

# The Growth and Spatial Distribution of China's ICT Industry: New Geography of Clustering and Innovation\*

CASSANDRA C. WANG AND GEORGE C.S. LIN

*The rapid growth of China's information and communications technology (ICT) industry in recent years has attracted much scholarly attention. However, studies of China's ICT industry have been hampered by the lack of systematic and comparable data. The first national economic census undertaken in 2004 offered us a valuable opportunity to fill this gap. This paper examines the growth and structural characteristics of China's ICT industry and reveals that the ICT manufacturing sector has a strong tendency to conglomerate in several eastern coastal areas. Our data analysis has found no significant relationship between spatial agglomeration on the one hand and innovation and economic performance on the*

CASSANDRA C. WANG (王琛) is a Ph.D. candidate in the Department of Geography, the University of Hong Kong. Her research interests include industrial clusters, technological innovation, and regional development in China. Miss Wang can be reached at <h0691009@hkusua.hku.hk>.

GEORGE C.S. LIN (林初昇) is professor and head of the Department of Geography, the University of Hong Kong. His research interests include the new geography of China's ICT industry, the political economy of Chinese urbanization, and regional development in the Pearl River Delta region. Professor Lin can be reached at <gcslin@hkucc.hku.hk>.

\***Acknowledgment:** The work described in this paper was sponsored by a grant awarded by the Research Grants Council of the Hong Kong Special Administrative Region, China (HKU 7666/05H). The authors wish to thank the anonymous reviewers for their constructive comments and suggestions.

<sup>©</sup>Institute of International Relations, National Chengchi University, Taipei, Taiwan (ROC).

other in the case of China's ICT industry. A survey in Guangdong explains why spatial agglomeration has not brought about better innovative performance. Although frequent local production linkages are identified within the ICT industrial cluster, there is no cooperation or exchange of information in research and development (R&D) and other innovative activities.<sup>2</sup> Strong local linkages have not reduced distrust among the firms within the cluster. More importantly, most local enterprises have engaged in "peripheral" innovation. They have no desire to seek R&D cooperation or acquire relevant knowledge and technology from others.

**KEYWORDS:** industrial clusters; technological innovation; knowledge spillover; information and communications technology (ICT) industry; China.

\* \* \*



The information and communications technology (ICT) industry is regarded as one of the most profitable and promising industries in the world economy. With the shift in manufacturing to China and the increasing contribution made by high-technology industry to economic development, the Chinese government has given high priority to the ICT industry since the 1990s.<sup>1</sup> Despite accounting for only 5.45 percent of employment and less than 9 percent of total assets of the manufacturing sector, the ICT industry contributed approximately 12 percent of total sales revenue in 2004.<sup>2</sup> At present, China is ranked number one in the world in both the production and consumption of electronic products.<sup>3</sup> The rapid

<sup>1</sup>The ICT industry in the 2004 economic census yearbook consists of both the ICT manufacturing sector and the service sector. The ICT manufacturing sector, with the industry code of 4000, includes eight subsectors: manufacturing of telecommunications equipment (4010); radar and related equipment (4020); broadcasting and television equipment (4030); electronic computers (4040); electronic devices (4050); electronic component (4060); audio and video equipment (4070); and other electronic equipment (4090). The ICT service sector, with the industry code G, includes the service of telecommunications and other information transmission (6000), the service of computers (6100), and the software industry (6200).

<sup>2</sup>National Bureau of Statistics, *Zhongguo jingji pucha nianjian* (China economic census yearbook) (Beijing: Zhongguo tongji chubanshe, 2004). According to the standard of national economic industry classification (國民經濟行業分類, GB/T4754-2002), "manufacture" in the 2004 economic census refers to all industries except the mining industry, electricity and gas production and supply, and construction in the secondary industry. It includes 13 sections, 30 divisions, 169 groups, and 482 classes. See [http://www.stats.gov.cn/tjbz/hyflbz/xgwj/t20030613\\_402154085.htm](http://www.stats.gov.cn/tjbz/hyflbz/xgwj/t20030613_402154085.htm) (accessed August 10, 2007)

<sup>3</sup>Michael Pecht, *China's Electronics Industry: The Definitive Guide for Companies and Policy Makers with Interests in China* (New York: William Andrew Publishing, 2006).

growth of China's ICT industry has attracted much attention from both researchers and policymakers. However, little is understood about its growth, innovative performance, and spatial distribution.

A great deal of theoretical and empirical research on industrial clusters has been done in the field of economics and economic geography since the 1980s.<sup>4</sup> There is heated debate on the relationship between industrial clusters and technological innovation in the existing literature. Some scholars insist that industrial clustering can intensify production linkages and facilitate knowledge spillover and the learning process, thereby leading to high productivity and innovation, while others argue that clustering has not necessarily led to innovation.<sup>5</sup> A number of scholars claim that whether or not spatial clustering is conducive to innovation depends on the type of industry, the life cycle of this industry, and its ability to access global knowledge or international knowledge nodes.<sup>6</sup> There are also researchers who cast doubt on the perceived notion that proximity can facilitate localized cooperation, stimulate mutual learning, and lead to knowledge spillover.<sup>7</sup> Against this context of ongoing theoretical inquiry

<sup>4</sup>Anders Malmberg, "Industrial Geography: Agglomeration and Local Milieu," *Progress in Human Geography* 20, no. 3 (1996): 392-403.

<sup>5</sup>See, for example, Cindy C. Fan and Allen J. Scott, "Industrial Agglomeration and Development: A Survey of Spatial Economic Issues in East Asia and a Statistical Analysis of Chinese Regions," *Economic Geography* 79, no. 3 (July 2003): 295-319; Michael E. Porter, *The Competitive Advantage of Nations* (New York: Free Press, 1990); Michael E. Porter, "Location, Competition, and Economic Development: Local Cluster in a Global Economy," *Economic Development Quarterly* 14, no. 1 (February 2000): 15-34; and Annalee Saxenian, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128* (Cambridge, Mass.: Harvard University Press, 1994).

<sup>6</sup>See Harald Bathelt, Anders Malmberg, and Peter Maskell, "Clusters and Knowledge: Local Buzz, Global Pipelines, and the Process of Knowledge Creation," *Progress in Human Geography* 28, no. 1 (February 2004): 31-56; Maryann P. Feldman, "The New Economics of Innovation, Spillovers, and Agglomeration: A Review of Empirical Studies," *Economics of Innovation and New Technology* 8, no. 1/2 (1999): 5-25; James Simmie, "Innovation and Urban Regions as National and International Nodes for the Transfer and Sharing of Knowledge," *Regional Studies* 37, no. 6/7 (August 2003): 607-20; James Simmie, "Innovation and Clustering in the Globalized International Economy," *Urban Studies* 41, no. 5/6 (May 2004): 1095-1112; and James Simmie and James Sennett, "Innovative Clusters: Global or Local Linkages?" *National Institute Economic Review* 170, no. 1 (October 1999): 87-98.

<sup>7</sup>See Paeivi Oinas, "Distance and Learning: Does Proximity Matter?" in *Knowledge, Innovation, and Economic Growth: The Theory and Practice of Learning Regions*, ed. Frans Boekema et al. (Cheltenham, UK: Edward Elgar, 2000), 57-69; and Anders Malmberg and

and debate, an analysis of the actual situation of China's ICT industry can generate significant insights that help us to interrogate some of the competing theoretical interpretations.

This paper examines the growth, structural characteristics, and spatial distribution of China's ICT industry based on data obtained from the 2004 economic census (see Appendix) and analyzes the relationship between spatial agglomeration of the industry on the one hand and innovation and economic performance on the other. Special attention will be paid to the ICT industrial cluster in Guangdong Province (廣東省) where we have conducted a questionnaire survey and in-depth interviews to obtain insights into the dynamics of industrial agglomeration and technological innovation.

This paper is organized in five parts. It begins with a critical review of the existing literature on China's ICT industry. This is followed by a clarification of data and methodological issues. The third part consists of a detailed analysis of China's ICT industry, including its growth over time and distribution across space. A focused assessment of China's ICT manufacturing sector is then conducted to further understand the correlation between industrial agglomeration on the one hand and economic performance and innovation on the other. A case study of ICT manufacturing enterprises in the Shenzhen (深圳)-Dongguan (東莞) region of Guangdong Province is presented for illustration. Important research findings are highlighted and their theoretical and practical implications are discussed in the conclusion.

### **Understanding Industrial Clustering and the Geography of Innovation: China and the Globalizing World**

In recent years, the dramatic growth of the ICT industry in China has been the subject of great scholarly interest. It is no easy task, however, to

---

Dominic Power, "(How) Do (Firms in) Clusters Create Knowledge?" *Industry and Innovation* 12, no. 4 (December 2005): 409-31.

fully understand the nature and dynamics of the growth of the Chinese ICT sector. This difficulty is the result of a number of long-standing problems. First, the "ICT industry" actually involves a large number of sectors and subsectors and there is, unfortunately, no standard definition or classification of the industry. As a consequence, researchers have defined the ICT industry according to their own understanding and collected data from different official or unofficial sources, which has led to not only confusion and misunderstanding, but also false comparison. For example, Amighini divides ICT products into office machines, information technology (IT) products, telecommunications products, and semiconductors.<sup>8</sup> In contrast, Meng and Li define China's ICT industry as the electronics industry, which includes electronic components, communications equipment, computer products, and software products.<sup>9</sup> The report produced by the International Finance Corporation focuses on ten subsectors: telecommunications equipment, IC industry and fabless chip design, software industry, security services, mobile data, online gaming, e-commerce, digital media applications, software outsourcing and IT services, and handset design.<sup>10</sup>

Second, research on China's ICT industry has long been hampered by the lack of accurate and consistent data. According to Katsuno, there are three main sources of official ICT statistics in China: the Ministry of Information Industry (信息產業部), the National Bureau of Statistics (國家統計局), and the Chinese Academy of Sciences (中國科學院).<sup>11</sup> He notes that there are great discrepancies between data from these different sources: "There are some coherency problems between the disaggregated

---

<sup>8</sup>Alessia Amighini, "China in the International Fragmentation of Production: Evidence from the ICT Industry," *The European Journal of Comparative Economics* 2, no. 2 (2005): 203-19.

<sup>9</sup>Qingxuan Meng and Mingzhi Li, "New Economy and ICT Development in China," *Information Economics and Policy* 14, no. 2 (June 2002): 275-95.

<sup>10</sup>Mohsen A. Khalil and Javed Hamid, "The ICT Landscape in the PRC: Market Trends and Investment Opportunities" (2005), [http://www.ifc.org/ifcext/eastasia.nsf/AttachmentsByTitle/IFCReport\\_Chinese/\\$FILE/Report+V.2.0.pdf](http://www.ifc.org/ifcext/eastasia.nsf/AttachmentsByTitle/IFCReport_Chinese/$FILE/Report+V.2.0.pdf) (accessed August 3, 2007).

<sup>11</sup>Masahiro Katsuno, "Status and Overview of Official ICT Indicators for China," *OECD Working Papers* (2005), <http://oberon.sourceoecd.org/vl=18652493/cl=11/nw=1/rpsv/cgi-bin/wppdf?file=5lgsjhvj74s6.pdf> (accessed August 3, 2007).

data of the Ministry of Information Industry and those supplied by the National Bureau of Statistics. Similar problems exist within the various statistics reported by the Ministry of Information Industry itself.<sup>12</sup> Moreover, it is questionable whether China's ICT statistics are comparable to those of OECD countries because of the different systems of classification.<sup>13</sup>

Third, most of the existing studies have taken the Chinese ICT industry as a whole and have never examined the spatial variation of this industry at a disaggregated provincial or county level.<sup>14</sup> In recognition of the importance of the ICT industry, Chinese local governments have committed themselves to its establishment and development. However, as a high-technology industry that requires a more demanding industrial environment than more traditional industries, its development has inevitably been unevenly distributed.

