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Innovation Capacity Comparison of China's Information Technology Industrial Clusters: The Case of Shanghai, Kunshan, Shenzhen and Dongguan

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ABSTRACT *The aim of this paper is twofold: first, to explore the effects of industrial cluster on innovation capacity, and second, to study the impact of external resources on firms' innovation capacity especially under Chinese regional economic policy. This is a critical subject that lacks sufficient analysis. Through years of investment and effort, several IT industrial clusters have developed in China with Shanghai, Kunshan, Shenzhen and Dongguan the better-known examples. These IT industrial clusters were chosen for an empirical study on the disparities in China's innovation capacity. All of the innovation capacity determinants at these four IT industrial clusters were different. It was confirmed that the regional dimension of Chinese economic policy affects firms' innovation capacity in the industrial cluster. The results also show whether the regional policy differences will moderate the cluster effect on innovation.*

1. Introduction

In the last decade, a growing interest in the industrial clustering phenomenon has occurred. The presence of a cluster helps increase information flow and the likelihood of innovation and new businesses from spin-offs, downstream, upstream and in related industries.[1] This issue has been researched by regional and urban economists and they have provided theoretical analyses of industrial location choice.[2] Porter[3] and Krugman[4] have been particularly influential in the increasing number of theoretical and empirical studies concerning industrial clusters involving both industrial organization and international trade.

Industrial clusters are defined as groups of related firms located in one geographical region or centered within one of a nation's science-based parks.[5] Firms located in an industrial cluster enjoy strong local demand and reduced consumer search costs.

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The supply-side benefits include technology spillovers, specialized labor, infrastructure benefits and informational externalities.[6] It has been found that a firm is more likely to innovate if it is located in a region where firms from its own industry have a strong presence.[7] In recent years, much literature on China's regional and provincial growth and on the economic disparities among the Chinese provinces has been produced. This large volume of literature is due to the confluence of two streams of scholarly interest. The first stream is China specific. Within China, and within the China research community, there has long been an interest in the problems in regional equity and industrialization patterns. The second stream consists of the new economic growth theories that have achieved prominence within the international community of economists.[8] Numerous researches have discussed the evolution of the disparities between the Chinese regions.[9] The regional dimension is thus very important in Chinese economic policy.[10] Burn and Renard[11] argued the positive effect of openness on the degree of industrial specialization in the Chinese regions using econometric analysis. However, although openness has a favorable effect on specialization, the latter is, of course, subject to other effects, such as the extent of economic activity, which can, on the contrary, encourage a certain diversification. Economists have long recognized that resource owners increase productivity through cooperative specialization.[12]

China began its transition from a planned to a market economy towards the end of the 1970s. By first improving incentives and microeconomic efficiency and then focusing on the allocation of newly created resources to more productive sectors, economic reform in China followed a gradualist approach with the Pareto-improvement characteristic.[13] China's reform approach in terms of stimulating economic growth has attracted much attention. In the last decade, the Chinese government has targeted information technology (IT) as a critical task for development through opening its market to foreign investment. Its goal is to reduce the dependence on technology-intensive product imports and to build domestic innovation capacity. Industrial clustering plays a pivotal innovation role in China. Most IT firms in China are process-innovation oriented operations that offer an 'operation excellence' value proposition according to Hope and Hope's[14] definition. Essentially, the organization of a firm formed around innovation goes through the usual transformations that entrepreneurial organizations experience as they become successful and shift their focus from innovative products to larger-scale standardized production.[15] In this stage, a set of efficient producers usually emerges. Considering the industry's fast clockspeed, firms must pay attention to designing the extended organization, defined here as the 'corporation', and its supply, distribution and alliance network.[16] A number of solid industrial clusters were established to enhance the competitive advantages of IT firms in China. The innovation capacities were embedded in these cluster systems.

Through years of investment and effort, several IT clusters blossomed; Shanghai, Kunshan, Shenzhen and Dongguan are the most typical. Although Porter[17] found that many of the determinants of cluster advantages are more different across nations than within a nation, China's geographical size, diverse population and growing openness contributes to the disparities among China's IT clusters. These differences have great influence on the innovation capacity of firms. This is a critical subject that has lacked sufficient analysis. The aim of this paper is two fold. First, we study the effects of industrial cluster on innovation capacity. Traditionally, neoclassical economics considered technology as a parameter of the production function, with a static nature, exogenous to the firm and with uniform distribution among companies. After the research done by

Schumpeter,[18] technology and innovation began to receive greater attention and came to be regarded as endogenous factors that firms can develop and manage thereby enhancing their competitive advantage. The source of innovation capability stems from internal or external resources.[19]

Second, the paper examines the impact of external resources on firms' innovation capacity especially the regional dimension of China's domestic economic policy, which appears to affect firms' innovation capacity in industrial clusters. This is the first empirical study aimed at Chinese firms in cluster research. This paper therefore adopts the Shanghai, Kunshan, Shenzhen and Dongguan IT industrial clusters to explore the disparities among these clusters and the impact on innovation capacity in China. A macro view rather than a micro view is taken, based on Porter's model for the innovation orientation of a national industrial cluster.[20] This paper proposes a model for analyzing China's innovation capacity. To facilitate this, published data sources were analyzed, and a questionnaire survey and in-depth interviews were used.[21]

This paper is organized as follows. Section 2 reviews the relevant literature on industrial clusters and innovation. Section 3 provides an overview of the IT industrial clusters in China. A model and methodologies applicable to the proposed model will be described in Section 4. Section 5 explores the disparities in innovation capacity at China's IT industrial clusters through the proposed model. The conclusion is documented in Section 6.

2. Literature Review

Baptista and Swann discussed the relationship between clusters and innovative activity from four perspectives, concerning the nature of the clustering process, the nature of technology, the nature of the innovative process and the nature of new economic growth.[22]

2.1 The Nature of the Clustering Process

The benefits of clustering can be divided into demand and supply sides.[23] On the demand side, firms may cluster to take advantage of strong local demand, particularly that deriving from related industries. Certain small businesses selling differentiated goods might choose to locate in a cluster because they are more likely to be 'found' by customers. Moreover, customers are a good source of ideas for innovation,[24] and firms can readily exploit these flows of information by locating near users and establishing customer services. On the supply side, the main sources of location externalities can be traced as far back as Marshall[25] and were restated by urban and regional economists,[26] and also by Krugman's widely known work on geography and trade.[27] A geographical concentration of firms in the same industry creates a pooled market for workers with the same skills, helping to cope with the uncertainty related to business cycles and unemployment. Also, being located in an industrial cluster allows for the provision of traded and non-traded inputs specific to an industry in a greater variety and at a lower cost. This is the second benefit of the supply side. The third benefit is that an industrial cluster generates positive externalities related to the transmission of knowledge between nearby firms. Easy access to infrastructure can also be viewed as a benefit of the supply side.

