University of British Columbia Press.
Lin, G. C. S. (2006) Peri-urbanism in globalizing China: a study of new urbanism in Dongguan. *Eurasian Geography and Economics*, 47: 28–53.
Ma, L. J. C., Fan, M. (1994) Urbanisation from below. *Urban Studies*, 31: 1625–1645.
Malecki, E. (1991) *Technology and Economic Development: The Dynamics of Local, Regional and National Change*. Essex, UK: Longman scientific and technical.
Markusen, A. (1996) Sticky places in slippery space: a typology of industrial districts. *Economic Geography*, 72: 293–313.
McGee, T. G., Lin, G. C. S., Marton, A. M., Wang, M. Y. L., Wu, J. (2007) *China's Urban Space: Development under Market Socialism*. London: Routledge.

Mervis, J. (2008) Top Ph.D. feeder schools are now Chinese. *Science*, 321: 15.
Ministry of Science and Technology (MOST, 2006). *China Science and Technology Statistical Yearbook*. 中国科技统计年鉴. Beijing: China Statistical Press.
Moodysson, J. (2008) Principles and practices of knowledge creation. *Economic Geography*, 84: 449–469.
National Bureau of Statistics of China, Economic Census office. (2006) *China 2004 Economic Census Yearbook*. Beijing: China National Statistical Press.
Naughton, B. (1997) *The China Circle: Economics and Technology in the PRC, Taiwan, and Hong Kong*. Washington DC: Brookings Institution Press.
O'Brien, L. (1993) Malaysian manufacturing sector linkages. In K. S. Jomo (ed.) *Industrializing Malaysia*, pp. 157–159. London: Routledge.
OECD. (2006) *OECD Information Technology Outlook: Information and Communication Technologies*.
Oi, J. (1999) *Rural China Takes Off*. Berkeley: University of California Press.
Oinas, P., Malecki, E. (2002) The evolution of technologies in time and space: from national and regional to spatial innovation systems. *International Regional Science Review*, 25: 102–131.
Ozawa, T. (2005) *Institutions, Industrial Upgrading, and Economic Performance in Japan: The 'Flying Geese' Paradigm of Catch-Up Growth*. Northampton, MA: Edward Elgar.
Pack, H. (2000) Research and development in the industrial development process. In L. Kim, R. Nelson (eds) *Technology, Learning, & Innovation: Experiences of Newly Industrializing Economies*, pp. 69–94. Cambridge University Press: Cambridge.
Pinch, S., Henry, N., Jenkins, M., Tallman, S. (2003) From 'industrial districts' to 'knowledge clusters': a model of knowledge dissemination and competitive advantage in industrial agglomerations. *Journal of Economic Geography*, 3: 373–388.
Porter, M. (2000) Location, competition, and economic development: local clusters in a global economy. *Economic Development Quarterly*, 14: 15–17.
Price Water House Coopers (PwC). (2008) *China's Impact on Semiconductor Industry: 2008 Update*.
Ramo, J. C. (2004) *The Beijing Consensus*. London: The foreign policy centre. http://fpc.org.uk/publications/TheBeijingConsensus.
Rigby, D. (2000) Geography and technological change. In E. Sheppard, T. Barnes (eds) *A Companion to Economic Geography*, pp. 202–224. Malden, MA: Blackwell.
Saxenian, A. (2007) *The New Argonauts: Regional Advantage in a Global Economy*. Cambridge, MA: Harvard University Press.
Saxenian, A. L., Hsu, J. (2001) The Silicon Valley-Hsinchu connection: technical communities and industrial upgrading. *Industrial and Corporate Changes*, 10: 893–920.
Scott, A. J. (1988) *The New Industrial Space: Flexible Production Organization and Regional Development in North America and Western Europe*. London: Pion.
Scott, A. J. (1993) *Technopolis: High-technology Industry and Regional Development in Southern California*. Berkeley, CA: University of California Press.
Scott, A. J., Storper, M. (2003) Regions, globalization, development. *Regional Studies*, 37: 549–578.
Segal, A. (2003) *Digital Dragon: High-technology Enterprises in China*. Ithaca, NY: Cornell University Press.