Finally, the technology level and innovative capability of the ICT industry remains unknown. As Katsuno has noted, ICT is a strategic sector for which the Chinese government wants to attract foreign direct investment and develop its own technology base.<sup>15</sup> It has been documented that China has its own innovative capability and has started to establish its own technical standards in selected fields, such as third-generation (3G) mobile telephony and the TD-SCDMA (time division synchronous code division multiple access) standard.<sup>16</sup> However, it has also been contended that "China's ICT industry today largely has been stuck at the lowest level of the high-tech value chain."<sup>17</sup> Furthermore, the technology landscape and innovative capability of China is highly uneven because of the "consider-

<sup>12</sup>Ibid., 17.

<sup>13</sup>Magnus Breidne, "Information and Communications Technology in China: A General Overview of the Current Chinese Initiatives and Trends in the Area of ICT," in *VINNOVA Report* (Stockholm: VINNOVA, 2005).

<sup>14</sup>Ibid.; Meng and Li, "New Economy and ICT Development in China," 275-95; and Katsuno, "Status and Overview," 3-4.

<sup>15</sup>Katsuno, "Status and Overview," 8.

<sup>16</sup>Richard P. Suttmeier and Xiangkui Yao, "China's Post-WTO Technology Policy: Standards, Software, and the Changing Nature of Techno-Nationalism" (2004), <http://www.nbr.org/publications/specialreport/pdf/SR7.pdf> (accessed August 20, 2007).

<sup>17</sup>Breidne, "Information and Communications Technology in China," 11.

able difference in local resources, cultures, and institutions as well as in the positions in MNCs' [multinational corporations'] global or China strategies."<sup>18</sup> The difficulties and problems identified here suggest that there is a noticeable gap in the existing literature and that further studies must be carried out to enhance our understanding of the nature and dynamics of the growth of China's ICT industry.

China is of course a latecomer in the global geography of industrial clustering and innovation. In the international arena of ICT research, there exists a fairly large body of literature on the growth dynamics and spatial distribution of the high-tech sector. Indeed, studies of spatial clustering of economic activities can be traced to classic agglomeration theory of the 1920s. Marshall was among the first to point out that industrial agglomeration engenders external economies of scale, which reduce costs and enhance economic performance through specialized division of labor, access to local labor markets, and technology and information spillover in industrial districts.<sup>19</sup> In recent years, there has been a renewed interest in the Marshallian model because of recognition of uneven growth in localized economies.<sup>20</sup> Building on Marshall's concept of externalities, recent studies of industrial clusters have mainly explained the positive relationship between industrial clusters and innovative performance as well as economic growth from two perspectives.

First, geographical proximity is believed to be conducive not only to interaction among local economic agents, which produces reduced transaction costs, but also to fierce competition, which stimulates firms to improve their performance.<sup>21</sup> Furthermore, long-term interaction tends to intensify

<sup>18</sup>Yu Zhou and Tong Xin, "An Innovative Region in China: Interaction between Multinational Corporations and Local Firms in a High-Tech Cluster in Beijing," *Economic Geography* 79, no. 2 (April 2003): 129-52.

<sup>19</sup>Alfred Marshall, *Principles of Economics: An Introductory Volume*, eighth edition (London: Macmillan, 1920).

<sup>20</sup>Bernard Fingleton, Danilo C. Iglori, and Barry Moore, "Cluster Dynamics: New Evidence and Projections for Computing Services in Great Britain," *Journal of Regional Science* 45, no. 2 (May 2005): 283-311.

<sup>21</sup>Fan and Scott, "Industrial Agglomeration and Development," 297; and Porter, *The Competitive Advantage of Nations*, 154-57.

mutual trust and produce other kinds of social capital which can in turn promote more cooperation in production and in research and development (R&D).<sup>22</sup> Linkages between suppliers and customers induced by geographical proximity may enhance product quality and eliminate market uncertainty while linkages among peers and rivals may stimulate agents to strengthen their capabilities of technological upgrading and market occupation.<sup>23</sup> In his research, Porter elaborates on the positive relationship between cluster, productivity, and innovation by emphasizing the production network of a cluster.<sup>24</sup> Porter has identified the advantages of clustering thus:

A firm within a cluster often can more rapidly source the new components, services, machinery, and other elements needed to implement innovations, whether a new product line, a new process, or a new logistical model. Local suppliers and partners can and do get closely involved in the innovation process, thus ensuring that the inputs they supply better meet the firm's requirements. New, specialized personnel can often be recruited locally to fill gaps required to pursue new approaches. The complementarities involved in innovating are more easily achieved among nearby participants.<sup>25</sup>

Saxenian conducted a comparative study of Silicon Valley and Route 128, and shows how regions could become more innovative and successful through the development of a network-based production system.<sup>26</sup>

<sup>22</sup>Roberto P. Camagni, "Local 'Milieu', Uncertainty and Innovation Networks: Towards a New Dynamic Theory of Economic Space," in *Innovation Networks: Spatial Perspectives*, ed. Roberto P. Camagni (London: Belhaven, 1991), 121-44; Philip Cooke, Nick Clifton, and Mercedes Oleaga, "Social Capital, Firm Embeddedness, and Regional Development," *Regional Studies* 39, no. 8 (November 2005): 1065-77; and Gernot Grabher, "Rediscovering the Social in the Economics of Interfirm Relations," in *The Embedded Firm: On the Socioeconomics of Industrial Networks*, ed. Gernot Grabher (London and New York: Routledge, 1993), 1-31.

<sup>23</sup>Porter, *The Competitive Advantage of Nations*; Porter, "Location, Competition, and Economic Development," 15-34; and Michael E. Porter, "Clusters and the New Economics of Competition," *Harvard Business Review* 76, no. 6 (November-December 1998): 77-90.

<sup>24</sup>Porter, "Clusters and the New Economics of Competition," 77-90.

<sup>25</sup>Michael E. Porter, "Locations, Clusters, and Company Strategy," in *The Oxford Handbook of Economic Geography*, ed. Gordon L. Clark, Meric S. Gertler, and Maryann P. Feldman (Oxford: Oxford University Press, 2000), 262.

<sup>26</sup>Saxenian, *Regional Advantage*; and Annalee Saxenian, "Inside-Out: Regional Networks and Industrial Adaptation in Silicon Valley and Route 128," *Citiescape: A Journal of Policy Development and Research* 2, no. 2 (May 1996): 41-60.

Considering that both electronics clusters were supported by similar advantageous locations, in close proximity to famous universities, having easy access to talented people and funding support from the government, it is intriguing how Silicon Valley was able to get through the crisis in the 1980s and achieve a sustainable competitive edge while Route 128, in contrast, was not able to buck the declining trend. To Saxenian, the reason lies in the fact that Silicon Valley formed a regional network-based system as well as a regional culture of encouraging cooperation and competition, whereas Route 128 remained stuck in a system of vertical integration, which internalized production linkages, failed to get useful information from other firms within the cluster, stifled the production and organization model, and retarded decision-making in the flexible market, ultimately leading to its failure.

Camagni, meanwhile, has examined the issue from a sociological point of view, and provides the following analysis:

Spatial proximity matters not really in terms of a reduction in physical "distance" and in the related transport costs, but rather in terms of easy information interchange, similarity of cultural and psychological attitudes, frequency of interpersonal contacts and cooperation, and density of factors mobility within the limits of the local area. All these elements in fact are crucial ... but particularly because they determine the local response capability to a changing external environment, its innovativeness and production flexibility.<sup>27</sup>

This highlights the role of local social relationships in the process of innovation.

Until recently, it was widely believed that spatial clustering facilitates learning and knowledge spillover, expedites the flow of new information and ideas, and hence improves technological and innovative capability.<sup>28</sup>

---

<sup>27</sup>Roberto P. Camagni, "Introduction: From the Local 'Milieu' to Innovation through Cooperation Networks," in Camagni, *Innovation Networks*, 2.

<sup>28</sup>Bjørn T. Asheim, "Interactive Learning and Localized Knowledge in Globalizing Learning Economies," *GeoJournal* 49, no. 4 (1999): 345-52; Jeremy R. L. Howells, "Tacit Knowledge, Innovation, and Economic Geography," *Urban Studies* 39, no. 5/6 (May 2002): 871-84; David Keeble and Frank Wilkinson, "Collective Learning and Knowledge Development in the Evolution of Regional Clusters of High Technology SMEs in Europe," *Regional Studies* 33, no. 4 (June 1999): 295-303; Stefano Breschi and Francesco Lissoni, "Knowledge Spillovers and Local Innovation Systems: A Critical Survey," *Industrial and*

With the advent of globalization and the knowledge-based economy, much of the literature shows that economic growth to a large extent depends on innovation,<sup>29</sup> and innovation is based on new knowledge or new combinations of existing knowledge.<sup>30</sup> Moreover, some scholars believe that the days when innovation was based on a single firm are over and that the external knowledge possessed by a firm is now more important for innovation.<sup>31</sup> Therefore, the ability to acquire external knowledge is the key to a firm's innovation and success. Influenced by endogenous growth theory, which highlights the characteristics of the non-rivalry, non-excludability, or partial excludability of knowledge,<sup>32</sup> scholars have argued that knowledge spillover is an important way for firms to acquire new and complementary knowledge.<sup>33</sup> In addition, knowledge is usually divided into

*Corporate Change* 10, no. 4 (December 2001): 975-1005; and Franz Tödtling, Patrick Lehner, and Michaela Trippel, "Innovation in Knowledge-Intensive Industries: The Nature and Geography of Knowledge Links," *European Planning Studies* 14, no. 8 (September 2006): 1035-58.

<sup>29</sup>Paul Geroski, "Markets for Technology: Knowledge, Innovation, and Appropriability," in *Handbook of the Economics of Innovation and Technological Change*, ed. Paul Stoneman (Oxford: Blackwell, 1995), 90-131; Frederic M. Scherer, *Innovation and Growth: Schumpeterian Perspectives* (Cambridge, Mass.: MIT Press, 1986); and Joseph A. Schumpeter, *The Theory of Economic Development*, trans. Redvers Opie (Cambridge, Mass.: Harvard University Press, 1934).

<sup>30</sup>Manfred M. Fischer, ed., *Innovation, Networks, and Knowledge Spillovers* (Berlin: Springer, 2006), 1.

<sup>31</sup>David B. Audretsch, "Globalization, Innovation, and the Strategic Management of Places," in *Innovation Clusters and Interregional Competition*, ed. Johannes Bröcker, Dirk Dohse, and Rüdiger Soltwedel (Berlin: Springer, 2003), 11-27; and Maryann P. Feldman, *The Geography of Innovation* (Dordrecht: Kluwer, 1994).

<sup>32</sup>Zoltan J. Acs and Attila Varga, "Geography, Endogenous Growth, and Innovation," *International Regional Science Review* 25, no. 1 (January 2002): 132-48.

<sup>33</sup>Feldman, *The Geography of Innovation*; Fischer, *Innovation, Networks, and Knowledge Spillovers*; David B. Audretsch and Maryann P. Feldman, "R&D Spillovers and the Geography of Innovation and Production," *American Economic Review* 86, no. 3 (June 1996): 630-40; Harald Bathelt, "Geographies of Production: Growth Regimes in Spatial Perspective (II)—Knowledge Creation and Growth in Clusters," *Progress in Human Geography* 29, no. 2 (April 2005): 204-16; Thomas Döring and Jan Schnellenbach, "What Do We Know about Geographical Knowledge Spillovers and Regional Growth? A Survey of the Literature," *Regional Studies* 40, no. 3 (May 2006): 375-95; Ray Hudson, "The Learning Economy, the Learning Firm, and the Learning Region: A Sympathetic Critique of the Limits to Learning," *European Urban and Regional Studies* 6, no. 1 (January 1999): 59-72; and David Keeble and Frank Wilkinson, eds., *High-Technology Clusters, Networking, and Collective Learning in Europe* (Aldershot: Ashgate, 2000).

two forms: codified knowledge and tacit knowledge. Tacit knowledge is more difficult to understand, assimilate, or apply than codified knowledge since it involves know-how and needs a certain knowledge background to be put into full use.<sup>34</sup> The more tacit the knowledge is, the higher its transfer cost.<sup>35</sup> In this sense, tacit knowledge is more valuable than codified knowledge in the process of innovation, and it is believed that geographical proximity can facilitate the circulation and transmission of tacit knowledge.<sup>36</sup> Further empirical research has also demonstrated that there is a significant correlation between innovation and spatial proximity or agglomeration economies.<sup>37</sup>

In recent years, however, scholars have cast doubt over the perceived relationship between industrial clusters and technological innovation. Having reviewed a huge body of literature, Malmberg and Power argue that there is much evidence that transactions within clusters are very limited.<sup>38</sup> Moreover, local production and service linkages do not necessarily bring about new knowledge or R&D in a cluster. In addition, Feldman contends:

There is evidence that there are geographic limits to the extent to which knowledge may spill over; however, this is not to say that location is important to innovation in all circumstances. There is further evidence that the degree to which location matters to innovation depends upon the type of activity, the stage of the industry life cycle, and the composition of activity within a location.<sup>39</sup>

<sup>34</sup>Howells, "Tacit Knowledge, Innovation, and Economic Geography," 871-84.

