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Abstract

Purpose – The purpose of this paper is to: first, divide external knowledge into different levels and understand how these different levels of external knowledge create different knowledge networks. Second, explore the relation among different levels of external knowledge, different types of knowledge and their influences on innovation. Different types of knowledge may act as mediators between different levels of external knowledge and innovation performance are also discussed. Third, further explicate the possible reasons behind the phenomena observed in the first and second objectives.

Design/methodology/approach – The quantitative and qualitative research methods were adopted in this study. In terms of the quantitative research method, data were collected from 157 information and communications technology (ICT) companies in Zhangjiang. There were 38 interviews carried out using the qualitative research method. Interviewees included 26 directors from the Zhangjiang ICT chip companies and 12 directors from China's domestic mobile phone manufacturing sector.

Findings – This study finds out that the source of external knowledge in the Zhangjiang Hi-Tech Park is mostly derived from cross-regional and cross-national connections. Through the connection with global companies, the firms in Zhangjiang acquire technical knowledge. Also, through the interaction with cross-regional companies, the firms in Zhangjiang absorb market knowledge. The results of this study indicate that the cross-regional connections are spurred by the increasing demand of the Chinese domestic market and the government's support for cross-regional interactions. Cross-national connections are encouraged and led by the Chinese Government after China's 3G communication standard is adopted.

Research limitations/implications – This study is built upon a case study in Zhangjiang of China. The findings of this study may not be applicable to other countries or regions in China. Also, this study only focusses on the ICT industry in Zhangjiang. Knowledge from different industries is not included in this study. In addition, the formal and informal knowledge flow is neglected in this study as well.

Practical implications – The findings of this study provide business executives and policymakers with a new way of thinking about the development of industrial clusters and local firms. Firms may be able to find new ways to raise innovation performance using different external knowledge.

Originality/value – The major contribution of this study is an initial attempt to provide a comprehensive analysis of external knowledge of industrial clusters, different types of knowledge and their influences on innovation performance. Moreover, the mediating effects of different types of knowledge are also discussed.

Keywords Innovation performance, Knowledge flow, External knowledge, Industrial cluster, Zhangjiang Hi-Tech Park

Paper type Research paper

1. Introduction

An industrial cluster has been considered to have the ability to increase the capability of innovation for firms. Since 1990s, the management and policy-making of industrial clusters have opened up a lot of discussions (e.g. Porter, 1990; Giuliani and Bell, 2005; He and Rayman-Bacchus, 2010; Andersen and Bøllingtoft, 2011; Giuliani, 2013; Lei and

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Huang, 2014; Expósito-Langa *et al.*, 2015). An industrial cluster is widely defined as a geographic agglomeration or hot spot that is attractive for firms looking for the cooperation in the same or interconnected sectors (Krugman, 1995; Pouder and John, 1996; Giuliani and Bell, 2005). The firms in an industrial cluster can often gain competitive advantages through cooperation. Some researchers argue that the competitive edge of firms in an industrial cluster results from the networking that provides innovation-boosting knowledge flows for companies (Uzzi, 1996; He and Rayman-Bacchus, 2010; Martínez *et al.*, 2012; Colovic and Lamotte, 2014).

It is important to note that the knowledge flow of an industrial cluster should not be limited within a zone, or the lock-in effect may take place. This effect can hinder the cluster development (Grabher, 1993; Yeung *et al.*, 2006). Also, it is thought to be the major reason why innovation and development are lacking and slowing down for firms in an industrial cluster (Trippl and Otto, 2009). The openness to external knowledge has become more and more important due to globalization (Cooke *et al.*, 2004; Isaksen and Kalsaas, 2009). Thus, an open system is required to elaborate different levels of knowledge links in a cluster (Schiele and Ebner, 2013).

However, where does external knowledge come from? As globalization becomes a popular research topic or even a trend, the studies of industrial clusters have often been conducted based on the socio-cultural background in developed countries (Fan, 2011). For example, in the concept of global production networks (Henderson *et al.*, 2002), global commodity chains (Gereffi, 1994), and global value chains (Gereffi *et al.*, 2005), advanced companies adopt a production model to divide the production into developing countries, enabling the latecomer companies to acquire technologies and knowledge (Qu and An, 2003; Humphrey and Schmitz, 2004). As for regional development in developing countries, therefore, the government initially designates a zone and then implements preferential policies to attract foreign investment, hoping that the settlement of those foreign companies causes the cluster effect and facilitates the development of local companies (Ai and Wu, 2015).

Nevertheless, several studies have been criticizing the perspective of local-global relationship dichotomy based on the development of industrial clusters (Freeman, 2002; Sotarauta *et al.*, 2011). The existing clustering literature has paid more attention to the perspective of a multilevel cluster network. Various external sources of knowledge including national, local and global sources should be highly considered in order to have a satisfactory and well-structured outcome (Lundvall and Johnson, 1994; Walck, 1995; Freeman, 2002; Isaksen, 2009; Sotarauta *et al.*, 2011; Schiele and Ebner, 2013).