An industrial cluster provides a set of knowledge inputs that make for a technological infrastructure that supports innovative activity.[28] These inputs can come from competitors, firms in related industries, suppliers, customers and other entities (e.g. universities and research institutions) carrying out research and development (R&D). Innovative activity will tend to geographically concentrate close to agglomerations of this infrastructure, which is relatively immobile and place-specific in order to benefit from spillovers.[29]

2.2 The Nature of Technology

This perspective was originally discussed by Nelson and Winter[30] and has been developed by Malerba and Orsenigo.[31] A combination of four factors influencing the rate of innovation is used to provide a characterization of the technological environment faced by a firm:

(1) *Appropriability conditions* reflect the possibility of protecting innovations from imitation, and therefore gaining a larger share of the profits.
(2) *Opportunity conditions* reflect a firm's likelihood to innovate, given the amount of investment in R&D.
(3) The *knowledge base* characterizes the type of knowledge upon which the firm's activities are based.
(4) Finally, the *degree of cumulativeness* represents the probability of innovating in a period, given the amount of innovations produced in previous periods.

It seems reasonable to argue that there is a spatial dimension to technological regimes and that the basic features defining a firm's technological regime will have consequences for its geographical location and for the spatial distribution of innovative activity.[32]

2.3 The Nature of the Innovative Process

Feldman[33] develops this perspective, drawing on five stylized facts about the innovation process presented by Dosi.[34] These are: (i) uncertainty, (ii) complexity, (iii) reliance upon basic research, (iv) importance of learning by doing and (v) cumulativeness. The formation of channels for exchange of information (e.g. networks of innovators) can be thought of as an approach to reducing uncertainty. Being part of a network enables a firm to exploit developments in a technology and solve problems by sharing experiences with those dealing with similar technologies.[35] Debresson and Amesse[36] argued that localized networks appear to be more durable than formal, international strategic alliances. This would happen because regional networks are reinforced by social, cultural and symbolic bonds that result in a kind of 'social solidarity' made possible by geographical proximity and frequent contact. Jaffe[37] and Acs *et al.* [38] also confirmed empirically the pervasiveness of academic research spillovers and their geographic concentration. Von Hippel[39] argued that innovative activity comes from direct contact with a variety of sources (e.g. suppliers, customers, competitors and providers of different kinds of services). Industrial clusters that accumulate high levels of innovative success have assembled information that facilitates the next round of innovation, since the ability to innovate successfully would be a function of the technological levels already achieved.

2.4 The Nature of New Economic Growth

The literature on new economic growth has considered the effects of knowledge externalities on growth,[40] resulting from the geographical agglomeration of industries. The external effects have been tested on both firm growth[41] and on innovative performance[42] in cities and metropolitan areas. It seems preferable to test the effects of external factors on innovative performance rather than firm growth. Furthermore, if industries that are spatially agglomerated innovative more and grow faster, then regions where these industries locate should account for the larger part of the innovative output.

The clustering process and interchange among industries in the cluster works best when the industries involved are geographically concentrated. Many of the advantage determinants are more alike within a nation than across nations. Government policy, legal rules, capital market conditions, factor costs and many other attributes that are common to a cluster make the boundaries important.[43] Porter[44] proposed a model to analyze local clusters using the four-dimension diamond metaphor that included 'factor conditions', 'demand conditions', 'related and supporting industries' and 'firm strategy, structure and rivalry'. This will be described, in detail, in Section 4.

The following findings were obtained through a literature review: a firm is more likely to innovate if it is located in a region where firms from its own industry are present. Disparities have been present in industrial clusters. There are no case study comparisons of China's IT industrial clusters reported in the literature. This paper therefore proposes a model to explore the disparities in innovation capacity at China's IT industrial clusters.

3. IT Industrial Clusters in China: An Overview

3.1 Shanghai IT Industrial Cluster

North of Shanghai, the Yangtze River flows into the East China Sea. It also assumes a central location along China's coastline. Thanks to its advantageous geographic location, Shanghai has become the pivot of economic development in China with the Pudong New Area now China's foremost IT industrial cluster. It stretches over Lujiazui, the Waigaoqiao tax-free zone, the Jinqiao export processing zone and the Zhangjiang High-tech Park (ZJHP). Several national R&D institutes and important universities surround it. ZJHP was established in 1992 as a national-level park for the development of new high technology. The Shanghai Municipal Government issued a 'Focus on ZhangJiang' policy to accelerate the ZJHP's rate of development. For instance, a one-stop service was developed for incoming firms; venture capital and special funds were made available for entrepreneurs; tax and financial incentives for industry; education and R&D were integrated. Through these efforts, the following industries have developed: integrated circuits (IC), software, information security, biotechnology (biotech) and pharmaceuticals. In the first eight years of development, this park has become the home to various national-level scientific bases, including the State Bio-Tech and Pharmaceutical base (Shanghai), the National Information Technology Industry base, the National Science and Technology Innovation base and the National 863 Information Security Industry base. Shanghai Jiao Tong University and Fudan University are both advanced academic institutes in Shanghai and nationally important universities. They provide the Shanghai IT industrial cluster with high quality human resources and on-job training (e.g. EMBA program). These universities also generate many start-up firms at specific parks nearby. It is helpful for universities to focus their research more closely on the needs of industry. In 2000, the ZJHP's industrial earnings were over RMB $53.38 billion.

3.2 Kunshan IT Industrial Cluster

The Kunshan IT industrial cluster is situated in the Shanghai economic zone with metropolitan Shanghai to the east and the renowned ancient Suzhou City to the west. Kunshan is a booming industrial cluster. Its rise is entirely local government oriented. With an export-oriented economy booming, it has grown into a modern base for the manufacturing and processing industry and a region noted for big in-flows of foreign capital, high profit-returns for overseas investors and fast economic growth. The total import and export volume in 2000 reached US $3.75 billion. Kunshan is also a recipient of investment from Taiwan. The volume of Taiwanese investment in Kunshan accounts for nearly one quarter of that for the Jiangsu Province and one tenth of that for the whole country. Electronics information, fine chemicals and precision machinery have developed into pillar industries. There are now more than 300 IT firms with an investment exceeding US $3 billion. For the past few years, the IT industry has been growing at a speed of 35%, making it the fastest growing sector. The Kunshan economic and technological development zone was set up in 1992 with the approval of the China government. It is now capable of executing large-scale high-tech projects focusing on IT and precision machinery. The export processing zone and software park are also competent actors in the Kunshan IT industrial cluster.