<sup>35</sup>Walter W. Powell and Stine Grodal, "Networks of Innovators," in *The Oxford Handbook of Innovation*, ed. Jan Fagerberg, C. David Mowery, and R. Richard Nelson (New York: Oxford University Press, 2005), 56-114.

<sup>36</sup>Döring and Schnellenbach, "What Do We Know," 375-95; and Simmie, "Innovation and Clustering," 1098.

<sup>37</sup>Audretsch and Feldman, "R&D Spillovers," 630-40; Saxenian, *Regional Advantage*, 162; Rui Baptista and Peter Swann, "Do Firms in Clusters Innovate More?" *Research Policy* 27, no. 5 (September 1998): 525-40; and Tai-shan Hu, Chien-yuan Lin, and Su-li Chang, "Role of Interaction between Technological Communities and Industrial Clustering in Innovative Activity: The Case of Hsinchu District, Taiwan," *Urban Studies* 42, no. 7 (June 2005): 1139-60.

<sup>38</sup>Malmberg and Power, "(How) Do (Firms in) Clusters Create Knowledge?" 413.

<sup>39</sup>Feldman, "The New Economics of Innovation, Spillovers, and Agglomeration," 21.

Oinas also shows that there is no observed positive correlation between proximity and learning both in qualitative and quantitative studies.<sup>40</sup> The empirical research conducted by Watts, Wood, and Wardle shows that spatial proximity does not lead to knowledge transfer between local customers and suppliers within an industrial cluster. For example, there was no important advantage to be gained from face-to-face contacts for learning and trust among agents within the Sheffield metal-working cluster.<sup>41</sup>

At the same time, a number of scholars have questioned the model of "tacit = local" versus "codified = global."<sup>42</sup> The conventional perception that tacit knowledge is confined to local milieu has been challenged by those who are in favor of the concept of a "global pipeline" that combines local linkages and global linkages in the form of not only products and services but also knowledge and information.<sup>43</sup>

A growing number of studies also emphasize the fact that access to national or international knowledge is more important than local knowledge spillover. According to Tödtling, metropolitan areas have been important "innovation poles" because they are nodes of communications and transportation at both the national and international level.<sup>44</sup> In his study of the Greater South East in the United Kingdom, Simmie argues that knowledge is a key resource for innovation but that most innovative firms have been those with access to international sources of knowledge.<sup>45</sup> Innovative firms need to transfer and share knowledge from local to international level, and the metropolitan area as the node of interaction for local

<sup>40</sup>Oinas, "Distance and Learning," 57-69.

<sup>41</sup>H. D. Watts, A. M. Wood, and P. Wardle, "Making Friends or Making Things?: Interfirm Transactions in the Sheffield Metal-Working Cluster," *Urban Studies* 40, no. 3 (March 2003): 615-30.

<sup>42</sup>Bathelt, Malmberg, and Maskell, "Clusters and Knowledge," 31-56; and Lars Hakanson, "Epistemic Communities and Cluster Dynamics: On the Role of Knowledge in Industrial Districts," *Industry and Innovation* 12, no. 4 (2005): 433-63.

<sup>43</sup>Bathelt, Malmberg, and Maskell, "Clusters and Knowledge," 31-56.

<sup>44</sup>Franz Tödtling, "The Uneven Landscape of Innovation Poles: Local Embeddedness and Global Networks," in *Globalization, Institutions, and Regional Development in Europe*, ed. Ash Amin and Nigel Thrift (New York: Oxford University Press, 1994), 68-90.

<sup>45</sup>Simmie, "Innovation and Urban Regions," 607-20.

knowledge and international knowledge is considered to be the best location for innovation. In his later paper, Simmie further challenges Porter's main arguments concerning the relationship between local clustering and technological innovation.<sup>46</sup> He claims that

national and international linkages are as significant for innovation as are more local networks. This provides at least a *prima facie* case suggesting that innovation must be understood in terms of trading nodes in an international system that encompasses both local and international knowledge spillovers and multi-layered economic linkages extending over several different spatial scales.<sup>47</sup>

The relationship between industrial clusters and innovation as discussed above has remained controversial and vague. In addition, the debate over the relationship between proximity, knowledge spillover, and innovation has ignored the source of original knowledge. Learning and knowledge spillover would never occur without the existence of new or complementary knowledge. Where does new knowledge come from? Who learns from whom? How and when is knowledge spilled over and transmitted? It could be very misleading to discuss knowledge spillover without clearly identifying the sources of knowledge or understanding how knowledge is generated and circulated. Therefore, there are at least four theoretical problems that need further research: Is geographical proximity necessarily conducive to local production linkages? If it is, do local production linkages facilitate knowledge spillover and R&D cooperation among the economic agents? Is geographical proximity necessarily conducive to local R&D activities or knowledge spillover? If it is, where does the original knowledge come from and how is knowledge spilled over?

Furthermore, most of the theoretical models were developed on the basis of Western experiences. It would not be appropriate to apply them directly to the Chinese situation. It is well known that Western firms are able to conduct independent innovation without any external assistance whereas firms in China are faced with a lack of finance and technology. For years, indigenous Chinese firms were trapped at the low end of the

---

<sup>46</sup>Simmie, "Innovation and Clustering," 1095-1112.

<sup>47</sup>*Ibid.*, 1103.

industrial chain and were forced to act only as technological followers of their Western counterparts.<sup>48</sup> It is a well-known fact that Chinese firms with limited innovative capability often had to import technology from advanced countries. It would be interesting to investigate whether or not industrial agglomeration in China could lead to the creation of new knowledge.

### Data and Methodology

Within the theoretical context identified above, the purposes of this study are threefold. The first is to examine the emerging geography of China's ICT industry, especially its spatial distribution and its innovation and performance at the national level. The second is to evaluate whether China's ICT industrial cluster is conducive to technological innovation and high productivity. The third is to examine and explain the dynamic process of local production linkages and the flow of knowledge and information within the ICT industrial cluster in southern China. In pursuit of these research objectives, several questions are raised: How is China's ICT industry distributed at the national level? What is the pattern of spatial variation in terms of innovation and performance? Is there any correlation between spatial agglomeration and the ICT industry's technological innovation and economic performance? Is China's ICT industrial cluster conducive to local production linkages? How do China's ICT firms acquire their core technology and new knowledge? Is China's ICT industrial cluster conducive to knowledge spillover and R&D cooperation? In order to answer these questions, three hypotheses are suggested. The first is that there are significant regional differences in the type and performance of the ICT industry in China. The second is that there is a significant relationship between spatial agglomeration and economic performance as

<sup>48</sup>Adam Segal, *Digital Dragon: High-Technology Enterprises in China* (London: Cornell University Press, 2003).

well as technological innovation. And the third is that geographical proximity is conducive to local production linkages, knowledge spillover, and R&D cooperation.

Before the overall situation of China's ICT industry is analyzed, several important concepts require clarification. First, based on Porter's definition, a cluster in this paper refers to a geographical concentration of several interconnected companies with similar or complementary functions in a particular field.<sup>49</sup> It is noted that cluster is different from agglomeration. A cluster is composed of interconnected companies whereas an agglomeration is only a geographical concentration in a particular field and the economic agents within it could have no linkages with others at all.<sup>50</sup> There are several measurements of an industrial cluster, such as the Herfindahl index (H-index), location quotient, growth-share matrix, EG index, and so on.<sup>51</sup> However, "one of the most common techniques employed by analysts to identify the presence of clusters within a specific geographical locale is the use of the employment location quotient."<sup>52</sup> The formula for this location quotient (LQ) is:  $LQ = (E_{ij}/E_j)/(E_{in}/E_n)$ , where  $E_{ij}$  is employment of industry  $i$  in region  $j$ ,  $E_j$  is total employment in region  $j$ ,  $E_{in}$  is national employment of industry  $i$ , and  $E_n$  is total national employment.<sup>53</sup> However, identifying a cluster purely by quantitative methods is regarded as inadequate by some scholars, and case studies have been suggested as a good way to supplement them.<sup>53</sup> The location quotient measures the degree of agglomeration but fails to measure the linkages among economic agents; thus in addition to the measurement of the employment location quotient, this paper will use case studies to further identify clusters.

<sup>49</sup>Porter, "Locations, Clusters, and Company Strategy," 253-54.

<sup>50</sup>Malmberg, "Industrial Geography," 392-403.

<sup>51</sup>Fan and Scott, "Industrial Agglomeration and Development," 295-319; David A. Wolfe and Meric S. Gertler, "Clusters from the Inside and Out: Local Dynamics and Global Linkages," *Urban Studies* 41, no. 5/6 (May 2004): 1071-93; and Glenn Ellison and Edward L. Glaeser, "Geographic Concentration in U.S. Manufacturing Industries: A Dartboard Approach," *Journal of Political Economy* 105, no. 5 (October 1997): 889-927.

<sup>52</sup>Wolfe and Gertler, "Clusters from the Inside and Out," 1080.

<sup>53</sup>*Ibid.*, 1081.

The definition and measurement of innovation also need clarification. Many scholars have tried to define innovation.<sup>54</sup> In this paper it is regarded as an attempt to introduce new products to market or better ways to improve productivity. It can be measured by patents or patent citations,<sup>55</sup> patent applications, patent certification, and sales of new products.<sup>56</sup> Innovation in this paper is measured by the average output value of new products generated per enterprise and the average number of inventive patent certifications held per ten enterprises. Finally, the economic performance of the ICT industry in a region is measured by labor productivity and capital profitability. Labor productivity is defined as the output value generated per worker. Capital profitability is calculated as total profit generated per *yuan* of capital investment.

This research analyzes three sets of data. The first set is from the first national economic census conducted in 2004. This census covered 19 sections and 875 classes using the standard of the national economic industry classification, and included all corporation units (5.17 million), establishments (6.82 million), and individual proprietors (39.22 million) engaged in secondary or tertiary industry in the People's Republic of China (PRC). It involved over ten million people and cost over ten billion *yuan* to conduct. The data collected in this census are the most comprehensive in the history of censuses in China. This set of data consists of two categories: national-level data obtained from the first national economic census yearbook and provincial-level data obtained from economic census yearbooks of all provincial units. A quantitative method will be used to analyze

<sup>54</sup>Porter, *The Competitive Advantage of Nations*; OECD and Eurostat, "Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data" (2005), <http://213.253.134.43/oecd/pdfs/browseit/9205111E.PDF> (accessed March 25, 2007); and James Simmie, "Knowledge Spillovers and Reasons for the Concentration of Innovative SMEs," *Urban Studies* 39, no. 5/6 (May 2002): 885-902.

<sup>55</sup>David B. Audretsch, "Agglomeration and the Location of Innovative Activity," *Oxford Review of Economic Policy* 14, no. 2 (Summer 1998): 18-29; Feldman, "The New Economics of Innovation, Spillovers, and Agglomeration," 5-25; and Feldman, *The Geography of Innovation*, 29-31.