Based on the aforementioned review, therefore, the first objective of this study is to divide external knowledge into different levels and understand how these different levels of external knowledge create different knowledge networks. Multilevel external knowledge is discussed in this study. Three types of external knowledge are mentioned according to the relevant research: inter-regional, cross-regional and cross-national knowledge. First, inter-regional knowledge implies that external knowledge is from outside the firm and inside the cluster (Camagni, 1991; Storper, 1997). The main knowledge originates from the region. Second, cross-regional knowledge implies that external knowledge comes from outside the cluster but still within the nation; in other words, the main knowledge source is the domestic market (Pietrobelli, 2008; Fan, 2011; Sotarauta *et al.*, 2011). Third, cross-national knowledge implies that external knowledge derives from outside the country (Henderson *et al.*, 2002; Coe *et al.*, 2004; Humphrey and Schmitz, 2004; Gereffi *et al.*, 2005; Ernst, 2011).

The second objective of this study is to explore the relation among different levels of external knowledge, different types of knowledge and their influences on innovation.

This study also tries to understand whether different types of knowledge may act as mediators between different levels of external knowledge and innovation performance. On one hand, several studies indicate that different levels of external knowledge may promote innovation (Sotarauta *et al.*, 2011; Schiele and Ebner, 2013). On the other hand, several studies indicate that different levels of external knowledge may have a positive effect on different types of knowledge (Amsden and Chu, 2003; Jin and Zhou, 2009; Sotarauta *et al.*, 2011), while some studies mention that different kinds of knowledge positively influence firms' innovation (Fan, 2011; Cai, 2012). Nevertheless, few studies focus on the relationship between different levels of external knowledge and innovation as well as on the mediating effects for different kinds of knowledge. Therefore, this study attempts to explore the relationships among different levels of external knowledge, different types of knowledge and their influences on innovation.

Two kinds of knowledge are adopted in this study: technical and market knowledge (Mitchell, 1992). Market knowledge refers to an understanding of the product needs and future market trends. This kind of knowledge can be obtained from customers, competitors, government agencies or suppliers and other channels (Quintas *et al.*, 1997; Li and Calantone, 1998). In contrast, technical knowledge is defined as specific information such as explicit knowledge (Smith, 2001; Gertler, 2008). This kind of knowledge often contains technical information, technology, know-how and skills. By acquiring technical knowledge, companies can add value to their products, and get a competitive advantage. In other words, in this study, technical knowledge refers to technical expertise of an industry while market knowledge is referred to as a market trend (Gertler, 2008; Sotarauta *et al.*, 2011).

The third objective is to further explicate the possible reasons behind the phenomena observed in the first and second objectives. In order to accomplish the third objective of this study, the qualitative and quantitative research methods are combined to respond to the research questions. First, the quantitative research method used to explore the source of external knowledge in various levels, the inflow of types of knowledge and its impact on firms' innovations is studied. The qualitative method is then used to further elaborate the results of sources of knowledge flow.

The reason why two methods are combined is to complement the shortcomings of both of the methods alone, as proposed by Johnson and Onwuegbuzie (2004). On one hand, data generated through the quantitative research can explain a certain phenomenon directly. However, the results are not comprehensive; the reasons behind certain facts cannot be found. On the other hand, the qualitative approach attempts to make an interpretation or explanation for some peculiar circumstances or conditions, but it is not broad enough (Wimmer and Dominick, 2006). Although two methods are essential, they may coexist to provide better research results. The mixed method may produce a flexible result for the study (Miles and Huberman, 1994).

This study adopts a case study design. The Zhangjiang Hi-Tech Park in Shanghai is used as the case representing a cluster that manufactures chips for the telecommunication industry. There are two reasons to explain why Zhangjiang is chosen. The first one is to have easy access to the data collection. The second one is that this study aims to study a domestic-funded cluster since a lot of studies of Chinese industrial clusters have selected foreign-funded clusters, for example, Suzhou (Wei *et al.*, 2009), Beijing Zhongguancun (Zhou and Xin, 2003) and Wuxi (Jin and Zhou, 2009). More and more studies have indicated that a foreign-funded cluster is more likely to turn into a satellite platform, which means that a better link exists between subsidiary companies and their parent companies (Markusen, 1996). However, these subsidiary companies seldom link and cooperate with each other within industrial clusters. Thus, attracting foreign investment helps little in developing industrial clusters. Increasing studies have stressed the role of local enterprises, because local companies are willing to cooperate with other local companies to upgrade the techniques, thereby benefiting the development of industrial clusters (Amsden and Chu, 2003; Jin and Zhou, 2009). In 2013, the respective amount of domestic and foreign capital in the Shanghai Zhangjiang Hi-Tech Park was 17.5 and 5.8 billion RMB, respectively (Shanghai Pudong Bureau of Statistics, 2013).