3.3 Shenzhen Industrial Cluster

The Shenzhen IT industrial cluster is located in Guangdong Province's coastal region along the South China Sea. In 1979, the Shenzhen special economic zone was established immediately to the north of the former Hong Kong and Macao colonies. This project was an experiment in reform and open-door policy. Shenzhen is the only mainland city that borders Hong Kong, giving it a unique geographical advantage. Many foreign companies began to set up factories in the region, attracted by the low labor costs and ease of procuring components. Shenzhen includes national-level high and new technology industry development zones, a tax-free zone and export processing zone for reinforcing economic capacity. With an annual growth rate of 53.3% (1991–2000) in the high-tech industry, it has shaped its industrial cluster with electronic information, electromechanical integration, biotechnology and advanced materials. In 2000, the high-tech product output in Shenzhen achieved RMB $106.45 billion, accounting for 42.3% of industrial output. It has become one of the largest bases for IT industrialization. Similar rapid development can be found in financial securities, insurance, information services and transportation. Beijing University, Tsinghua University and Central China University of Science and Technology established research institutes or branches in Shenzhen. They are the leading technology-oriented research institutes in this cluster. Shenzhen has a complete policy and legal system supportive to high-tech development. A favorable environment was created for intellectual property protection. From 1980 to 2001, its annual increase in GDP averaged 29.5%, annual increase in industrial output value averaged 45.4% and annual increase in import and export value averaged 39.1%.

3.4 Dongguan Industrial Cluster

The Dongguan IT industrial cluster is situated mid-south of Guangdong and northeast of the Pearl River Delta, with Shenzhen to the south. In the 20 years of reform and 'opening', it has fully utilized its geographical advantage and executed several policies. At the end of 2001, there were 227 IT firms in this cluster. The world's computer processing and manufacturing base has shifted from Taiwan to South China with Dongguan as the core. Firms from Taiwan bring their management and customers to this area. Dongguan-made computers and peripherals (C&P) products have a large share of the international market. It produces 40% of the world's hard-disk heads, cases and semis. Nearly one in three disk drives and one in five scanners and mini-motors are made in this southern city. The C&P industry serves as the main force in Dongguan. Nearly all computer components can be obtained within an hour and half in this area. For component makers, competition is intense, but the area attracts many customers because of its business opportunities. In 2000, the industry achieved overseas sales of RMB $86.5 billion, accounting for 45.5% of the exports in Dongguan. Electronics, machinery and chemistry are also regarded as focal industries by this municipality. The Xongshanhu Scientific & Technological Industry Park (XSTIP) is one of the national-level 'high and new technology industry development zones'. It furnishes Dongguan with the technical, logistics, administrative and financial infrastructure that young firms need as they struggle to gain a toehold for their products in an increasingly competitive market. Several universities have established research institutes in Dongguan, such as Shanghai Jiao Tong University, Hong Kong Polytechnic University and Northeastern University.

4. The Model and Methodologies

Porter developed a model enumerating the environmental characteristics of a nation's industrial clusters.[45] As several researchers have emphasized, it is important to recognize the dynamics of innovation within clusters, and particularly the role of the dynamic interactions between clusters and specific institutions—from universities to public institutes—within given geographic areas.[46] Porter's model encapsulates these forces by identifying four critical drivers (see Figure 1).[47] The first is the availability of high-quality and specialized innovation inputs. For example, the overall availability of trained scientists and engineers is important for economy-wide innovation potential. The second driver is the nature of the domestic and international demand for cluster producers and services. Demanding customers encourage domestic firms to offer best-in-the-world technologies. This provides an incentive for the firms to pursue innovations that are globally novel. The third driver is the extent to which the local competitive context is both intense and rewards successful innovators. This depends on general innovation incentives such as intellectual property protection and regulations affecting particular products, consistent pressure from intense local rivalry, and openness to international competition in the cluster.[48] The final driver is the availability, density and interconnectedness of vertically and horizontally related industries. These relationships generate positive externalities both from knowledge spillovers, transactional efficiencies and cluster-level scale economies, which are enhanced when clusters are concentrated geographically.[49] In this model, each industrial cluster driver not only interacts with the others but also affects the industrial cluster. The industrial clusters affect each driver correspondingly. This model helps to explain the disparities in innovation capacity between each industrial cluster. With this model, these disparities might be observed, described and evaluated.[50]

In order to explore the disparities in innovation capacity at China's IT industrial clusters, several methodologies will be introduced. Data analysis of the published or

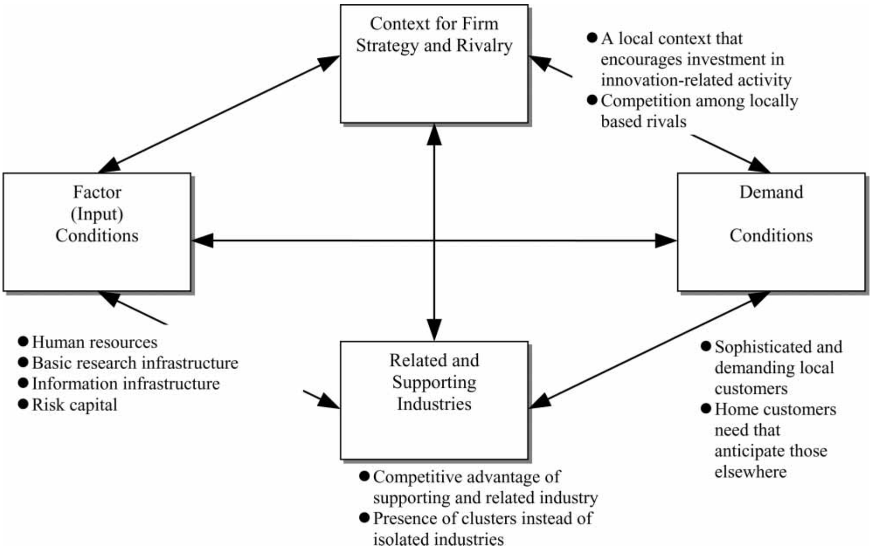

Figure 1. The innovation orientation of national industry clusters. *Source*: J.L. Furman, M.E. Porter & S. Stern, The Determinants of National Innovative Capacity, *Research Policy*, 31, 6, 2002, pp. 899–933.