<sup>56</sup>Yifei Sun, "Sources of Innovation in China's Manufacturing Sector: Imported or Developed In-House?" *Environment and Planning A* 34, no. 6 (2002): 1059-72.

the spatial pattern of China's ICT industry and to identify the extent to which the industry varies geographically. The employment location quotient of the ICT manufacturing sector at a disaggregated provincial level will be calculated in order to further examine the geographical variation of clustering at this level. In addition, the spatial variation in economic and innovative performance of the industry will be analyzed by calculating a number of indicators including labor productivity, capital profitability, the average output value of new products, and the number of inventive patent certifications of the ICT manufacturing sector. Two correlation analyses will be conducted to identify the relationship between spatial agglomeration and economic as well as innovative performance.

The second set of data is derived from a questionnaire survey conducted among the ICT enterprises in Shenzhen and Dongguan cities in 2006.<sup>57</sup> As mentioned above, the employment location quotient merely identifies the spatial agglomeration; it cannot measure the linkages among economic agents. The data we obtained from the questionnaire survey is used to examine the dynamics and linkages among economic agents in the industrial cluster of southern China. The last set of data is obtained from our own in-depth interviews conducted in ICT enterprises in Shenzhen, the relevant industrial associations in that city, and government agencies in 2007.<sup>58</sup> This set of data is used to further explain the relationship between

---

<sup>57</sup>This questionnaire survey was conducted from September 15 to October 31, 2006. Following the sample selected by the first national economic census in 2004, the survey covered 3,300 enterprises in the following manufacturing subsectors: telecommunications equipment, electronic computers, electronic devices and electronic components, and the service subsector of software in the Shenzhen-Dongguan area. However, only 10 percent of the questionnaires were returned, including 266 from manufacturing enterprises and 70 from software enterprises. This section focuses on the 266 enterprises in the manufacturing sector in the Shenzhen-Dongguan area.

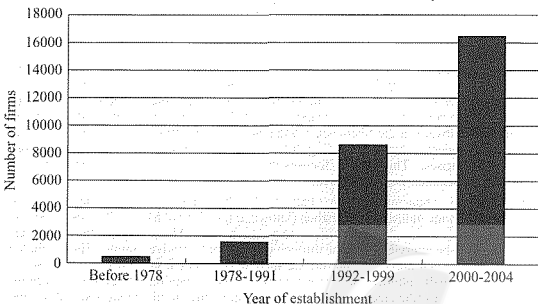
<sup>58</sup>This survey was conducted in the first half of July 2007. In recognition of the importance of the mobile phone industry in Shenzhen (known as the "City of Mobile Phones"), the survey focused on mobile phone manufacturing enterprises. Although only thirteen enterprises agreed to be interviewed, these thirteen were a representative sample. They included not only well-known domestic enterprises, such as Huawei (华为) and ZTE (中兴通讯), but also some small unknown private enterprises. The in-depth interviews with three industrial associations (the electronic industry association, the mobile phone association, and the electronic computer association) gave us overall information about Shenzhen's ICT industry. The interviews with the Bureau of Intellectual Property Rights yielded the S&T policies and patent status of Shenzhen's ICT industry.

firm behavior, institutional environment, and innovative performance in the ICT industry in southern China.

### Growth and Distribution of China's ICT industry

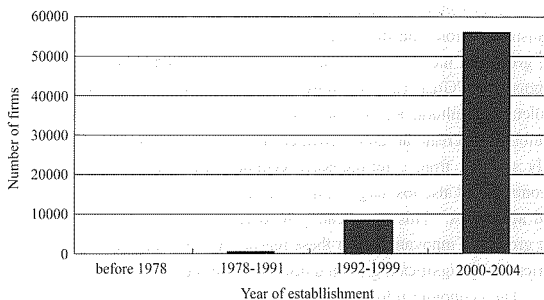
China's ICT industry has experienced rapid growth since the 1990s. However, it received little attention until recently. There were few ICT manufacturing enterprises before 1991, but the number grew during the 1990s and there was a dramatic increase in the period 2000-04 (see figure 1). The temporal development of the ICT service sector is different from that of the ICT manufacturing sector. There were very few firms in the service sector before the 1990s, but during the period 2000-04 there were nearly five times as many start-ups in this sector as there had been in the 1990s (see figure 2). The recent growth of China's ICT industry has been boosted by the state policies and guidelines that have been introduced at

**Figure 1**  
**ICT Manufacturing Start-ups at Different Stages**



**Source:** National Bureau of Statistics, *Zhongguo jingji pucha nianjian* (China economic census yearbook) (Beijing: Zhongguo tongji chubanshe, 2004).

**Figure 2**  
**ICT Service Start-ups at Different Stages**



Source: See figure 1.

different stages. To understand the evolution of China's ICT industry, it is necessary to examine the changing political context, particularly the organization structure and state policies pertaining to science and technology (S&T).

After the foundation of the PRC in 1949, the Chinese Communist Party (CCP) committed itself to building up a centrally controlled economic system. Under the influence of the former Soviet Union, R&D activities were initially separated from industrial enterprises and restricted only to institutions established and supported by the state within the planned economy. This not only suppressed initiative among industrial and commercial enterprises but also impeded the commercialization and application of research output.<sup>59</sup> Because of the unstable domestic and international environment prevalent at the time, S&T activities were concentrated in the fields of the military, defense, and national security.<sup>60</sup> An

<sup>59</sup>Qiwen Lu, *China's Leap into the Information Age: Innovation and Organization in the Computer Industry* (Oxford: Oxford University Press, 2000).

<sup>60</sup>Pecht, *China's Electronics Industry*, 48.

ideology that undervalued technological knowledge and the incentive to innovate severely constrained S&T development.<sup>61</sup> Meanwhile, the ideology of Mao Zedong (毛澤東), that overvalued the primary and secondary industrial sectors and discriminated against tertiary industries, hindered the growth of the ICT service sector. In the 1950s and 1960s, two campaigns—the "Great Leap Forward" (大躍進) (1958-60) and the "Great Proletarian Cultural Revolution" (無產階級文化大革命) (1966-76)—combined to create an unprecedented disaster in the country. China not only suffered from a retrogressive economy and unstable political environment but also lost large numbers of talented people such as scientists and academics. This significantly hindered S&T activities and harmed the growth of innovation. For these reasons, the ICT industry did not experience any significant growth during much of the Mao era.

The economic reform initiated in late 1978 was a turning point in China's economic development and inevitably influenced the growth of innovation in the country. The Third Plenum of the CCP's Eleventh Central Committee in December 1978 turned out to be a watershed that had a far-reaching influence on the growth of the ICT industry. It marked a shift of emphasis from class struggle to economic development and the "four modernizations," namely the modernization of agriculture, industry, S&T, and the military. At this plenum, Deng Xiaoping (鄧小平) argued that science and technology are the primary forces driving production.<sup>62</sup> In addition, the plenum introduced the policy of reform and opening-up that would permit foreign direct investment and accept technology transfers. Students were encouraged to go abroad to study and return to the motherland with advanced knowledge and technology. However, a number of political campaigns launched in the late 1970s and early 1980s did have a negative influence on S&T and innovation in China.<sup>63</sup>

<sup>61</sup>Denis Fred Simon and Merle Goldman, eds., *Science and Technology in Post-Mao China*, Harvard Contemporary China Series (Cambridge, Mass.: Harvard University Press, 1989).

<sup>62</sup>Pecht, *China's Electronics Industry*, 49.

<sup>63</sup>Simon and Goldman, *Science and Technology in Post-Mao China*, "14-15.

In 1985, a reform of the S&T system was launched to strengthen the linkage between the market mechanism and R&D capability.<sup>64</sup> Then in 1992, during his "southern tour," Deng reiterated the principle that "S&T are the primary driving productive forces." In 1995, it was formally announced that the S&T system would be further improved to accelerate technological innovation. The ninth (1996-2000) and tenth (2001-05) five-year plans reflected China's dedication to long-term S&T development.<sup>65</sup> Considering its limited resources of capital and talent, China decided to focus on the ICT industry. According to Pecht, the major development goals of the ninth and tenth five-year plans included

focusing on the development of integrated circuits (ICs), new devices, new computers, and telecommunications equipment to provide economic and social development with up-to-date information systems, and making preferential policies to support IC development; developing microchip devices, new displays, and photoelectric devices, and establishing production and export bases for computer and accessory devices; developing and producing digital programmed exchanges, mobile communications and optical communications equipment; improving the electronics industry's technical level and international competitiveness.<sup>66</sup>

This explained why the number of ICT enterprises in both the manufacturing and service sectors increased dramatically during the period 2000-04.

China is a large country with an uneven geographical distribution of natural and labor resources. The spatial distribution of the ICT industry is also geographically uneven at the national level. There are only six regions whose location quotient is larger than 1 (see table 1), and five of them are eastern coastal city-regions in advantageous locations with an abundance of highly-qualified human resources and high levels of capital accumulation, the exception being Shaanxi (陕西省).<sup>67</sup>

<sup>64</sup>Hung-bin Ding, "International Technology Transfer to China: The Case of Biotechnology," *Issues & Studies* 36, no. 2 (March/April 2000): 133-54.

<sup>65</sup>Pecht, *China's Electronics Industry*, 50.

<sup>66</sup>*Ibid.*

<sup>67</sup>As will be demonstrated later in this research, ICT industrial concentration in Shaanxi was driven to a large extent by the ICT service sector, including the design of integrated circuits and the software industry. There are two reasons for this. First, Xi'an (西安市), the capital of Shaanxi, is famous not only for its history but also for its electronics industry. Xi'an

**Table 1**  
**Regions with Employment Location Quotient for the ICT Industry above 1, 2004**

Region	Employment	% of the nation	Location quotient of employment	Output value of the ICT manufacturing sector (billion yuan)	% of the nation
Guangdong (廣東省)	2,356,200	34.25	2.83	821.47	36.36
Beijing (北京市)	405,000	5.89	1.70	124.62	5.52
Tianjin (天津市)	161,200	2.34	1.40	137.35	6.08
Jiangsu (江蘇省)	927,900	13.49	1.37	441.64	19.55
Shanghai (上海市)	419,000	6.09	1.23	285.89	12.65
Shaanxi (陝西省)	138,700	2.16	1.04	14.52	0.64
Total of the nation	6,880,200	100		2,259.40	100

**Source:** China economic census yearbook 2004; Guangdong economic census yearbook 2004; Beijing economic census yearbook 2004; Tianjin economic census yearbook 2004; Jiangsu economic census yearbook 2004; Shanghai economic census yearbook 2004; Shaanxi economic census yearbook 2004.

Jiaotong University (交通大學) produces large numbers of engineers for local enterprises and the city provides a supply of labor in the field of electronics and telecommunications. This is why the well-known international enterprise Infineon Technologies has its marketing office in Shanghai but has located its national R&D center in Xi'an. Indeed, this R&D center is Infineon's largest such center in the Asia-Pacific region and its second largest worldwide. Another reason for Shaanxi's leadership in this area is the "Go West" (西部大開發) strategy initiated in 1999 in order to maintain the economic balance and social stability among the eastern, central, and western parts of China. This has attracted a lot of talented people and foreign investment to Xi'an. Susan M. Walcott, in "Chinese Industrial and Science Parks: Bridging the Gap," *Professional Geographer* 54, no. 3 (August 2002): 349-64, also notes that the development of high-tech industry in China's interior is mainly concentrated in Xi'an because of its highly-qualified labor force and supportive research centers and specialized universities.

The ICT manufacturing sector presents a very different spatial pattern from that of the ICT service sector. The manufacturing sector is concentrated in five city-regions on the eastern coast, with the highest concentration being in Guangdong Province. The ICT service sector is dispersed extensively over western and central China with the greatest concentration being in Beijing. Shanghai is the only city-region where both manufacturing and service activities have flourished.

### *Clustering, Innovation, and Performance*

1. *Spatial heterogeneity in labor productivity and capital profitability*: The rapid development and growing economic contribution of the ICT industry in China have attracted much scholarly attention, but the spatial heterogeneity of its economic performance at the national level has remained poorly understood. The 2004 economic census offered important information to fill the gap in our knowledge. Because of the important role played by the ICT manufacturing sector and the lack of data for the ICT service sector, the economic performance of the ICT industry as a whole will be evaluated here on the basis of the manufacturing sector only.