Shanghai Information Industry Commission (SHIC) & Shanghai IC Industry Association (SHICA). (2008) *Shanghai IC Industry Development Report 2008* 年上海集成电路产业发展研究报告. Shanghai: Shanghai Educational Publishing House.
Simmie, J. (2004) Innovation and clustering in the globalized international economy. *Urban Studies*, 41: 1095–1112.
Sklair, L. (2001) *The Transnational Capitalist Class*. Oxford: Blackwell Publishers Ltd.
Smart, A., Lin, George C. S. (2007) Local capitalisms, local citizenship and translocality: rescaling from below in the Pearl River Delta Region, China. *International Journal of Urban and Regional Research*, 31: 280–302.
Steinfeld, E. (2004) China's shallow integration: networked production and the new challenges for late industrialization. *World Development*, 32: 1971–1987.
Storper, M. (1997) *The Regional World: Territorial Development in a Global Economy*. New York: The Guilford Press.

Sun, Y. (2002) Sources of innovation in China's manufacturing sector: imported or developed in-house? *Environment and Planning A*, 34: 1059–1072.
Sun, Y. (2003) Strategic or tactical? Foreign research and development in developing countries, A case study of China. *Asian Geographer*, 22: 143–167.
Sun, Y., Du, D., Huang, L. (2006) Foreign R&D in developing countries: empirical evidence from Shanghai, China. *The China Review*, 6: 67–91.
Sun, Y., von Zedtwitz, M., Simon, D. F. (eds) (2008) *Global R&D in China*. London; New York: Routledge.
UNCTAD (United Nations Conference on Trade and Development). (2005) *Figure IV.11: Most Attractive Prospective R&D Locations in the UNCTAD Survey, 2005–2009, Chapter IV in World Investment Report*. Geneva: United Nations.
Vang, J., Asheim, B. (2006) Regions, absorptive capacity and strategic coupling with high-tech TNCs: Lessons from India and China. *Science, Technology and Society*, 11: 39–66.
Wallerstein, I. (1979) *The Capitalist World-Economy*. New York: Cambridge University Press.
Walsh, K. (2007) China R&D: a high-tech field of dreams. *Asia Pacific Business Review*, 13: 321–335.
Wang, C. C., Lin, G. C. S. (2008) The growth and spatial distribution of China's ICT industry: new geography of clustering and innovation. *Issues & Studies*, 44: 145–192.
Wang, J. H. (2006) China's dualist model on technological catching up: a comparative perspective. *Pacific Review*, 19: 385–403.
Webber, M. J., Rigby, D. L. (1996) *The Golden Age Illusion: Rethinking Postwar Capitalism*. New York: The Guilford press.
Wei, Y. D, Leung, C. K. (2005) Development zones, foreign investment, and global city formation in Shanghai. *Growth and Change*, 36: 16–40.
Wei, Y. H. D. (2000) *Regional Development in China: States, Globalization, and Inequality*. London: Routledge.
Wei, Y. H. D. (2002) Beyond the Sunan model: trajectories and underlying factors of development in Kunshan, China. *Environment and Planning A*, 34: 1725–1747.
Wolfe, D. A., Meric, S. G. (2004) Clusters from the inside and out: local dynamics and global linkages. *Urban Studies*, 41: 1071–1093.
Yeung, H. W. (2007) *Handbook of Research on Asian Business*. Northampton, MA: Edward Elgar.
Zeng, M., Williamson, P. J. (2003) The hidden dragons. *Harvard Business Review*, 8192–99+137.
Zhao, S. X. B., Zhang, L. (2007) Foreign direct investment and the formation of global city-regions in China. *Regional Studies*, 41: 979–994.
Zhou, Y. (2005) 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. (2008a) *Inside Story of China's High-Tech Industry: Making Silicon Valley in Beijing*. Lanham, MA: Rowman & Littlefield.
Zhou, Y. (2008b) Synchronizing export orientation with import substitution: creating competitive indigenous high-tech Companies in China. *World Development*, 36: 2353–2370.
Zhou, Y., Tong, X. (2003) Interaction between multinational corporations and domestic firms in a high-tech service cluster in Beijing. *Economic Geography*, 79: 129–152.