archived data is widely utilized in the literature as an objective method for corroborating proposed models and hypotheses. The questionnaire survey is a multi-purposed approach capable of measuring either substantial or intangible indicators. The in-depth interview is a judgment-based approach that can help researchers to know the holistic system and the insider's operations, which are important for identifying critical drivers and interrelationships.[51]

5. Exploring the Disparities in Innovation Capacity at China's IT Industrial Clusters

5.1 Sample and Questionnaire

A questionnaire survey was selected to provide information about the 10 determinants for the four critical drivers (see Figure 1) in Porter's model for the innovation orientation of a national industrial cluster[52] to explain any disparities in innovation capacity (Shanghai, Kunshan, Shenzhen and Dongguan). The respondents in each industrial cluster were asked to describe their perceptions of the industrial cluster's impact on 10 determinants for the four critical drivers using a 5-level scale (1 = significant weak effect, 2 = weak effect, 3 = average effect, 4 = strong effect, 5 = significant strong effect). This survey was started in July 2002 and ended in September 2002. In this survey, the respondents were R&D and general managers at foreign-owned firms and domestic-owned IT firms in the Shanghai, Kunshan, Shenzhen and Dongguan clusters. Five hundred questionnaires were sent to Shanghai, 300 were sent to Kunshan, 250 were sent to Shenzhen and 180 were sent to Dongguan.[53] In all, 1230 questionnaires were sent out with 423 valid returns, constituting a 34.39% valid return rate. Within the 423 valid questionnaires, 162 were from the Shanghai industrial cluster, 62 were from the Kunshan industrial cluster, 108 were from the Shenzhen industrial cluster and 91 were from the Dongguan industrial cluster. The descriptive statistics are shown in Table 1.

5.2 Empirical Results

After the questionnaire collection was completed in October 2002, one-way ANOVA (parametric method) and the Kruskal–Wallis (K–W) test (non-parametric method) were used to examine if the four critical drivers make the industrial clusters diverse in innovation capacity. The results are shown in Table 2. Using one-way ANOVA and the K–W test, the means and medians (see Appendix 2) were both significantly different in all 10 determinants for the four drivers at the 0.05 significant levels.

Pairwise comparisons were then used to determine the priority for the four industrial clusters in the 10 determinants for the four critical drivers (see Table A1). The results indicated that the priority for the four industrial clusters on 'factor conditions' ranked as 'Shanghai', 'Kunshan', 'Shenzhen' and 'Dongguan'. The precedence for the four industrial clusters on 'demand conditions' was 'Shanghai', 'Kunshan', 'Shenzhen' and

Table 1. Descriptive statistics

	Shanghai	Kunshan	Shenzhen	Dongguan
A. Factor conditions[a]	3.531 (0.592)[b]	3.290 (0.584)	2.994 (0.531)	2.692 (0.543)
A1. Human resources	3.685 (0.635)	3.565 (0.692)	3.363 (0.623)	3.030 (0.692)
A2. Basic research infrastructure	3.747 (0.643)	3.516 (0.565)	3.369 (0.706)	3.045 (0.650)
A3. Information infrastructure	3.605 (0.751)	3.032 (0.724)	2.476 (0.734)	2.294 (0.639)
A4. Risk capital	3.241 (0.825)	3.355 (0.704)	2.863 (0.758)	2.582 (0.682)
B. Demand conditions	3.451 (0.580)	3.532 (0.503)	3.280 (0.514)	3.130 (0.503)
B1. Sophisticated and demanding local customers	3.722 (0.603)	3.871 (0.424)	3.530 (0.628)	3.408 (0.658)
B2. Home customers need that anticipate those elsewhere	3.117 (0.491)	3.161 (0.486)	3.054 (0.399)	3.000 (0.374)
C. Related and supporting industries	3.352 (0.682)	3.623 (0.583)	3.328 (0.670)	3.861 (0.557)
C1. Competitive advantage of supporting and related industry	3.296 (0.713)	3.516 (0.504)	3.423 (0.722)	3.667 (0.620)
C2. Presence of clusters instead of isolated industries	3.358 (0.745)	3.597 (0.735)	3.238 (0.736)	3.970 (0.565)
D. Context for firm strategy and rivalry	3.673 (0.619)	3.161 (0.772)	3.030 (0.530)	3.030 (0.538)
D1. A local context that encourages investment in innovation-related activity	3.562 (0.780)	3.065 (0.885)	2.524 (0.766)	2.299 (0.671)
D2. Competition among locally based rivals	3.784 (0.685)	3.565 (0.668)	3.554 (0.673)	3.741 (0.594)

Notes: [a]In each questionnaire, the grades of the determinants in one driver are averaged into the driver's grade. [b]The number in the bracket is the standard deviation.

Table 2. Results of ANOVA and Kruskal–Wallis test for the 10 determinants for the four drivers

	Significance levels of ANOVA[b]	Significance levels of K–W test[b]
A. Factor conditions[a]	0.000	0.000
A1. Human resources	0.000	0.000
A2. Basic research infrastructure	0.000	0.000
A3. Information infrastructure	0.000	0.000
A4. Risk capital	0.000	0.000
B. Demand conditions	0.000	0.000
B1. Sophisticated and demanding local customers	0.000	0.000
B2. Home customers need that anticipate those elsewhere	0.017	0.014
C. Related and supporting industries	0.000	0.000
C1. Competitive advantage of supporting and related industry	0.000	0.000
C2. Presence of clusters instead of isolated industries	0.000	0.000
D. Context for firm strategy and rivalry	0.000	0.000
D1. A local context that encourages investment in innovation-related activity	0.000	0.000
D2. Competition among locally based rivals	0.003	0.006

Notes: [a]In each questionnaire, the grades of the determinants in one driver are averaged into the driver's grade. [b]The mean difference is significant at the 0.05 level.

'Dongguan'. However, 'Shanghai' and 'Kunshan' are not significantly different. The priority for the four industrial clusters on 'related and supporting industries' was 'Dongguan', 'Kunshan', 'Shanghai' and 'Shenzhen'. However, 'Shanghai' and 'Shenzhen' were not significantly different. The precedence for the four industrial clusters on 'context for firm strategy and rivalry' was 'Shanghai', 'Kunshan', 'Shenzhen' and 'Dongguan'. No significant difference was found for the last three drivers. 'Dongguan' was significantly superior to the other three clusters on 'related and supporting industries'. 'Shanghai' was significantly preferable to the other three clusters for each of the four drivers. The priority for the four industrial clusters on each determinant for the four drivers will be described, in detail, in Appendix 3.