2. Theoretical framework and hypothesis development

The purpose of this study is to explore the relation among different levels of external knowledge, different types of knowledge and their influences on innovation. The study also investigates whether different types of knowledge may act as mediators between different levels of external knowledge and innovation performance. Therefore, this study develops its hypotheses using different levels of connections.

Numerous studies have mentioned the importance of cross-national connections, suggesting that these connections help to create innovation (Humphrey and Schmitz, 2004; Gereffi *et al.*, 2005). On one hand, the relationship between local and foreign firms is crucial for local firms because the companies in developing countries can improve their capacity by cooperating with foreign companies from developed countries (Henderson *et al.*, 2002; Coe *et al.*, 2004; Ernst, 2011) and the introduction of technologies from advanced to latecomer companies brings about technical upgrades (Gereffi, 1994; Henderson *et al.*, 2002; Coe *et al.*, 2004; Humphrey and Schmitz, 2004; Gereffi *et al.*, 2005). Acquiring knowledge from foreign companies enables latecomer companies to upgrade their capacity. This upgrade may have a positive effect on latecomer companies to increase innovation performance. However, these studies have various views on what kinds of knowledge and innovation can be obtained using cross-national links. For example, Amsden and Chu (2003) indicate that high-tech industries in Taiwan with the help from developed countries to upgrade their technical capacity from original equipment manufacturer to original design manufacturer and own branding and manufacturing. This upgrade has a positive effect on Taiwanese firms to acquire advantages and becomes more capable of innovation. In other words, relevant studies have put emphasis on the technical upgrade while discussing latecomer countries cooperating with advanced countries.

On the other hand, several studies have focussed on the market knowledge obtained through cross-national connections among firms. For example, Birkinshaw and Hood (1998) indicate that by establishing subsidiaries in foreign markets within an industrial cluster, the parent company can have links with subsidiaries and gain market knowledge. The knowledge is then transferred to the regional subsidiary, and thus helps to open up the business of subsidiaries (Birkinshaw and Hood, 1998). Alternatively, Jin and Zhou (2009) note that the success of industrial clusters in Wuxi results from the cooperation with multinational companies. This cooperation positively helps to gain market knowledge, boost local manufacturers' production, and further promote local innovation. Also, Ai and Wu (2015) reveal that in China, the connections of firms with foreign manufacturers can help to gain market knowledge. The combination of market knowledge and domestic demand further boosts innovation. Accordingly, the following hypotheses are proposed:

H1a. Cross-national connections have a positive effect on acquiring technical knowledge.

H1b. Cross-national connections have a positive effect on acquiring market knowledge.

H1c. Cross-national connections have a positive effect on increasing innovation performance.

In cluster development, many studies have mentioned the importance of cross-regional connections, suggesting that the connections positively promote innovation. However, in respect of cross-regional connections, various studies have different views on the influences of technical and market knowledge on firms. On one hand, some studies have stressed that obtaining domestic market knowledge can increase manufacturer capabilities. For example, Pietrobelli (2008) mentions that domestic connections can help companies to acquire information regarding local markets, and that this market knowledge can help companies to innovate. Ai and Wu (2015) explain how Chinese mobile phone manufacturers are integrated into a domestic market. The mobile phone manufacturers first absorb market knowledge, and this domestic market knowledge positively helps their product to gain access to the market. On the other hand, some studies put emphasis on the cross-regional connection, suggesting that the connection can be helpful in acquiring technical knowledge. For example, Sotarauta *et al.* (2011) investigated 95 vendors in the smart machine and digital content and the services industry in South Ostrobothnia and Tampere, finding that the majority of technical knowledge was obtained through the national pipeline with other companies. Moreover, because the telecommunication industry is a highly sensitive industry that is related to the national security, the government often plays a crucial role in its development, which is the same case as in the cluster development and local industry development in developing countries (Johnson, 1982; Amsden, 1989; Wang, 2010). In order to prevent foreign companies from controlling the telecommunication industry, companies should develop their own technical capacity. Thus, the Chinese Government should improve technical levels of domestic manufacturers through market protection and government interference. Therefore, as for cross-regional connections, domestic manufacturers have different positive relationships in acquiring technical knowledge. Accordingly, the following hypotheses are formulated:

H2a. Cross-regional connections positively influence the absorption of technical knowledge.

H2b. Cross-regional connections positively influence the absorption of market knowledge.

H2c. Cross-regional connections positively influence innovation performance.