There are a few eastern coastal city-regions where labor productivity is above the national average. Beijing has the highest labor productivity, closely followed by Shanghai. The labor productivity of Beijing and Shanghai is more than twice the national average, but they suffer from very low capital profitability. The explanation for this may be that these regions have invested a huge amount of capital in costly fixed assets, such as advanced equipment, high standard factories, and so on, which helps improve their productivity but which has reaped little immediate return.

Capital profitability is also geographically uneven. Only eight city-regions are higher than the national average. Inner Mongolia is ranked first with a capital profitability of seven times the national average.<sup>68</sup> Guang-

<sup>68</sup>There are only sixteen ICT manufacturing enterprises above-scale in Inner Mongolia according to the first national economic census. However, they made profits of 12.68 billion yuan with total assets of 32.69 billion yuan and had an output value of 49.63 billion yuan with only 4,300 employees by the end of 2004. There are two main reasons for this high

dong is slightly above the national average but its labor productivity is low. Inner Mongolia, Tianjin, and Fujian are the only three city-regions where both labor productivity and capital profitability are much higher than the national average.

*2. Correlation between spatial agglomeration and economic performance:* An analysis of the combination of location quotient and regional difference in terms of capital profitability and labor productivity reveals an interesting pattern. Guangdong Province, with the highest location quotient, is lower than the national average in labor productivity but higher than the national average in capital profitability. Beijing, Shanghai, and Jiangsu are productive but not very profitable. Tianjin and Fujian are both productive and profitable. It is surprising that Inner Mongolia shows high capital profitability and labor productivity in the ICT manufacturing sector despite having no spatial concentration. It appears that spatial agglomeration may lead to higher productivity or profitability but high productivity and profitability can also occur without spatial agglomeration.

In order to further examine the relationship between spatial agglomeration (measured by employment location quotient) and both capital profitability and labor productivity in the ICT manufacturing sector, a Pearson correlation analysis has been carried out. Because data on ICT enterprises are not available in Tibet and Qinghai, these two regions are excluded from the analysis (see table 2). The results reveal that the Pearson correlation coefficients between location quotient and both capital profitability and labor productivity are low and insignificant (see table 4). This

---

level of capital profitability and labor productivity. First, although the industrial scale in terms of both number of firms and employment is small, there are several well-known and high-profit enterprises in Inner Mongolia, such as TCL and Skyworth. These enterprises have abundant capital and a high-quality team. It was reported that two enterprises (TCL television and TCL communications technology) contributed 90 percent of the output value of the entire ICT manufacturing sector in Inner Mongolia in 2004. Second, enterprises in Inner Mongolia benefit a lot from low production costs, including labor and land costs. For example, electricity costs in Inner Mongolia are reportedly half those of south China and one-third those of Beijing. If an enterprise like TCL has sufficient productive technology in its specific field, then reducing production costs is an important strategy to adopt to increase its market share. In this case, enterprises in Inner Mongolia have no doubt achieved higher profits than their counterparts in the regions of Beijing, Shanghai, and Guangdong.

Table 2

Comparison of the Spatial Distribution between the ICT Manufacturing Sector and the ICT Service Sector, 2004

Region	Manufacturing sector		Service sector	
	Employment	Location quotient	Employment	Location quotient
<b>North</b>				
Beijing (北京市)	125,500	0.72	279,500	3.45
Tianjin (天津市)	133,600	1.60	27,600	0.71
Hebei (河北省)	32,900	0.15	86,100	0.85
Shanxi (山西省)	12,900	0.09	71,000	1.07
Inner Mongolia (内蒙古)	5,100	0.08	24,200	0.84
Shandong (山东省)	179,800	0.41	121,600	0.60
<b>Northeast</b>				
Liaoning (辽宁省)	85,100	0.43	65,800	0.70
Jilin (吉林省)	13,100	0.16	64,600	1.67
Heilongjiang (黑龙江省)	7,400	0.06	128,500	2.33
<b>East</b>				
Shanghai (上海市)	271,000	1.10	148,000	1.28
Jiangsu (江苏省)	790,200	1.60	137,700	0.60
Zhejiang (浙江省)	287,300	0.69	122,100	0.63
Anhui (安徽省)	29,900	0.22	33,300	0.52
<b>Central</b>				
Jiangxi (江西省)	31,500	0.32	51,000	1.11
Henan (河南省)	24,200	0.09	67,300	0.54
Hubei (湖北省)	32,900	0.22	65,300	0.92
Hunan (湖南省)	30,100	0.19	78,500	1.09
<b>Southeast</b>				
Guangdong (广东省)	2,082,900	3.44	273,300	0.97
Guangxi (广西)	12,100	0.15	72,200	1.94
Hainan (海南省)	1,200	0.06	6,800	0.68
Fujian (福建省)	172,400	1.04	44,500	0.58
<b>Southwest</b>				
Chongqing (重庆市)	10,800	0.11	31,100	0.69
Sichuan (四川省)	98,800	0.51	96,300	1.07
Guizhou (贵州省)	13,900	0.26	32,100	1.29
Yunnan (云南省)	1,900	0.03	31,000	0.90
Tibet (西藏)	0	0	2,100	1.54
<b>Northwest</b>				
Shaanxi (陕西省)	74,900	0.77	63,800	1.41
Gansu (甘肃省)	13,900	0.22	26,100	0.87
Qinghai (青海省)	0	0	11,700	1.91
Ningxia (宁夏)	1,000	0.05	11,800	1.35
Xinjiang (新疆)	2,500	0.06	26,200	1.41

Source: Calculated from data obtained from China economic census yearbook 2004.

**Table 3**  
**Labor Productivity and Capital Profitability of ICT Manufacturing**  
**Enterprises (Above-Scale\*) by Provinces, 2004**

Region	Labor productivity (yuan/person)	Percent (national average = 100)	Capital profitability (%)	Percent (national average = 100)
<b>North</b>				
Beijing	1,233,100	<b>209.82</b>	4.28	80.55
Tianjin	1,103,300	187.73	17.07	<b>321.24</b>
Hebei	264,500	45.01	4.25	79.95
Shanxi	115,800	19.70	-0.67	-12.62
Inner Mongolia	1,154,100	<b>196.38</b>	38.79	<b>729.84</b>
Shandong	539,600	91.82	6.41	<b>120.62</b>
<b>Northeast</b>				
Liaoning	581,700	98.98	1.47	27.67
Jilin	186,500	31.73	-8.12	-152.71
Heilongjiang	356,700	60.69	1.30	24.37
<b>East</b>				
Shanghai	1,202,100	<b>204.54</b>	4.08	76.74
Jiangsu	666,900	<b>113.48</b>	4.96	93.30
Zhejiang	423,900	72.13	5.46	<b>102.82</b>
Anhui	349,200	59.42	5.53	<b>104.02</b>
<b>Central</b>				
Jiangxi	146,300	24.89	2.34	44.02
Henan	469,500	79.89	3.72	69.96
Hubei	513,900	87.44	2.93	55.20
Hunan	357,000	60.75	3.42	64.33
<b>Southeast</b>				
Guangdong	469,100	79.82	6.08	<b>114.41</b>
Guangxi	218,300	37.14	2.76	51.96
Hainan	383,800	65.31	3.46	65.04
Fujian	745,400	<b>126.83</b>	9.79	<b>184.22</b>
<b>Southwest</b>				
Chongqing	536,900	91.36	2.72	51.26
Sichuan	269,400	45.84	-12.26	-230.85
Guizhou	249,900	42.52	-0.15	-2.85
Yunnan	448,400	76.03	3.67	69.13
Tibet	—	—	—	—

Table 3 (Continued)

Region	Labor productivity (yuan/person)	Percent (national average = 100)	Capital profitability (%)	Percent (national average = 100)
<b>Northwest</b>				
Shaanxi	238,000	40.50	-3.54	66.62
Gansu	80,800	13.75	-1.91	-35.93
Qinghai	—	—	—	—
Ningxia	120,000	20.42	-5.08	-95.57
Xinjiang	269,100	45.79	6.07	114.28
Total	587,700 <sup>a</sup>	100	5.31	100

<sup>a</sup>"Above-scale" includes all state-owned enterprises and non-state-owned enterprises with an annual product sales revenue equal to or larger than five million yuan. [http://www.stats.gov.cn/was40/gjtjj\\_detail.jsp?searchword=%B9%E6%C4%A3%D2%D4%C9%CF&channelid=18938&record=70](http://www.stats.gov.cn/was40/gjtjj_detail.jsp?searchword=%B9%E6%C4%A3%D2%D4%C9%CF&channelid=18938&record=70) (accessed August 10, 2007).

<sup>#</sup>Output value of the whole country/total employees of the whole country.

Source: Calculated from data obtained from China economic census yearbook 2004.

Table 4

**Pearson Correlation Results between Location Quotient and Economic Performance, 2004**

		Capital profitability	Labor productivity
Location quotient	Pearson correlation	.146	.346
	Sig. (2-tailed)	.450	.066
	Number of observations	29	29

Note: Tibet and Qinghai are not included here because of the lack of data.

Source: China economic census yearbook 2004.

finding appears to contradict the normal theoretical expectation that agglomeration results in reduced transaction costs and therefore higher productivity. The Chinese anomaly cannot be used to totally reject the normal theoretical expectation. Nevertheless, the lack of a significant correlation between agglomeration and high productivity in the case of China does suggest that there are distinct and even exceptional dynamics in industrial agglomeration and production in China that cannot be satisfactorily explained by existing theoretical models.

**Table 5**  
**Measures of Innovative Output Generated by the ICT Manufacturing Enterprises (Above-Scale) by Province, 2004**

Region	Output value of new products (million yuan)	The average output value of new products per enterprise (million yuan)	Number of inventive patent certifications	The average number of inventive patent certifications per ten enterprises
Beijing	47,745.46	95.87	525	10.54
Tianjin	89,779.42	269.61	325	9.76
Hebei	648.332	8.88	3	0.41
Shanxi	384.14	13.25	—	—
Inner Mongolia	—	—	4	2.5
Shandong	32,814.53	71.18	65	1.41
Liaoning	6,611.55	30.47	24	1.11
Jilin	563.26	17.07	3	0.91
Heilongjiang	17.70	0.59	—	—
Shanghai	78,229.71	112.56	—	—
Jiangsu	48,537.91	29.61	199	1.21
Zhejiang	22,095	21.77	341	3.36
Anhui	1,262.84	14.52	45	5.17
Jiangxi	657.54	13.42	2	0.41
Henan	3,497.74	77.73	11	2.44
Hubei	2,313.98	25.15	139	15.11
Hunan	5,786.93	68.89	31	3.69
Guangdong	147,399.93	48.70	1497	4.95
Guangxi	374.35	7.49	47	9.40
Hainan	85.03	14.17	—	—
Fujian	48,222.70	137.00	278	7.90
Chongqing	1,016.76	42.37	—	—
Sichuan	—	—	—	—
Guizhou	738.64	24.62	—	—
Yunnan	349.12	31.74	—	—
Tibet	—	—	—	—
Shaanxi	1,079.94	16.36	44	6.67
Gansu	—	—	—	—
Qinghai	—	—	—	—
Ningxia	—	—	—	—
Xinjiang	217.70	54.42	3	7.50

**Sources:** China economic census yearbook 2004; and economic census yearbooks of corresponding regions 2004.

**Table 6**  
**Pearson Correlation Results between Location Quotient and Innovative Output, 2004**

		Average output value of new products per enterprise	Average number of inventive patent certification per ten enterprises
Location Quotient	Pearson correlation	.390	.086
	Sig. (2-tailed)	.054	.1726
	Number of observations	25*	19#

**Note:** \* Inner Mongolia, Sichuan, Tibet, Gansu, Qinghai, and Ningxia are not included because of the lack of data on output value of new products; # Shanxi, Heilongjiang, Shanghai, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Gansu, Qinghai, and Ningxia are excluded because data on the number of inventive patent certifications is not available.