The Tukey multiple comparisons test could be applied to produce a ranking to indicate the sequence for the four driver effects on the four industrial clusters (see Tables 3–6).[54] The 'context for firm strategy and rivalry' was significantly preferable to 'demand conditions' and 'related and supporting industries' in Shanghai, but not significantly superior to 'factor conditions'. The 'context for firm strategy and rivalry' and 'demand conditions' might be regarded as the main effects at the Kunshan and Shenzhen industrial clusters. However, the priority for the four driver effects on Dongguan was ranked 'related and supporting industries', 'context for firm strategy and rivalry', 'demand conditions' and 'factor conditions'. However, 'demand conditions' and 'factor conditions' were not significantly different. 'Related and supporting industries' was the most important effect at three industrial clusters. It might be determined that the phenomenon of clustering is significantly in the Kunshan, Shenzhen and Dongguan industrial clusters.

Table 3. Results of Tukey test for Shanghai industrial clusters in four drivers

i	*j*	Mean difference ($i-j$)	Significance levels[b]	Multiple comparisons[c]
A[a]	B	0.001	0.648	
	C	0.179	0.046	
	D	−0.142	0.165	
B	A	−0.001	0.648	
	C	0.000	0.477	
	D	−0.222	0.007	(D, B)
C	A	−0.179	0.046	
	B	−0.001	0.477	
	D	−0.321	0.000	(D, C)
D	A	0.142	0.165	
	B	0.222	0.007	(D, B)
	C	0.321	0.000	(D, C)

Notes: [a]A: Factor conditions; B: Demand conditions; C: Related and supporting industries; D: Context for firm strategy and rivalry. [b]The difference is significant at the 0.05 level. [c](A, B) means that factor conditions has significantly higher grade than demand conditions at 0.05 significant level.

5.3 Discussions

Through a series of analyses, the innovation capacity in these four industrial clusters is discussed based on the four drivers.

A. Factor conditions

In the last decade, the rise of the Chinese economy and the growing accumulation of industry in China's coastal regions have steadily begun to change the industrial map of Asia. This area has become a magnet for human resources worldwide, especially for the surrounding nations. Shanghai is one of the most critical gateways to Central China. Shanghai also serves as the principal high-tech industry location with its high quality

Table 4. Results of Tukey test for Kunshan industrial clusters on the four drivers

i	*j*	Mean difference ($i-j$)	Significance levels[b]	Multiple comparisons[c]
A[a]	B	−0.242	0.129	
	C	−0.323	0.019	(C, A)
	D	0.129	0.651	
B	A	0.242	0.129	
	C	−0.001	0.887	
	D	0.371	0.005	(B, D)
C	A	0.323	0.019	(C, A)
	B	0.001	0.887	
	D	0.452	0.000	(C, D)
D	A	−0.129	0.651	
	B	−0.371	0.005	(B, D)
	C	−0.452	0.000	(C, D)

Notes: [a]A: Factor conditions; B: Demand conditions; C: Related and supporting industries; D: Context for firm strategy and rivalry. [b]The difference is significant at the 0.05 level. [c](A, B) means that factor conditions has significantly higher grade than demand conditions at 0.05 significant level.

Table 5. Results of Tukey test for Shenzhen industrial clusters on the four drivers

i	*j*	Mean difference ($i - j$)	Significance levels[b]	Multiple comparisons[c]
A[a]	B	−0.286	0.000	(B, A)
	C	−0.333	0.000	(C, A)
	D	−0.001	0.938	
B	A	0.286	0.000	(B, A)
	C	−0.001	0.866	
	D	0.250	0.000	(B, D)
C	A	0.333	0.000	(C, A)
	B	0.001	0.866	
	D	0.298	0.000	(C, D)
D	A	0.000	0.938	
	B	−0.250	0.000	(B, D)
	C	−0.298	0.000	(C, D)

Notes: [a]A: Factor conditions; B: Demand conditions; C: Related and supporting industries; D: Context for firm strategy and rivalry. [b]The difference is significant at the 0.05 level. [c](A, B) means that factor conditions has significantly higher grade than demand conditions at 0.05 significant level.

R&D human resources from national critical universities. The Kunshan IT industrial cluster takes advantage of its proximity to Shanghai.

The proximity to Hong Kong, an international service center, is the advantage of the Shenzhen and Dongguan industrial clusters. As a manufacturing base for Hong Kong, they use Hong Kong as a platform to expand production. With its labor-intensive industry, Shenzhen has received its human resources from Guangdong's low-development areas and hinterland. Because of the lack of advanced education institutions, Shenzhen has reached outside for talent to fulfill a shortage of senior managers, engineers and R&D specialists in its stride to upgrade its innovation capacity. The same problem is faced by the Dongguan IT industrial cluster.

Table 6. Results of Tukey test for Dongguan industrial clusters on the four drivers

i	*j*	Mean difference ($i - j$)	Significance levels[b]	Multiple comparisons[c]
A[a]	B	−0.438	0.000	(B, A)
	C	−1.169	0.000	(C, A)
	D	−0.338	0.000	(D, A)
B	A	0.438	0.000	(B, A)
	C	−0.731	0.000	(C, B)
	D	0.001	0.244	
C	A	1.170	0.000	(C, A)
	B	0.731	0.000	(C, B)
	D	0.831	0.000	(C, D)
D	A	0.338	0.000	(D, A)
	B	−0.001	0.244	
	C	−0.831	0.000	(C, D)

Notes: [a]A: Factor conditions; B: Demand conditions; C: Related and supporting industries; D: Context for firm strategy and rivalry. [b]The difference is significant at the 0.05 level. [c](A, B) means that factor conditions has significantly higher grade than demand conditions at 0.05 significant level.

Currently, great efforts are being made by Shenzhen and Dongguan to strengthen ties with advanced education institutions. Cooperation with more than 200 universities in conducting research and commercializing research results is ongoing. As an immigrant region, Shenzhen and Dongguan offer opportunities that attract a large amount of talents from other parts of China. This talent provides a strong support for industrial development and innovation advancement.