Numerous studies suggest that inter-regional connections help to create innovation (Fan, 2011; Sotarauta *et al.*, 2011). However, regarding cross-regional connections, different studies have different views on their influences on technical and market knowledge. On one hand, some studies suggest that one of the benefits of an industrial cluster is innovative milieu. This milieu is difficult to be copied by other areas. Tacit knowledge can easily be spread in a cluster with this milieu. In their study, Amsden and Chu (2003) mention that informal partnerships are from inside the Taiwan Hsinchu Science Park because of nearby research institutions and universities. In this park and around the area, market knowledge can easily be spread and accessed, and this background positively helps manufacturers to increase innovation. However, some studies suggest that the formation of an industrial cluster can help to reduce the manufacturers' cost. The interactive connection between upstream and downstream firms further positively enhances technical knowledge promotion. Wang (2009) indicates that in the integrated circuits (IC) industry, the upstream and downstream firms should cooperate with each other for completing the production of an IC wafer. Therefore, if one firm is exposed to certain new technical knowledge, it will encourage downstream firms to cooperate with and learn from each other. In this way, the total time spent in cooperation will be shortened and technical capacity can also be enhanced. This type of industrial cluster can also be given out of the localized economy. Therefore, the following hypotheses are proposed:

H3a. Inter-regional connections have a positive effect on acquiring technical knowledge.

H3b. Inter-regional connections have a positive effect on acquiring market knowledge.

H3c. Inter-regional connections have a positive effect on innovation performance.

Different kinds of knowledge may help firms to boost innovation performance. Technical and market knowledge are important to produce innovation (Dougherty, 1992). The firms with technical knowledge can locate markets and create business opportunities in a rapidly changing environment (Shane, 2000). Market knowledge gives companies a better understanding of consumers' needs. These two types of knowledge can positively help companies to satisfy consumer demand, solve problems and develop products that fit the market need (Roberts, 1991). A cluster is like open systems with no boundaries. Knowledge exchange networks provide companies with opportunities of cooperating with other companies (Chesbrough, 2004). However, only few studies of market knowledge and technical expertise attempt to explore what kind of impact on innovation can be brought about by different kinds of knowledge. Accordingly, the results in the following hypotheses are proposed:

H4a. Technical knowledge has a positive effect on boosting innovation performance for manufacturers in a cluster.

H4b. Market knowledge has a positive effect on increasing innovation performance for manufacturers in a cluster.

Several studies have mentioned that different levels of external knowledge can positively influence firms' innovation. Cross-national connection (Henderson *et al.*, 2002; Humphrey and Schmitz, 2004; Gereffi *et al.*, 2005), cross-regional connection (Pietrobelli, 2008; Ai and Wu, 2015) and inter-regional connection (Pietrobelli, 2008; Fan, 2011; Sotarauta *et al.*, 2011) may have positively influence on companies innovation performance.

In addition, different levels of external knowledge may also have a positive effect on different types of knowledge and innovation (Amsden and Chu, 2003; Jin and Zhou, 2009; Sotarauta *et al.*, 2011). As for cross-national connections, Amsden and Chu (2003) indicate that multinational firms can help to promote a formal relationship and upgrade technology knowledge. Jin and Zhou (2009) mention that multinational firms can be helpful in obtaining market knowledge, and then receiving innovation. In terms of cross-regional connections, Sotarauta *et al.* (2011) indicate that links with domestic manufacturers have a positive effect on having access to technical knowledge, while Ai and Wu (2015) believe that these links are helpful in gaining market knowledge and innovation. As for inter-regional connections, Amsden and Chu (2003) mention that the industrial cluster effect results from the spread of market knowledge, while Wang (2010) argues that the industrial cluster effect is the flow of technical knowledge that provides innovation sources for the zone.

Overall, different levels of external knowledge lead to different kinds of knowledge acquisition. Also, different kinds of knowledge have a positive effect on innovation performance (Dougherty, 1992; Shane, 2000; Chesbrough, 2004). Therefore, this study proposes that the effects of external knowledge and innovation performance within manufacturing clusters can be mediated by various kinds of knowledge. Therefore, the following hypotheses are formulated:

H5a. Technical knowledge mediates the relationship between cross-national connections and innovation performance.

H5b. Market knowledge mediates the relationship between cross-national connections and innovation performance.

H5c. Technical knowledge mediates the relationship between cross-regional connections and innovation performance.

H5d. Market knowledge mediates the relationship between cross-regional connections and innovation performance.

H5e. Technical knowledge mediates the relationship between inter-regional connections and innovation performance.

H5f. Market knowledge mediates the relationship between inter-regional connections and innovation performance.

The hypotheses of this study are presented in Figure 1.

3. Methodology

3.1 Quantitative method

3.1.1 Design of the questionnaire. Six variables are included in this study. They are cross-national connections, cross-regional connections, inter-regional connections, technical knowledge, market knowledge and innovation performance, respectively. These variables indicate three "zones," including sources of external knowledge, types of knowledge and innovation performance. First, five questions based on the studies of Chen (2008), Tabata (2007), and Sotarauta *et al.* (2011) were developed to measure cross-national, cross-regional and inter-regional connections. Second, three questions referring to the study of Østergaard and Park (2012) were developed to investigate technical and