**Sources:** China economic census yearbook 2004; and economic census yearbooks of corresponding regions 2004.

3. *Spatial agglomeration and innovative performance:* Innovative performance is measured by two indicators: the output value of new products and the number of inventive patent certifications. Data on output value of new products in 2004 are available for twenty-five administrative units; thus the analysis in this section is based on data from these units. There is a spatial variation in the innovative performance of China's ICT industry at the national level. The eastern coastal areas have better innovative performance than other regions in terms of both output value of new products and number of inventive patent certifications. Although the total output value of new products in Guangdong Province is much higher than that of other regions, its average output value per enterprise is lower than that of many regions (see table 5). This shows that the highest level of agglomeration does not necessarily lead to the highest innovative output. Furthermore, a Pearson correlation between location quotient and the average output value of new products per enterprise in these twenty-five regions reveals that the correlation coefficient is quite low and insignificant. Therefore, no correlation has been identified between location quotient and output value of new products in China's ICT industry (see table 6). In addition, a Pearson correlation analysis of location quotient

and the average number of inventive patent certifications held per ten enterprises in nineteen regions (see table 5) reveals no correlation between location quotient and inventive patent certification either (see table 6). Again, the Chinese case turns out to be an anomaly that deviates from the theoretical expectation. In contrast to the normal situation in which industrial agglomeration facilitates knowledge spillover, technological collaboration, and innovation as described in many of the existing theoretical models, our analysis of the Chinese case presents no convincing evidence to suggest that there is a definitive and positive relationship between agglomeration and innovation. While the Chinese case cannot be used to deny the existence of such a relationship in many regions of the world, it does suggest that there are noticeable irregularities in China that require further investigation. A single case study cannot totally invalidate the well-received conventional wisdom. Nevertheless, the peculiar Chinese case cannot be fully and satisfactorily explained by the existing theoretical models.

#### *Growth and Distribution of the ICT Industry in Guangdong Province*

Guangdong Province is selected to further examine the relationship between industrial clustering and technological innovation. As noted above, Guangdong Province accounts for more than one-third of China's total employment in the ICT industry (see table 1). Furthermore, its manufacturing sector is ranked first in terms of employment location quotient, with a much higher quotient than that of other regions (see table 2). In view of this, a detailed examination of the ICT industry in Guangdong Province will offer a good indication of the future development trajectory of the ICT industry in China as a whole. Theoretically, one would expect Guangdong's ICT manufacturing enterprises to have better economic performance and a higher degree of technological innovation than their counterparts elsewhere. However, close analysis reveals that Guangdong's economic performance as measured by labor productivity and capital profitability is average and its innovative performance as measured by the average output value of new products and the average number of inventive patent certifications is actually worse than that of

**Table 7**  
**ICT Industry in Shenzhen and Dongguan, 2004**

	Number of firms	Employment
Shenzhen	2,992	802,200
Dongguan	1,992	539,200
Guangdong	8,833	2,082,900
Ratio of Shenzhen to Guangdong	34%	39%
Ratio of Dongguan to Guangdong	23%	26%

**Sources:** China economic census yearbook 2004; and Guangdong economic census yearbook 2004.

many other regions. In order to gain further insight into the ICT industry in Guangdong Province, this paper probes the various linkages among 266 ICT manufacturing enterprises in Shenzhen and Dongguan based on a questionnaire survey conducted in 2006. The survey was conducted in Shenzhen and Dongguan because these two cities accounted for 57 percent of the enterprises and 65 percent of the total workforce in Guangdong Province (see table 7). The purpose of the questionnaire survey is to examine the dynamic linkages within the ICT manufacturing cluster, including productive interaction, the circulation of knowledge and information, cooperation in R&D activities, and the flow of employees.

The location selection of an enterprise can reflect whether or not it has the motive to interact with other local enterprises. When asked why they selected the Shenzhen-Dongguan area as their investment location, 36 percent of 263 enterprises (3 enterprises did not or would not answer this question) indicated that proximity to main customers or suppliers was the chief attraction. This indicates that these enterprises are motivated to seek the agglomeration effect, including the intensification of production linkages, reduction of production costs, and the opportunity to observe and imitate their competitors. Twenty-two percent of enterprises indicated that an important reason for locating in this area was its proximity to ports and 11 percent valued low labor costs most highly (see table 8). Approximately 70 percent of enterprises in this area pursued local production linkages and put a great deal of emphasis on cost-reduction, including production,

**Table 8**  
**The Most Important Reason for Location**

<i>Reasons for location</i>	<i>Frequency</i>	<i>Percent</i>
Industrial clustering, and nearness to main customers or suppliers	95	36.1
Local market potential	21	8.0
High-qualified professional service	4	1.5
Human resource (technological and management)	25	9.5
Favorable policies	15	5.7
Near to port	59	22.4
Lower labor costs	29	11.0
Cooperation with local universities and research institutes	1	0.4
Supportive infrastructure	14	5.3
Total	263	100.0

transaction, and time costs. However, there is no significant evidence that they were motivated by a desire to exchange knowledge and technology or to intensify R&D cooperation. Only one of the 263 enterprises indicated a desire to cooperate with local universities and research institutes. This could be explained by the lack of supportive universities and research institutes in this area.

1. *Local linkages among ICT enterprises in the Shenzhen-Dongguan area:* Local linkage is one of the most important characteristics of an industrial cluster. In this paper, the intensity of local linkages is measured by the ratio of local suppliers and customers to total suppliers and customers for an ICT manufacturing enterprise. The 266 enterprises surveyed were asked to report the ratio of their customers located in the Pearl River Delta (PRD 珠江三角洲) to their total customers. Although 26 percent of all enterprises had no downstream linkages in the PRD, 34 percent reported that at least half of their customers were located there. In terms of upstream linkages, less than 10 percent of the 249 enterprises had no production linkages with local suppliers (those within two-hour distance). However, nearly 50 percent of them had strong local linkages; that is, more than 50 percent of their suppliers were local enterprises. Only 6 percent had neither upstream nor downstream linkages with local enterprises, while around

Table 9

Local Linkages among ICT Enterprises in the Shenzhen-Dongguan Area

	Customers in PRD area		Suppliers within two-hour distance	
	Frequency	Percent	Frequency	Percent
0	69	25.9	24	9.6
1-25%	57	21.4	54	21.7
26-50%	49	18.4	50	20.1
51-75%	29	10.9	32	12.9
76-100%	62	23.3	89	35.7
Total	266	100.0	249	100.0

20 percent had both strong upstream and downstream linkages (see table 9). In a word, local linkages based on production are very strong among enterprises in the Shenzhen-Dongguan area, and thus the area is well-qualified to be termed an ICT industrial cluster.

2. *R&D cooperation and exchange of R&D information and employees*: According to the theory of learning and knowledge spillover, industrial clusters facilitate the flow of knowledge and information, stimulate mutual learning, intensify R&D cooperation, and hence may be conducive to technological innovation. In this section, we will examine the R&D linkages and the exchange of knowledge within the Shenzhen-Dongguan ICT industrial cluster by analyzing the source of core technology, the status of R&D cooperation, the frequency of exchange of R&D employment, and exchange of knowledge and information within the industrial cluster.

Most enterprises acquire their core technology neither from knowledge spillover inside the cluster nor from imports of technology from outside the area, but from in-house R&D activities in the Shenzhen-Dongguan area. Out of 263 enterprises, 73 percent obtained their core technology in this way (see table 10). Only 8 percent of enterprises imported core technology from other enterprises within China; thus the proportion importing core technology from local enterprises must be much less than 8 percent. This finding indicates that geographical proximity has not speeded up the flow of technology and knowledge in this area.

**Table 10****Sources of Core Technology**

Sources of core technology	Frequency	Percent
No R&D or technological imports	6	2.3
In-house R&D and innovative activities	191	72.6
Imports of foreign technology with modification through use	19	7.2
From other domestic enterprises	21	8.0
Imports of foreign technology without any modification through use	22	8.4
From domestic universities and research institutes	4	1.5
Total	263	100.0

**Table 11****Importance of R&D Cooperation with Other Domestic Enterprises**

	Frequency	Percent
None	211	79.3
Unimportant	5	1.9
Medium	11	4.1
Important	31	11.7
Very important	8	3.0
Total	266	100.0

R&D cooperation was actually considered unnecessary and unimportant in this cluster. Many of the enterprises did not cooperate with their neighbors at all in terms of R&D and they considered such cooperation as unimportant for innovation. Only 12 percent of enterprises considered that R&D cooperation was important and a mere 3 percent considered it very important, while as many as 79 percent reported that they had never engaged in such cooperation with other local enterprises (see table 11).

Although the enterprises surveyed reported extensive production linkages, the exchange of R&D employment and information was infrequent, which seems to contradict existing theories. There was no exchange of R&D employment with other local enterprises among 75 percent of the respondents and 80 percent did not exchange ideas or information con-

**Table 12****Frequency of Exchange of R&D Employees and R&D Information**

Frequency of exchange	Exchange of R&D employees (%)	Exchange of R&D information (%)
None	74.8	80.1
Seldom	4.1	6.4
Medium	12.8	8.6
Frequent	7.1	3.0
Very frequent	1.1	1.9
Total	100.0	100.0

cerning R&D and technological innovation with others in this area. Only 1 percent of all enterprises claimed that the exchange of R&D employment was very frequent and 2 percent claimed that the exchange of R&D information was very frequent.

All of our analyses thus far have revealed that enterprises in the Shenzhen-Dongguan area were interested in reducing their production, transaction, or time costs by locating close to suppliers, customers, and supportive enterprises, or near to port facilities. However, their original location choice was not influenced by local linkages involving R&D cooperation or exchange of information and knowledge. There are strongly localized production linkages but there is seldom R&D cooperation, exchange of R&D information, or flow of employees among enterprises in the cluster. First, most enterprises are able to create their core technology through in-house R&D activities. Second, most enterprises conduct R&D or innovative activities on their own without any cooperation from other local enterprises. Finally, the dense clustering in the area does not lead to frequent exchanges of R&D employment and knowledge or information. In brief, the dense clustering in the Shenzhen-Dongguan area intensifies production linkages but fails to facilitate R&D cooperation or the exchange of knowledge and information.

It is intriguing that geographical proximity, while being conducive to local production linkages, fails to facilitate knowledge spillover in the case of the ICT industry of southern China. In order to make sense of this

**Table 13**  
**Economic Indicators of Eight ICT Manufacturing Subsectors in Guangdong Province, 2004**

Industry code*	Employment	Total asset (billion yuan)	Annual revenue (billion yuan)
4000	208,290	4,964.44	8,239.65
4010	24,870 (11.94%)	1,315.70 (26.50%)	1,691.52 (20.53%)
4020	190 (0.09%)	0.74 (0.01%)	1.04 (0.01%)
4030	3,730 (1.79%)	42.36 (0.85%)	57.01 (0.69%)
4040	41,050 (19.71%)	1,199.29 (24.16%)	3,055.06 (37.08%)
4050	22,160 (10.64%)	605.04 (12.19%)	808.53 (9.81%)
4060	70,200 (33.70%)	992.25 (19.99%)	1,187.61 (14.41%)
4070	39,250 (18.84%)	726.19 (14.63%)	1,340.93 (16.27%)
4090	6,830 (3.28%)	82.87 (1.67%)	97.94 (1.19%)

\* Industry code: 4000: manufacturing of telecommunications equipment, computer, and other electronic equipment; 4010: manufacturing of telecommunications equipment; 4020: manufacturing of radar and related equipment; 4030: manufacturing of broadcasting and television equipment; 4040: manufacturing of electronic computers; 4050: manufacturing of electronic devices; 4060: manufacturing of electronic components; 4070: manufacturing of audio and video equipment; 4090: manufacturing of other electronic equipment.