The central, provincial and Shanghai governments invested over 25 billion RMB in infrastructure during 1990–1995. This initial investment included the construction of an expanded utility infrastructure. A new water plant, gas works, power plant, sewage facilities and telephone lines were all built in the Pudong District by 1995. The second phase of infrastructural investment began in 1996. It included the construction of a new international airport, metro line, light rail line, ring road, information port and harbor expansion. The government has set several goals for the Pudong District for the years leading up to 2010. Furthermore, the Shanghai Municipal Government issued 'Focus on Zhangjiang' policy to accelerate the ZJHP's rate of development. For instance, through one-stop service for incoming firms, Shanghai has become significantly superior to the other three clusters on 'basic research infrastructure' and 'information infrastructure'.

The Dongguan IT industrial cluster is under transition and there is no longer any demand for development land. Electric power deficiencies have also adversely influenced Dongguan's development. Furthermore, Shenzhen and Dongguan, with their export processing orientation, are deficient in basic research and information infrastructure. This will result in firms insufficiently investing in innovation activities. Shenzhen and Dongguan will also be affected by China's membership of the World Trade Organization, losing their advantages (low labor costs and ease of procuring components). They should try to mold themselves into logistics and R&D centers to stay ahead of the competition.

B. Demand conditions

The income, consumption, information and level of education of the consumers in Shanghai are higher than that in the other three clusters. Hence, the sophistication and demand for products and technology are much more complex in Shanghai. High-tech firms in Shanghai should be able to react quickly and diversify to satisfy their local customers. The Kunshan IT industrial cluster is significantly inferior to Shanghai on this determinant.

In the last decade, the Chinese government has targeted IT as a critical task for development by opening its market to foreign investment. Its goal is to reduce its dependence on IT product imports and build domestic production and innovation capacity. Technology acquisition and transfer strategies were adopted to accelerate industry upgrades. Many firms in China have inserted themselves into global commodity chains through the simplest original equipment manufacturing contracting arrangements (OEM). However, few of them have more complex design and manufacture (ODM) and brand manufacturing (OBM) activities. Most of the critical technologies depend on other leading countries. Domestic firms with lower levels of technology are moving out. This will not lead to innovative products and technology in the international market. The degree of satisfaction on 'home customer needs that anticipate those elsewhere' in the four industrial clusters are all below average (see Table 1).

With a domestic market, firms can advance when possible and pull back when necessary. They can develop their innovation capacity using the domestic market and then expand step-by-step into the international market.

C. Related and supporting industries

Dongguan was significantly superior to the other three IT industrial clusters on 'competitive advantage of supporting and related industry' and 'presence of clusters instead of isolated industries'. Dongguan is focused on C&P which has formed a complete related industry structure. Of the required accessories, 70–90% are available locally. Dongguan's computer magnetic head, motherboard, monitor, power supply, scanner, disk drive and micro-motor output ranks among the first in the world. Major C&P manufacturers worldwide all go to Dongguan for sourcing. Firms in the Dongguan industrial cluster should leverage their clustering and large-scale domestic market superiority to shift OEM into ODM or OBM. The government is therefore undertaking to build a high-tech development zone, XSTIP, in an effort to boost Dongguan's innovation capacity and increase the IT content of its industry. It hopes to attract famous Chinese and foreign firms to develop opto-electronic, biotech and other high value-added projects and industrial support services in this park. However, as a manufacturing base for a wide range of industries in Shenzhen, it should not stress 'presence of clusters instead of isolated industries' significantly. The development of Shenzhen's high-tech industries has created a huge demand for upstream parts and components. With an ample supply of both upstream and downstream products, firms are assured a strong supply chain as they can easily find supporting industries, products and spare parts locally. The Shenzhen authority should initiate a related policy to encourage investment projects that can cope with the related and supporting industrial development. Shanghai should keep watch for this as well.

D. Context for firm strategy and rivalry

Because China is the main source of low-cost, efficient, manufacturing capacity for foreign firms, often these parts are purchased by assemblers and are eventually sold as a part of a completed system. There has been a decided transition from China's traditional position as a vital manufacturer of IT products. Most IT firms in China are therefore process-improvement-oriented firms that offer the value-propositions of 'operation excellence'. This effect in Kunshan, Shenzhen and Dongguan could contribute to the average degree of satisfaction for 'a local context that encourages investment in innovation-related activity' (see Table 1). Shanghai with its talent enforcement activities, high quality human resource and R&D support, was significantly superior to the other three clusters. About 70% of the factories in Dongguan are involved in further-processing transfers (also known as factory transfers) or subcontractors for foreign firms. This resulted in firms investing insufficiently in innovation activities. However, with the increasing competition from a number of developing regions around China, Shenzhen and Dongguan can no longer take this advantage for granted. To cope with the challenges ahead, the authorities should put forth various programs to encourage investment in innovation, acquisition of new technologies and the upgrading of human resources.

We have discussed the effects of industrial clusters on innovation capacity. Furthermore, it was confirmed that the regional dimension of Chinese economic policy affects firms' innovation capacity in industrial clusters. The four industrial clusters, all quite different in their determinants for innovation capacity, functionally complement one another. At the same time, they compete for success, increasing their overall innovation capacity, attracting investment from all over the world and are continuously spawning new local industries. We also study the external resources focusing on cluster effect under the regional dimension of Chinese economic policy. The results can show whether the regional policy differences will moderate the cluster effect on innovation.

6. Conclusions

This paper chose Shanghai, Kunshan, Shenzhen and Dongguan for an empirical study that explored the disparities in innovation capacity to discuss the IT industrial clusters in China. Based on a model for national industrial clusters, this paper proposed a model for analyzing China's IT industrial clusters. Recommendations for improvement at these four IT industrial clusters were suggested.

There were many parallels between the findings of this paper and the actual situation. It was confirmed that the determinants for innovation capacity were different among China's IT industrial clusters. Government policy, legal rules, market conditions, factor conditions and many other attributes make the differences important. 'Dongguan' was significantly superior to the other three clusters on 'related and supporting industries'. 'Shanghai' was significantly preferable to the other three clusters on each of the four drivers. 'Context for firm strategy and rivalry' and 'demand conditions' might be regarded as the main effects at the Kunshan and Shenzhen IT industrial clusters. 'Related and supporting industries' was the most important effect for three industrial clusters. The clustering phenomenon was significant at Kunshan, Shenzhen and Dongguan. This case study contributes to the literature on the different innovation capacities between industrial clusters by providing a practical case in China neglected in the previous researches.