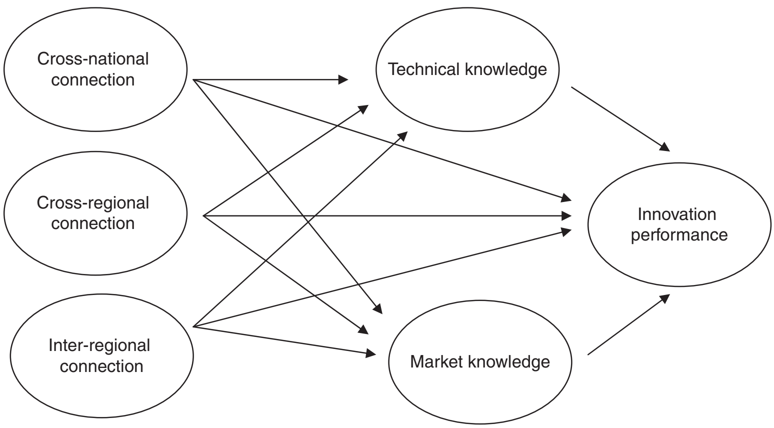

Figure 1.
A research framework

market knowledge. Finally, referring to Yang (2005) and Cheng *et al.* (2014), six questions were developed to assess innovation performance.

In the beginning, this study developed a questionnaire which consisted of 27 items. In order to confirm the validity of the questionnaire, a pre-test has been conducted to expose the weaknesses in the questionnaire design and instrumentation (Hair *et al.*, 2010). The researchers held a discussion which was composed of five managers from the information and communications technology (ICT) companies, and three engineers and three managers from the ICT industry associations in Zhangjiang, respectively. All of them specialized in the ICT industry. During the pre-test procedure, respondents were encouraged to comment the questions that they thought remained unclear, ambiguous, or that they were unable to respond. Following this process, some minor changes were made to the survey questions (Cooper and Schindler, 2006). As a result, three items were omitted, leaving a final 24-item set to form a complete scale for this study.

The questionnaire was conducted and answered as follows. Respondents were first required to give their basic information, including the name of the affiliated company, the seniority and job title. Next, they were asked whether they were aware of the source of external knowledge of their companies. For example, they might answer that my company had a strong cooperation with universities and research institutions in the park. They were also asked the possible relationship between external connections and different types of knowledge. For example, they might indicate that the external connections could help my company to acquire knowledge about product development. To avoid any misunderstandings of the questionnaire items and ensure their validity, the researchers accompanied respondents to fill out the questionnaires. A seven-point Likert scale, which ranges from Strongly Disagree (1) to Strongly Agree (7), is used for all items.

3.1.2 Sampling and data collection. There were totally 397 manufacturing companies on the member list compiled by the Shanghai IC Industry Association in 2014. The Zhangjiang Hi-Tech Park was founded in 1992. By now, 62.8 percent of the companies in this park were from the ICT industry, 12 percent from the optoelectronics industry, 9 percent from the biology industry, and 9 percent from the animation industry, respectively. Therefore, a relatively high number of companies in the Zhangjiang Hi-Tech Park were from the ICT industry (Shanghai Pudong Bureau of Statistics, 2013). With the help of Shanghai Zhangjiang Incubator Center and the Shanghai Semiconductor Industry Union, there were 500 questionnaires distributed, and 157 were collected with the sampling rate of 31.4 percent. The low sampling rate indicates the limitation of the company survey (Xu, 1999). Therefore, this study adopted the qualitative research method to counterbalance the limit of low sampling rate of this questionnaire.

Following the recommendations of Armstrong and Overton (1977), non-response bias was assessed. In this study, 77 responses were received during the period from April 1 to May 1, 2011 and the last 80 questionnaires were received during the period between May 2 and June 20, 2011. The underlying assumption is that later respondents are in some way more like non-respondents. No statistically significant differences ($p > 0.10$ in all cases) exist between the two groups on the means for different levels of external knowledge, different kinds of knowledge and innovation performance. These results recommend that non-response bias is not an issue in this study.

The demographics profile of the respondents is shown in Table I. In total, 44.6 percent of the respondents aged between 41 and 50 years. Most of them had a seniority of 21 to 25 years (39.5 percent) and worked in companies with 51-250

Options	Frequency	%
Age		
20-30	3	1.9
31-40	18	11.5
41-50	70	44.6
51-60	61	38.9
61-70	5	3.1
Over 71	0	0.0
Seniority		
0-5 years	3	1.9
6-10 years	8	5.1
11-15 years	18	11.5
16-20 years	32	20.4
21-25 years	62	39.5
25-30 years	33	21.0
Over 31 years	1	0.6
Number of employees		
10 employees	7	4.5
11-50 employees	48	30.6
51-250 employees	96	61.1
More than 251 employees	6	3.8
Type of companies		
Electronic component manufacturing	44	28.0
Computer industry	12	7.6
Optical product manufacturing	10	6.3
Telecommunication	50	31.8
IT industry	34	21.7
Semiconductor wafer manufacturing	7	4.5

Note: $n = 157$

Table I.
Demographic profile of the respondents

employees (61.1 percent). A majority of them came from the electronic component manufacturing, telecommunications and IT industry (totaling 81.5 percent).