**Note:** Figures in parentheses are ratios of subsectors to sector 4000.

**Source:** Guangdong economic census 2004.

anomaly, we conducted in-depth interviews in Shenzhen's mobile phone industry. There are three reasons for selecting the telecommunications equipment subsector for these interviews. First, although this subsector is not the largest of the eight subsectors in terms of employment, it does rank first in terms of total assets and second in terms of annual revenue (see table 13). Second, the purpose of the interviews was to understand why Guangdong has performed so poorly in terms of innovation despite its high level of geographical clustering, and the mobile phone industry serves this purpose well. Despite the fact that the number of above-scale firms in this subsector represents only 11 percent of the total for the whole of the ICT manufacturing sector, the mobile phone industry contributed 34 percent of the total output value of new products of the whole ICT manufacturing sector (see table 14). Every single indicator of S&T activity and

**Table 14**  
**S&T Activity and Innovation of Above-Scale Enterprises in Eight ICT Manufacturing Subsectors in Guangdong Province, 2004**

Industry code	Firm number	Employees engaged in S&T activities	Output value of new products (million yuan)	Inventive patent applications	Inventive patent certifications
4000	3,027	68,469	14,740	2,572	1,497
4010	326	30,790	5,001	2,280	939
4020	3	—	—	—	—
4030	105	705	18.75	7	12
4040	464	16,114	3,666.70	65	215
4050	358	3,371	967.91	25	51
4060	1,067	8,565	1,076.42	45	136
4070	552	8,019	3,993.26	130	108
4090	152	905	15.43	20	36

**Note:** — denotes that data are not available.

**Source:** Same as table 13.

innovation in table 14 indicates that this industry has an absolute advantage in terms of innovative performance over the other seven subsectors. Furthermore, it accounted for almost all the inventive patent applications of the whole ICT manufacturing sector and for 63 percent of the inventive patent certifications issued to the sector. Our final reason for selecting this subsector was that limited resources forced us to be focused and selective in our intensive interviews.

Our in-depth interviews have generated a great deal of interesting information. Among many others, two important points are helpful in understanding the peculiar pattern of industrial agglomeration without innovation identified in the previous sections. First, intense competition among firms has impeded communications among enterprises in the local cluster. The mobile phone industry is very different from other industries in that enterprises that want to produce mobile phones are supposed to apply for a license from the Ministry of Information Industry. In order to qualify, the applicant must have more than two billion yuan in registered funds, more than three years' sales achievement, and the ability to carry out in-house R&D. Although this policy has barred many enterprises from

entering the subsector, it has not stopped the unlicensed production and sale of mobile phones. The high profits to be gained from the manufacturing of mobile phones have attracted many enterprises, and Shenzhen, with its free and open industrial environment, has become a center of mobile phone manufacturing, both licensed and unlicensed. The flourishing mobile phone manufacturing and assembly business has boosted the development of upstream suppliers, thus encouraging more and more related enterprises to concentrate in Shenzhen. A relatively intact value chain has been established.

However, this dense clustering to a large extent hampers communications among competitors. One manager we interviewed admitted to being reluctant to communicate with competitors. These firms depend on new ideas or designs for their survival, and to communicate them to other enterprises would be to risk having new ideas stolen.

The second point to emerge from the interviews is that the core technology involved in mobile phone manufacturing is mature and has been gradually standardized. Indeed, most enterprises in Shenzhen only focus on innovation in the function and appearance of mobile phones. Enterprises in Shenzhen believe that they can conduct simple innovations of this kind independently. This survey indicates that chip manufacturing is one of the most difficult and complex processes in the manufacturing of mobile phones. Manufacturers and assemblers have tended to purchase their chips from foreign companies such as Texas Instruments, Infineon, Qualcomm, and Media Tek, and therefore the only innovative activities they are engaged in are so-called peripheral innovations, namely new designs and new but simple functions. Most enterprises in the area already have a good grasp of this kind of peripheral technology and continuously adjust it to the market. Therefore, they have no need to cooperate with other enterprises in terms of R&D or innovation. Furthermore, the city-region's poor record on intellectual property rights protection means that peripheral innovations of this kind can only produce short-term profits because they are very easy to imitate. For this reason, enterprises are reluctant to communicate with others before their new products come onto the market.

## **Discussion and Conclusion**

Over the past decade, China's ICT industry has achieved rapid growth both in terms of the number of firms established and the size of the workforce. The present authors have carried out an overall assessment of China's ICT industry using data mainly obtained from the first national economic census of 2004. The development of a high-tech industry like ICT has to a large extent been affected by national S&T policies and the evolution of China's innovation system. The ICT industry, especially the service sector, did not develop under the Mao regime. It was not until the 1990s that the industry started to expand. The period from 2000 to 2004 witnessed a sharp increase in the number of manufacturing and service enterprises. However, this rapid growth did not occur evenly across different regions of China. An analysis of the geographical distribution of the industry reveals that the ICT manufacturing sector has had a strong tendency to concentrate along the eastern coast, while the service sector has been extensively distributed in central and western areas of the country.

The highest degree of spatial agglomeration in the industry, in Guangdong, has not produced a correspondingly high level of economic performance and innovation. Several correlation analyses at the national level disclose that there is no significant relationship between spatial agglomeration and either economic or innovative performance in China's ICT manufacturing sector. A case study of the ICT industrial cluster in southern China reveals that geographical proximity has failed to inspire R&D cooperation and speed up the flow of knowledge and information, although it has intensified local production linkages.

This study has important implications for research on high-tech industrial clusters in China. First, the debate over the relationship between industrial clustering on the one hand and economic performance and innovation on the other is based on the experiences of successful regions in the West. This body of literature focuses on endogenous process versus exogenous force, and urbanized economies versus localized economies, but it has overlooked the effects of clustering on knowledge spillover in regions at different stages of development. Although China has achieved

technological breakthroughs in selected fields and gradually established its own technology base, it is still a technological follower in many fields. Therefore, even though China's ICT industry is regarded as "high-tech," its core technology still comes from advanced countries. In this sense, innovation in Shenzhen is mainly "peripheral," consisting of simple changes of product appearance and function. However, this does not mean that China has no potential to carry out core innovation in the future. The ICT industrial cluster in Shenzhen is still in its fledgling stage. Most enterprises pay more attention to cost-reduction than to the innovation of core technology. They import core technology from advanced countries and modify it in order to acquire a short-term competitive advantage. This is unlikely to have the effect of intensifying R&D cooperation or facilitating the flow of knowledge and information. However, the industrial cluster is evolving along with industrial development. Knowledge spillover and learning processes may occur when enterprises in this cluster can no longer make profits merely by reducing their costs or carrying out peripheral innovation.

Another finding in this research is that the relationship between industrial clustering and technological innovation may be more complicated than how it is described in the existing literature, which is derived primarily from the experiences of advanced economies in the West. Although there is abundant evidence to support the theoretical interpretation of a positive relationship between industrial clustering and technological innovation, the Chinese experience appears to deviate from the theoretical norm. While this anomaly does not mean that we can totally reject the well-established theoretical models, it does suggest that there exist significant irregularities for which conventional wisdom can offer no satisfactory explanation. Theoretically, this may suggest that the relationship between clustering and innovation is not independent of regional conditions. The positive relationship between clustering and innovation may work in some locations (e.g., Silicon Valley) but not in others (e.g., high-tech parks in China). It would be meaningless to discuss the relationship between industrial clustering and technological innovation outside a place-specific regional context. In the case of Shenzhen's ICT industry, institutions constitute an

important factor affecting innovation. On the one hand, the state has introduced a number of regulations to govern firm behavior, while on the other, the laissez-faire attitude of the local government or its limited ability to regulate, say, the mobile phone industry has permitted the establishment of unlicensed enterprises, engendered excessive competition, and developed an environment of distrust. The lack of protection for intellectual property rights has also to a large extent stifled enthusiasm for innovation among ICT enterprises. In this unfavorable institutional environment, enterprises would rather make a quick profit by imitating others than invest in high-risk innovation. In view of the complicated regional variation identified in this study, a situational, place-specific, and contextually sensitive approach would be more appropriate in depicting the relationship between industrial clustering and technological innovation in different regions of a globalizing world.

In recent years, it has become fashionable for local governments to establish high-tech parks as a means of fostering better economic performance and technological innovation. Our analysis has found no convincing evidence to confirm the popular perception that industrial agglomeration necessarily leads to high productivity and technological innovation. What really matters is not the degree of concentration but rather the institutional environment within which production and innovation take place. It would be futile for local governments to mark out a designated zone and force related or even competing firms to locate within it. A more effective approach would be for these local governments to provide a supportive institutional environment while at the same time encouraging and stimulating innovation among industrial enterprises.

Finally, this study is based on a statistical analysis of aggregate national census data and our own case study in the Shenzhen-Dongguan region. Future studies are needed to investigate the innovative capability of China's ICT industry in other regions of the country. The ICT industrial clusters in Beijing and Shanghai are different from the ones we have looked at in southern China. In Beijing, the industry is supported by well-known universities and research institutes, and the innovative capability of Shanghai is promoted to a large extent by enterprises whose founders returned

from the West with advanced technologies and ideas.<sup>69</sup> Furthermore, the local culture and policies pertaining to the ICT industry in different regions are also important subjects for comparative study.

## APPENDIX

The 2004 economic census was the first national census of its kind in China. It combined the second national tertiary industry census (which had been scheduled for 2003), the fourth national industry census (scheduled for 2005), and the third national basic units census (scheduled for 2006), and also encompassed the construction industry. This economic census consisted of 19 sections and 875 classes in line with the national economic industry classification standard. This makes it the most comprehensive census in China's history. The purpose of the economic census was to comprehensively examine the real situation of the scale, structure, and efficiency of China's secondary and tertiary industry, to produce accurate data upon which to base national economic and social development planning, and to lay a statistical foundation for better management and decision-making. The economic census will be conducted twice a year in the future. Preparation for the first census began at the beginning of 2004 when certain districts and counties in Beijing, Sichuan, Zhejiang, and Jilin were selected as test sites by the Office of the Leading Group of the First National Economic Census, directly under the State Council. On the basis of information gathered in these four test sites, and suggestions from all relevant departments, the Leading Group of the First National Economic Census submitted a proposal for a nationwide economic census to the State Council. The proposal was approved in September 2004 and census work began on January 1, 2005. The standard time for the census was December 31, 2004. The census was conducted in four phases. In addition to the preliminary phase from January to

<sup>69</sup>The most typical example is Spreadtrum Communications (Shanghai) Co., Ltd. (展訊通信 [上海]有限公司), founded in 2001 in Shanghai. Its founder is a Chinese engineer with many years' experience working in Silicon Valley. Spreadtrum has focused on independent technological innovation from the outset and it has successfully developed the world's first single chip TD-SCDMA/GSM dual mode solution and the first advanced GSM/GPRS baseband chip. Coupled with the corresponding software and handset reference design solutions, the core chips have been adopted by several handset manufacturers. This has given Spreadtrum a national market-share comparable to that of manufacturers in advanced countries, such as TI, Infineon, and Media Tek. The success of Spreadtrum in this field shows that Chinese domestic enterprises are able to carry out innovation of core products in the ICT industry. See <http://www.spreadtrum.com/eng/about.asp?name=about> (accessed August 20, 2007).

December 2004, in the second phase (January-May 2005) the census forms were completed. Data processing and reports took place in the period February-August 2005. Then data was evaluated and released at the end of 2005. The census involved over ten million people and cost over ten billion *yuan*. It covered all corporation units (5.17 million), establishments (6.82 million), and individual proprietors (39.22 million) engaged in secondary or tertiary industry within the borders of the People's Republic of China, excluding the Hong Kong Special Administrative Region and the Macao Special Administrative Region. The main work of this economic census was to collect data on the basic attributes of all these units, their employment, financial situation, production and sales, productive capability, consumption of raw materials and energy, science and technology activities, and so on. The census covered all corporation units and establishments, but only targeted a sample of individual proprietors on account of the huge numbers in this group. The statistical data was synthetically evaluated and revised by the National Bureau of Statistics. The census provided important reference material for drawing up the Eleventh Five-Year Plan and served as a benchmark for revising data collected in previous surveys.