Based on these findings, the authorities could identify their comparative advantages and defects. Furthermore, they should initiate related policies for their industrial clusters to leverage the clusters advantages to reinforce R&D-based industrial and innovative activity. Firms could mold their innovation strategies to match the conditions in their home industrial clusters. New IT firms might select the most suitable industrial clusters to match their strengths.

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53. In December 2001, there were 621 IT firms in Shanghai, 380 in Kunshan, 324 in Shenzhen and 227 in Dongguan.
54. In Tables 3–6, we applied Tukey multiple comparisons test to produce a ranking to indicate the sequence for the four driver effects on the Shanghai industrial clusters. Table 3 indicated that 'D: Context for firm strategy and rivalry' is much more significant than the other three driver effects. In Tables 4 and 5, they both indicated that 'C: Related and supporting industries' is much more significant than the other three driver effects in Kunshan and Shenzhen industrial cluster. In Table 6, 'C: Related and supporting industries' is the most significant driver effect in the Dongguan industrial cluster.

Appendix 1

Table A1. Results of pairwise test for the four industrial clusters

	i	*j* [a]	Mean difference (*i* − *j*)	Significance levels of ANOVA[b]	Multiple comparisons[c]
A. Factor conditions	1	2	0.241	0.020	(1, 2)
		3	0.537	0.000	(1, 3)
		4	0.839	0.000	(1, 4)
	2	1	−0.241	0.020	(1, 2)
		3	0.296	0.002	(2, 3)
		4	0.599	0.000	(2, 4)
	3	1	−0.537	0.000	(1, 3)
		2	−0.296	0.002	(2, 3)
		4	0.303	0.000	(3, 4)

(*Table continued*)

Table A1. Continued

	i	j [a]	Mean difference $(i - j)$	Significance levels of ANOVA[b]	Multiple comparisons[c]
	4	1	−0.839	0.000	(1, 4)
		2	−0.599	0.000	(2, 4)
		3	−0.303	0.000	(3, 4)
A1. Human resources	1	2	0.121	0.609	
		3	0.322	0.000	(1, 3)
		4	0.655	0.000	(1, 4)
	2	1	−0.121	0.609	
		3	0.201	0.166	
		4	0.535	0.000	(2, 4)
	3	1	−0.322	0.000	(1, 3)
		2	−0.201	0.166	
		4	0.333	0.000	(3, 4)
	4	1	−0.655	0.000	(1, 4)
		2	−0.535	0.000	(2, 4)
		3	−0.333	0.000	(3, 4)
A2. Basic research infrastructure	1	2	0.231	0.086	
		3	0.378	0.000	(1, 3)
		4	0.702	0.000	(1, 4)
	2	1	−0.231	0.086	
		3	0.147	0.433	
		4	0.471	0.000	(2, 4)
	3	1	−0.378	0.000	(1, 3)
		2	−0.147	0.433	
		4	0.324	0.000	(3, 4)
	4	1	−0.702	0.000	(1, 4)
		2	−0.471	0.000	(2, 4)
		3	−0.324	0.000	(3, 4)
A3. Information infrastructure	1	2	0.573	0.000	(1, 2)
		3	1.129	0.000	(1, 3)
		4	1.311	0.000	(1, 4)
	2	1	−0.573	0.000	(1, 2)
		3	0.556	0.000	(2, 3)
		4	0.739	0.000	(2, 4)
	3	1	−1.129	0.000	(1, 3)
		2	−0.556	0.000	(2, 3)
		4	0.183	0.064	
	4	1	−1.311	0.000	(1, 4)

(*Table continued*)

Table A1. Continued

	i	j [a]	Mean difference ($i-j$)	Significance levels of ANOVA[b]	Multiple comparisons[c]
		2	−0.739	0.000	(2, 4)
		3	−0.183	0.064	
A4. Risk capital	1	2	−0.114	0.736	
		3	0.378	0.000	(1, 3)
		4	0.659	0.000	(1, 4)
	2	1	0.114	0.736	
		3	0.492	0.000	(2, 3)
		4	0.773	0.000	(2, 4)
	3	1	−0.378	0.000	(1, 3)
		2	−0.492	0.000	(2, 3)
		4	0.281	0.002	(3, 4)
	4	1	−0.659	0.000	(1, 4)
		2	−0.773	0.000	(2, 4)
		3	−0.281	0.002	(3, 4)
B. Demand conditions	1	2	−0.001	0.728	
		3	0.171	0.017	(1, 3)
		4	0.321	0.000	(1, 4)
	2	1	0.001	0.728	
		3	0.253	0.007	(2, 3)
		4	0.403	0.000	(2, 4)
	3	1	−0.171	0.017	(1, 3)
		2	−0.253	0.007	(2, 3)
		4	0.150	0.032	(3, 4)
	4	1	−0.321	0.000	(1, 4)
		2	−0.403	0.000	(2, 4)
		3	−0.150	0.032	(3, 4)
B1. Sophisticated and demanding local customers	1	2	−0.149	0.366	
		3	0.193	0.023	(1, 3)
		4	0.314	0.000	(1, 4)
	2	1	0.149	0.366	
		3	0.341	0.001	(2, 3)
		4	0.463	0.000	(2, 4)
	3	1	−0.193	0.023	(1, 3)
		2	−0.341	0.001	(2, 3)
		4	0.122	0.229	
	4	1	−0.314	0.000	(1, 4)
		2	−0.463	0.000	(2, 4)

(*Table continued*)

Table A1. Continued

	i	j [a]	Mean difference ($i - j$)	Significance levels of ANOVA[b]	Multiple comparisons[c]
		3	−0.122	0.229	
B2. Home customers need that anticipate those elsewhere	1	2	−0.001	0.901	
		3	0.001	0.529	
		4	0.117	0.046	(1, 4)
	2	1	0.001	0.901	
		3	0.108	0.326	
		4	0.161	0.046	(2, 4)
	3	1	−0.001	0.529	
		2	−0.108	0.326	
		4	0.001	0.628	
	4	1	−0.117	0.046	(1, 4)
		2	−0.161	0.046	(2, 4)
		3	−0.001	0.628	
C. Related and supporting industries	1	2	−0.261	0.028	(2, 1)
		3	0.001	0.985	
		4	−0.509	0.000	(4, 1)
	2	1	0.261	0.028	(2, 1)
		3	0.286	0.012	(2, 3)
		4	−0.248	0.034	(4, 2)
	3	1	−0.001	0.985	
		2	−0.286	0.012	(2, 3)
		4	−0.533	0.000	(4, 3)
	4	1	0.509	0.000	(4, 1)
		2	0.248	0.034	(4, 2)
		3	0.533	0.000	(4, 3)
C1. Competitive advantage of supporting and related industry	1	2	−0.220	0.120	
		3	−0.126	0.311	
		4	−0.370	0.000	(4, 1)
	2	1	0.220	0.120	
		3	0.001	0.780	
		4	−0.151	0.404	
	3	1	0.126	0.311	
		2	−0.001	0.780	
		4	−0.244	0.003	(4, 3)
	4	1	0.370	0.000	(4, 1)
		2	0.151	0.404	
		3	0.244	0.003	(4, 3)