3.1.3 Validity and reliability of the questionnaire. Before the final version of the questionnaire was confirmed, the experts were asked to give advice to ensure validity. Therefore, the questionnaire had a good level of validity. The results are presented in Table II. The Cronbach's coefficient α estimates for six variables ranged between 0.73 and 0.92, exceeding the minimum value of 0.70, as suggested by Bland and Altman (1997). The standardized factor loadings and average variance extracted (AVE) estimate were higher than the threshold of 0.50, as suggested by Fornell and Larcker (1981) and Bagozzi and Yi (1989). The composite reliability (CR) representing each construct is used to verify convergent reliability. As suggested by Fornell and Larcker (1981), the CR values were higher than the threshold value of 0.60. Therefore, these results indicated that the instrument had good convergent validity. The data collected for the study indicated strong evidence of construct validity and reliability for variables that represented the sources of external knowledge, types of knowledge and innovation performance. Therefore, the results of Cronbach's α estimates, AVEs, CRs and descriptive statistics are presented in Table II.

The χ^2/df ratios (1.74) were lower than the threshold value of 3.0, as suggested by Carmines and McIver (1981). The root mean square error of approximation value was

Item	Dimension	Statement	Factor loading	Cronbach's α	CR	AVE
A1	Inter-regional connections	1. My company often participates in seminars that are held in the park	0.954	0.810	0.876	0.643
		2. My company has a strong cooperation with universities and research institutions in the park	0.846			
		3. My company has a good relationship with other companies in the same industry or different industries in the park	0.740			
		4. The employees in my company have a good personal relationship in the park	0.631			
A2	Cross-regional connections	1. My company often participates in seminars that are held in China	0.605	0.822	0.843	0.583
		2. My company has a strong cooperation with Chinese universities and research institutions	0.870			
		3. My company has a good relationship with other Chinese companies in the same or different industries	0.920			
		4. The employees in my company have a good personal relationship in other regions of China	0.601			
A3	Cross-national connections	1. My company often participates in international seminars	0.782	0.785	0.849	0.854
		2. My company has a strong cooperation with foreign universities and research institutions	0.810			
		3. My company has a good informal relationship with other international companies	0.765			
		4. The employees in my company have a good personal relationship around the world	0.696			
A4	Technical knowledge	1. My company can acquire knowledge of product development using external knowledge	0.660	0.732	0.801	0.576
		2. My company can acquire technical knowledge using external knowledge	0.847			
		3. External knowledge helps to generate innovation	0.758			
A5	Market knowledge	1. My company can learn market trends using external knowledge	0.871	0.811	0.856	0.667
		2. My company can acquire market information using external knowledge	0.879			
		3. External knowledge helps my company to receive competitors' information	0.686			
A6	Innovation performance	1. Market shares rise significantly	0.766	0.923	0.958	0.793
		2. The product innovation of my company outperforms competitors and we have better market responses	0.865			
		3. My company has significant progress in terms of the technologies and techniques	0.921			
		4. Sales profit increases	0.912			
		5. New patents are issued to us	0.932			
		6. The efficiency of R&D rises	0.934			

Notes: CR, composite reliability; AVE, average variance extracted

Table II. Validity and reliability of the questionnaire items

(0.06) lower than 0.08, indicating adequate fit (Browne and Cudeck, 1993). Some indices (e.g. CFI, GFI, IFI, NNFI) were greater than the recommended value of 0.90 (e.g. Tucker and Lewis, 1973; Browne and Cudeck, 1993; Hu and Bentler, 1999). The standardized root mean residual value (0.04) was equivalent to or less than the recommended threshold value of 0.08 (Hu and Bentler, 1999). The adjusted goodness-of-fit index was 0.89, exceeding the recommended threshold level of 0.8, which indicated acceptable fit (Zikmund *et al.*, 2012). Therefore, the overall fit of the measurement models was adequate (see Table III).

3.2 Qualitative method

3.2.1 Interview outline. In this study, semi-structured and in-depth interviews were conducted in order to collect primary data. There are three major research aspects of the interview: the reason why the manufacturers choose to station in the Zhangjiang Hi-Tech Park, the source of innovation knowledge, and the opinion on the quantitative results. The interview questions would be adjusted in accordance to the actual situation (see Appendix 1).

3.2.2 Sampling. This study adopted both of the purposive sampling and snowball sampling methods. It also used the annual report on the IC industry development, which was published by the China Semiconductor Industry Association (CSIA) used for sampling selection. The researchers chose well-established companies and invited senior managers as many as possible to be respondents. With the help of the Shanghai Zhangjiang Incubator Center and the Shanghai Semiconductor Industry Union, the researchers had 38 interviewees in total (see Table AI).