#### BIBLIOGRAPHY

- Acs, Zoltan J., and Attila Varga. 2002. "Geography, Endogenous Growth, and Innovation." *International Regional Science Review* 25, no. 1 (January): 132-48.
- Amighini, Alessia. 2005. "China in the International Fragmentation of Production: Evidence from the ICT Industry." *The European Journal of Comparative Economics* 2, no. 2:203-19.
- Asheim, Bjørn T. 1999. "Interactive Learning and Localized Knowledge in Globalizing Learning Economies." *GeoJournal* 49, no. 4:345-52.
- Audretsch, David B. 1998. "Agglomeration and the Location of Innovative Activity." *Oxford Review of Economic Policy* 14, no. 2 (Summer): 18-29.
- . 2003. "Globalization, Innovation, and the Strategic Management of Places." In *Innovation Clusters and Interregional Competition*, edited by Johannes Bröcker, Dirk Dohse, and Rüdiger Soltwedel, 11-27. Berlin: Springer.
- , and Maryann P. Feldman. 1996. "R&D Spillovers and the Geography of Innovation and Production." *American Economic Review* 86, no. 3 (June): 630-40.

- Baptista, Rui, and Peter Swann. 1998. "Do Firms in Clusters Innovate More?" *Research Policy* 27, no. 5 (September): 525-40.
- Bathelt, Harald. 2005. "Geographies of Production: Growth Regimes in Spatial Perspective (II)—Knowledge Creation and Growth in Clusters." *Progress in Human Geography* 29, no. 2 (April): 204-16.
- \_\_\_\_\_, Anders Malmberg, and Peter Maskell. 2004. "Clusters and Knowledge: Local Buzz, Global Pipelines, and the Process of Knowledge Creation." *Progress in Human Geography* 28, no. 1 (February): 31-56.
- Breidne, Magnus. 2005. "Information and Communications Technology in China: A General Overview of the Current Chinese Initiatives and Trends in the Area of ICT." In *VINNOVA Report*. Stockholm: VINNOVA.
- Breschi, Stefano, and Francesco Lissoni. 2001. "Knowledge Spillovers and Local Innovation Systems: A Critical Survey." *Industrial and Corporate Change* 10, no. 4 (December): 975-1005.
- Camagni, Roberto P., ed. 1991. *Innovation Networks: Spatial Perspectives*. London: Belhaven.
- Cooke, Philip, Nick Clifton, and Mercedes Oleaga. 2005. "Social Capital, Firm Embeddedness, and Regional Development." *Regional Studies* 39, no. 8 (November): 1065-77.
- Ding, Hung-bin. 2000. "International Technology Transfer to China: The Case of Biotechnology." *Issues & Studies* 36, no. 2 (March/April): 133-54.
- Döring, Thomas, and Jan Schnellenbach. 2006. "What Do We Know about Geographical Knowledge Spillovers and Regional Growth? A Survey of the Literature." *Regional Studies* 40, no. 3 (May): 375-95.
- Ellison, Glenn, and Edward L. Glaeser. 1997. "Geographic Concentration in U.S. Manufacturing Industries: A Dartboard Approach." *Journal of Political Economy* 105, no. 5 (October): 889-927.
- Fan, Cindy C., and Allen J. Scott. 2003. "Industrial Agglomeration and Development: A Survey of Spatial Economic Issues in East Asia and a Statistical Analysis of Chinese Regions." *Economic Geography* 79, no. 3 (July): 295-319.
- Feldman, Maryann P. 1994. *The Geography of Innovation*. Dordrecht: Kluwer.
- \_\_\_\_\_. 1999. "The New Economics of Innovation, Spillovers, and Agglomeration: A Review of Empirical Studies." *Economics of Innovation and New Technology* 8, no. 1/2:5-25.

- Fingleton, Bernard, Danilo C. Iglori, and Barry Moore. 2005. "Cluster Dynamics: New Evidence and Projections for Computing Services in Great Britain." *Journal of Regional Science* 45, no. 2 (May): 283-311.
- Fischer, Manfred M., ed. 2006. *Innovation, Networks, and Knowledge Spillovers*. Berlin: Springer.
- Geroski, Paul. 1995. "Markets for Technology: Knowledge, Innovation, and Appropriability." In *Handbook of the Economics of Innovation and Technological Change*, edited by Paul Stoneman, 90-131. Oxford: Blackwell.
- Grabher, Gernot. 1993. "Rediscovering the Social in the Economics of Inter-firm Relations." In *The Embedded Firm: On the Socioeconomics of Industrial Networks*, edited by Gernot Grabher, 1-31. London and New York: Routledge.
- Hakanson, Lars. 2005. "Epistemic Communities and Cluster Dynamics: On the Role of Knowledge in Industrial Districts." *Industry and Innovation* 12, no. 4:433-63.
- Howells, Jeremy R. L. 2002. "Tacit Knowledge, Innovation, and Economic Geography." *Urban Studies* 39, no. 5/6 (May): 871-84.
- Hu, Tai-shan, Chien-yuan Lin, and Su-li Chang. 2005. "Role of Interaction between Technological Communities and Industrial Clustering in Innovative Activity: The Case of Hsinchu District, Taiwan." *Urban Studies* 42, no. 7 (June): 1139-60.
- Hudson, Ray. 1999. "The Learning Economy, the Learning Firm, and the Learning Region: A Sympathetic Critique of the Limits to Learning." *European Urban and Regional Studies* 6, no. 1 (January): 59-72.
- Katsuno, Masahiro. 2005. "Status and Overview of Official ICT Indicators for China." *OECD Working Papers*. <http://oberon.sourceoecd.org/vl=18652493/cl=11/nw=1/rpsv/cgi-bin/wppdf?file=5lgsjvhv74s6.pdf>.
- Keeble, David, and Frank Wilkinson. 1999. "Collective Learning and Knowledge Development in the Evolution of Regional Clusters of High Technology SMEs in Europe." *Regional Studies* 33, no. 4 (June): 295-303.
- \_\_\_\_\_, eds. 2000. *High-Technology Clusters, Networking, and Collective Learning in Europe*. Aldershot: Ashgate.
- Khalil, Mohsen A., and Javed Hamid. 2005. "The ICT Landscape in the PRC: Market Trends and Investment Opportunities." [http://www.ifc.org/ifcext/eastasia.nsf/Attachments/ByTitle/IFCReport\\_Chinese/\\$FILE/Report+V.2.0.pdf](http://www.ifc.org/ifcext/eastasia.nsf/Attachments/ByTitle/IFCReport_Chinese/$FILE/Report+V.2.0.pdf).

- Lu, Qiwen. 2000. *China's Leap into the Information Age: Innovation and Organization in the Computer Industry*. Oxford: Oxford University Press.
- Malmberg, Anders. 1996. "Industrial Geography: Agglomeration and Local Milieu." *Progress in Human Geography* 20, no. 3:392-403.
- \_\_\_\_\_, and Dominic Power. 2005. "(How) Do (Firms in) Clusters Create Knowledge?" *Industry and Innovation* 12, no. 4 (December): 409-31.
- Marshall, Alfred. 1920. *Principles of Economics: An Introductory Volume*, eighth edition. London: Macmillan.
- Meng, Qingxuan, and Mingzhi Li. 2002. "New Economy and ICT Development in China." *Information Economics and Policy* 14, no. 2 (June): 275-95.
- National Bureau of Statistics (國家統計局). 2004. *Zhongguo jingji pucha nianjian* (中國經濟普查年鑒, China economic census yearbook). Beijing: Zhongguo tongji chubanshe.
- OECD, and Eurostat. 2005. "Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data."
- Oinas, Paeivi. 2000. "Distance and Learning: Does Proximity Matter?" In *Knowledge, Innovation, and Economic Growth: The Theory and Practice of Learning Regions*, edited by Frans Boekema, Kevin Morgan, Silvia Bakkers, and Roel Rutt, 57-69. Cheltenham, UK: Edward Elgar.
- Pecht, Michael. 2006. *China's Electronics Industry: The Definitive Guide for Companies and Policy Makers with Interests in China*. New York: William Andrew Publishing.
- Porter, Michael E. 1990. *The Competitive Advantage of Nations*. New York: Free Press.
- \_\_\_\_\_. 1998. "Clusters and the New Economics of Competition." *Harvard Business Review* 76, no. 6 (November-December): 77-90.
- \_\_\_\_\_. 2000a. "Location, Competition, and Economic Development: Local Cluster in a Global Economy." *Economic Development Quarterly* 14, no. 1 (February): 15-34.
- \_\_\_\_\_. 2000b. "Locations, Clusters, and Company Strategy." In *The Oxford Handbook of Economic Geography*, edited by Gordon L. Clark, Meric S. Gertler, and Maryann P. Feldman, 253-89. Oxford: Oxford University Press.
- Powell, Walter W., and Stine Grodal. 2005. "Networks of Innovators." In *The Oxford Handbook of Innovation*, edited by Jan Fagerberg, C. David Mowery, and R. Richard Nelson, 56-114. New York: Oxford University Press.

- Saxenian, Annalee. 1994. *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge, Mass.: Harvard University Press.
- \_\_\_\_\_. 1996. "Inside-Out: Regional Networks and Industrial Adaptation in Silicon Valley and Route 128." *Cityscape: A Journal of Policy Development and Research* 2, no. 2 (May): 41-60.
- Scherer, Frederic M. 1986. *Innovation and Growth: Schumpeterian Perspectives*. Cambridge, Mass.: MIT Press, 1986.
- Schumpeter, Joseph A. 1934. *The Theory of Economic Development*. Translated by Redvers Opie. Cambridge, Mass.: Harvard University Press.
- Segal, Adam. 2003. *Digital Dragon: High-Technology Enterprises in China*. London: Cornell University Press.
- Simmie, James. 2002. "Knowledge Spillovers and Reasons for the Concentration of Innovative SMEs." *Urban Studies* 39, no. 5/6 (May): 885-902.
- \_\_\_\_\_. 2003. "Innovation and Urban Regions as National and International Nodes for the Transfer and Sharing of Knowledge." *Regional Studies* 37, no. 6/7 (August): 607-20.
- \_\_\_\_\_. 2004. "Innovation and Clustering in the Globalized International Economy." *Urban Studies* 41, no. 5/6 (May): 1095-1112.
- \_\_\_\_\_, and James Sennett. 1999. "Innovative Clusters: Global or Local Linkages?" *National Institute Economic Review* 170, no. 1 (October): 87-98.
- Simon, Denis Fred, and Merle Goldman, eds. 1989. *Science and Technology in Post-Mao China*, Harvard Contemporary China Series Cambridge, Mass.: Harvard University Press.
- Sun, Yifei. 2002. "Sources of Innovation in China's Manufacturing Sector: Imported or Developed In-House?" *Environment and Planning A* 34, no. 6: 1059-72.
- Suttmeier, Richard P., and Xiangkui Yao. 2004. "China's Post-WTO Technology Policy: Standards, Software, and the Changing Nature of Techno-Nationalism." <http://www.nbr.org/publications/specialreport/pdf/SR7.pdf>.
- Tödtling, Franz. 1994. "The Uneven Landscape of Innovation Poles: Local Embeddedness and Global Networks." In *Globalization, Institutions, and Regional Development in Europe*, edited by Ash Amin and Nigel Thrift, 68-90. New York: Oxford University Press.
- \_\_\_\_\_, Patrick Lehner, and Michaela Trippl. 2006. "Innovation in Knowledge-Intensive Industries: The Nature and Geography of Knowledge Links."

- Watts, H. D., A. M. Wood, and P. Wardle. 2003. "Making Friends or Making Things?": Interfirm Transactions in the Sheffield Metal-Working Cluster." *Urban Studies* 40, no. 3 (March): 615-30.
- Wolfe, David A., and Meric S. Gertler. 2004. "Clusters from the Inside and Out: Local Dynamics and Global Linkages." *Urban Studies* 41, no. 5/6 (May): 1071-93.
- Zhou, Yu, and Tong Xin. 2003. "An Innovative Region in China: Interaction between Multinational Corporations and Local Firms in a High-Tech Cluster in Beijing." *Economic Geography* 79, no. 2 (April): 129-52.