(*Table continued*)

Table A1. Continued

	i	j [a]	Mean difference $(i-j)$	Significance levels of ANOVA[b]	Multiple comparisons[c]
C2. Presence of clusters instead of isolated industries	1	2	−0.239	0.091	
		3	0.120	0.384	
		4	−0.612	0.000	(4, 1)
	2	1	0.239	0.091	
		3	0.359	0.002	(2, 3)
		4	−0.373	0.001	(4, 2)
	3	1	−0.120	0.384	
		2	−0.359	0.002	(2, 3)
		4	−0.732	0.000	(4, 3)
	4	1	0.612	0.000	(4, 1)
		2	0.373	0.001	(4, 2)
		3	0.732	0.000	(4, 3)
D. Context for firm strategy and rivalry	1	2	0.512	0.000	(1, 2)
		3	0.643	0.000	(1, 3)
		4	0.643	0.000	(1, 4)
	2	1	−0.520	0.000	(1, 2)
		3	0.132	0.432	
		4	0.131	0.412	
	3	1	−0.643	0.000	(1, 3)
		2	−0.132	0.432	
		4	−0.001	1.000	
	4	1	−0.643	0.000	(1, 4)
		2	−0.131	0.412	
		3	0.001	1.000	
D1. A local context that encourages investment in innovation-related activity	1	2	0.497	0.000	(1, 2)
		3	1.038	0.000	(1, 3)
		4	1.263	0.000	(1, 4)
	2	1	−0.497	0.000	(1, 2)
		3	0.541	0.000	(2, 3)
		4	0.766	0.000	(2, 4)
	3	1	−1.038	0.000	(1, 3)
		2	−0.541	0.000	(2, 3)
		4	0.225	0.022	(3, 4)
	4	1	−1.263	0.000	(1, 4)
		2	−0.766	0.000	(2, 4)
		3	−0.225	0.022	(3, 4)

(*Table continued*)

Table A1. Continued

	i	j [a]	Mean difference ($i-j$)	Significance levels of ANOVA[b]	Multiple comparisons[c]
D2. Competition among locally based rivals	1	2	0.219	0.107	
		3	0.230	0.007	(1, 3)
		4	0.001	0.925	
	2	1	−0.219	0.107	
		3	0.001	0.999	
		4	−0.177	0.240	
	3	1	−0.230	0.007	(1, 3)
		2	−0.001	0.999	
		4	−0.188	0.055	
	4	1	−0.001	0.925	
		2	0.177	0.321	
		3	0.188	0.055	

Notes: [a]1: Shanghai; 2: Kunshan; 3: Shenzhen; 4: Dongguan. [b]The mean difference is significant at the 0.05 level. [c](1, 2) means that Shanghai has significantly higher grade than Kunshan at 0.05 significant level.

Appendix 2

An ANOVA is a parametric analysis of the variation present in an experiment. It is a test of the hypothesis that the variation in an experiment is no greater than that due to normal variation of individuals' characteristics and error in their measurement. One-way ANOVA can find out if any groups in a set larger than two differ significantly from each other. As data analysts, you may have to find out if any groups in a set of three or more groups differ from each other. To do this, we must have measurement data and calculate the mean and standard deviation for each of the groups in the study. In one-way analysis of variance we can solve three types of questions: (1) Do any of the groups differ significantly from each other? The F-ratio gives the answer (e.g. significance levels of ANOVA in Table 2). (2) Which specific groups differ? Comparison techniques will tell us this (e.g. Tables 3–6 and A1). (3) Are the differences relatively big or small? Measures of explained variance will proviede us with answer.

The K–W test is a non-parametric test for the null hypothesis that k samples from possibly different populations actually originate from similar populations, at least as far as their central tendencies, or medians are concerned. The test assumes that the variables under consideration have underlying continuous distributions. In K–W test, the collected data on the five-level scale was transformed into ordinal scale grade.

The K–W H-test is often viewed as the non-parametric equivalent of the parametric One-way ANOVA, with both tests used to serve the same purpose of comparing possible differences between various 'groups'. The K–W test is used when the data do not meet the rigor of interval data associated with the parametric one-way ANOVA test. It may help to think of the K–W test as an ANOVA test by ranks.

Appendix 3

The priority of the four industrial clusters on 'human resources', 'basic research infrastructure' could be both ranked as 'Shanghai', 'Kunshan', 'Shenzhen' and 'Dongguan', but 'Kunshan' and 'Shenzhen' are not significantly different. The precedence of four industrial clusters on 'information infrastructure' could be judged as 'Shanghai', 'Kunshan', 'Shenzhen' and 'Dongguan', but 'Shenzhen' and 'Dongguan' are not significantly different. The priority of the four industrial clusters on 'risk capital' should be ranked as 'Shanghai', 'Kunshan', 'Shenzhen' and 'Dongguan', but 'Shanghai' and 'Kunshan' are not significantly different. The precedence of four industrial clusters on 'sophisticated and demanding local customers' could be judged as 'Shanghai', 'Kunshan', 'Shenzhen' and 'Dongguan', but 'Shenzhen' and 'Dongguan', 'Shanghai' and 'Kunshan' are not significantly different. 'Dongguan' was significantly inferior to 'Shanghai', 'Kunshan' on 'home customer needs that anticipate those elsewhere', but not significantly inferior to 'Shenzhen'. 'Dongguan' was superior to the other three clusters on 'competitive advantage of supporting and related industry', especially 'Shanghai' and 'Shenzhen'. The precedence of the four industrial clusters on 'presence of clusters instead of isolated industries' could be judged as 'Dongguan', 'Kunshan', 'Shanghai' and 'Shenzhen', but 'Shanghai' and 'Kunshan' are not significantly different. The priority of the four industrial clusters on 'a local context that encourages investment in innovation-related activity' could be ranked as 'Shanghai', 'Kunshan', 'Shenzhen' and 'Dongguan'.