The data of this study were collected based on eight times of fieldwork in Zhangjiang and Shanghai and six times in Shenzhen from December 2011 to June 2013. There were 38 interviews carried out using the qualitative research method. The interviewees were 26 directors from the IC industry (22 from the IC design, one from the IC manufacturing, one from the IC equipment supplying, and two from other industries related to the IC industry, respectively), and 12 directors from China's domestic mobile phone manufacturing sector (including six from the knock-off mobile phone manufacturing market). Other sources of data collection for this research included the IC manufacturers' websites, open information materials, the report on the Shenzhen mobile phone manufacturers, the annual industry report on the development of the Zhangjiang Hi-tech Park published by the Shanghai Zhangjiang Group, and the annual report on the IC industry development published by CSIA.

In order to validate practical and theoretical value of the interview results, two experts were invited to cross-check the content of the interview dialogue. In addition, in order to have a smooth interview process and ensure that critical information is obtained, interviewees were informed in advance and given the interview outline. In each interview, two to four researchers were involved. The researchers took a step-by-step approach to acquire the information. The finding and discussion are as follows.

Table III. Results of the structural model tests

Model	χ^2/df	p	RMSEA	SRMR	CFI	GFI	IFI	NNFI	AGFI
Structural model – overall model	1.743	0.000	0.062	0.040	0.905	0.904	0.945	0.928	0.885
Recommended value	< 3.0	–	< 0.08	$\leqslant 0.08$	> 0.90	> 0.90	> 0.90	> 0.90	$\geqslant 0.80$

Notes: *p*, *p*-value; RMSEA, root mean square error of approximation; SRMR, standardized root mean residual; CFI, comparative fit index; GFI, goodness-of-fit index; IFI, incremental fit index; NNFI, non-normed fit index; AGFI, adjusted goodness-of-fit index

4. Findings

4.1 Hypothesis verification

In order to test the hypotheses in the conceptual research model (see Figure 1), this study applies structural equation modeling with the Analysis of Moment Structure (AMOS) version 7.0. The results are given in Table IV.

H1 predicts that cross-national connections have a positive effect on acquiring technical and market knowledge and increasing innovation performance. The results support *H1a* and *H1c*, suggesting that cross-national connections help to spread technical knowledge ($b = 0.39$, $p < 0.05$) and have a positive influence on innovation performance ($b = 0.49$, $p < 0.01$). However, *H1b* is not supported. Cross-national connections have no significant positive effect on market knowledge ($b = 0.23$).

H2 postulates that cross-regional connections have a positive influence on acquiring technical and market knowledge and increasing innovation performance. The results support *H2b* and *H2c*, indicating that cross-regional connections help to absorb market knowledge ($b = 0.37$, $p < 0.01$) and have a positive influence on innovation performance ($b = 0.57$, $p < 0.05$). However, *H2a* is not supported. Cross-regional connections have no significant positive effect on technical knowledge ($b = 0.08$).

H3 assumes the positive effect of inter-regional connections on technical knowledge, market knowledge and innovation performance. The hypotheses are not fully supported. The results do not support *H3a*, *H3b* and *H3c*, showing that inter-regional connections do not help firms to acquire technical knowledge ($b = -0.55$) and market knowledge ($b = -0.29$) and increase innovation performance ($b = -0.36$).

H4 predicts that technical and market knowledge positively influences innovation performance. Both of the hypotheses are fully supported. The results support *H4a* ($b = 0.25$, $p < 0.01$) and *H4b* ($b = 0.28$, $p < 0.05$), indicating that technical and market knowledge helps firms to boost innovation performance.

Overall, the quantitative research results reveal that not all sources of external knowledge have a positive influence on acquiring knowledge. The technical knowledge of a firm mostly derives from cross-national connections (*H1a*) while the market knowledge of a firm mostly comes from cross-regional connections (*H2b*). Moreover, both of cross-national and cross-regional connections positively influence innovation performance (*H1c* and *H2c*). In addition, the results show that by acquiring technical and market knowledge (*H4a* and *H4b*), the innovation performance of a firm can be increased. In others words,

Hypothesized relationship	Standardized coefficient	p-value	Hypothesis	Hypothesis supported
Cross-national connections →technical knowledge	0.387	0.014*	*H1a*	Yes
Cross-national connections →market knowledge	0.231	0.265	*H1b*	No
Cross-national connections →innovation performance	0.489	0.003**	*H1c*	Yes
Cross-regional connections →technical knowledge	0.076	0.439	*H2a*	No
Cross-regional connections →market knowledge	0.374	0.007**	*H2b*	Yes
Cross-regional connections →innovation performance	0.569	0.042*	*H2c*	Yes
Inter-regional connections →technical knowledge	−0.548	0.865	*H3a*	No
Inter-regional connections →market knowledge	−0.293	0.243	*H3b*	No
Inter-regional connections →innovation performance	−0.364	0.325	*H3c*	No
Technical knowledge →innovation performance	0.247	0.007**	*H4a*	Yes
Market knowledge →innovation performance	0.280	0.026*	*H4b*	Yes

Notes: $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

Table IV. Hypothesis test results

technical and market knowledge is a stimulant and facilitator for innovation performance. Different types of external knowledge result in the absorption of different knowledge. Technical and market knowledge can spur the innovation performance of a firm.

However, inter-regional connections do not have a positive influence on acquiring technical and market knowledge and innovation performance (*H3a*, *H3b* and *H3c*). In addition, the cross-national connections of a firm have a positive effect on spreading market knowledge (*H1b*). Also, the cross-regional connections of a firm positively influence the absorption of technical knowledge (*H2a*)

4.2 Verification of mediating effects

The first objective of this study is to examine the source of external knowledge in different levels, and to analyze different types of knowledge and their influences on innovation performance. The second objective of this study is to understand whether different types of knowledge may mediate different levels of knowledge and their innovation performance.

According to Kenny (1988), there are two the basic conditions to detect the effect of mediation. First, independent variables (cross-national, cross-regional and inter-regional connections) and a dependent variable (innovation performance) should be significant. Second, independent variables (cross-national, cross-regional and inter-regional connections) and mediating variables (technical and market knowledge); and mediating variables (technical and market knowledge) and a dependent variable (innovation performance) should also be significant (as shown in Table IV). Therefore, this study tests the path of cross-national connections→technical knowledge→innovation performance ($z = 2.18$, $p = 0.029$). The p-value of this path is significant, which shows that there is partial mediation. As for the path of cross-regional connections→market knowledge→innovation performance ($z = 2.21$, $p = 0.026$), the p-value of this path is significant, which shows that there is partial mediation. Therefore, *H5a* and *H5d* are supported.

As for the path of cross-national connections→market knowledge→innovation performance and the path of cross-regional connections→technical knowledge→ innovation performance, z-value is not greater than 1.96 (Sobel, 1982). Therefore, this is no mediating effect in these two paths. As for *H5b* and *H5c*, the path of an independent variable (inter-regional connections)→a dependent variable (innovation performance) does not have any significant results. The verification of mediation does not meet the basic condition of measurement as indicated by Kenny (1988). Therefore, *H5e* and *H5f* are not supported (Table V).

5. Discussion

In order to further explicate the results of the quantitative research, two intriguing questions need to be answered and discussed. First, why can cross-regional connections help firms to acquire market knowledge and improve innovation performance? Second, why are cross-national connections beneficial for firms in obtaining technical knowledge and improving innovation performance? This study, through qualitative interviews, attempts to make a detailed explanation for the knowledge source from the Zhangjiang Hi-Tech Park.

5.1 Why do cross-regional connections help firms to acquire market knowledge and improve innovation performance?

From the in-depth interview, this study found two reasons used for explaining the question: the satisfaction of domestic market demand and the national support for cross-regional interactions.

Relational model	Unstandardized coefficient	SE
Cross-national connections → innovation performance (total effect)	0.733	
Cross-regional connections → innovation performance (total effect)	0.853	
Inter-regional connections → innovation performance (total effect)	0.546	
Cross-national connections → technical knowledge	0.35	0.11
Cross-national connections → market knowledge	0.19	0.10
Cross-regional connections → technical knowledge	0.03	0.11
Cross-regional connections → market knowledge	0.32	0.07
Inter-regional connections → technical knowledge	−0.18	0.15
Inter-regional connections → market knowledge	−0.32	0.20
Technical knowledge → innovation performance	0.27	0.09
Market knowledge → innovation performance	0.43	0.17

Path of statistical mediation	Sobel's *z*-value	*p*-value	% of mediating effects in total	Mediating effect	Hypothesis	Hypothesis supported
Cross-national connections → technical knowledge → innovation performance	2.18	0.029	12.9	Partial mediation	*H5a*	Yes
Cross-national connections → market knowledge → innovation performance	1.52	0.128	–	Non	*H5b*	No
Cross-regional connections → technical knowledge → innovation performance	0.11	0.911	–	Non	*H5c*	No
Cross-regional connections → market knowledge → innovation performance	2.21	0.026	16.1	Partial mediation	*H5d*	Yes
Inter-regional connections → technical knowledge → innovation performance	−1.11	0.26	–	Non	*H5e*	No
Inter-regional connections → market knowledge → innovation performance	−1.35	0.178	–	Non	*H5f*	No

Note: SE, standard error

Table V. Sobel test of mediation

5.1.1 The satisfaction of domestic market demand. Most of the companies in Zhangjiang Hi-Tech Park are IC design companies. However, the clients of Zhangjiang's companies mostly come from Shenzhen. A majority of Chinese mobile phone companies are situated in Shenzhen. If compared with international mobile phone companies focussing on the market of first-tier cities, the Chinese mobile phone companies target cheaper mobiles phone market.

In order to accomplish the manufacturing process of mobile phones, the companies located in Shenzhen need to find IC design companies because most of the firms in Shenzhen do not have the capacity for the production of chips for the telecommunication industry (source: interviewees).

In general, the chips have two important parts: hardware and software. In the production division of mobile phone chips, IC design and mobile phone companies are responsible for the hardware and software parts, respectively. IC design companies are responsible for the hardware part while mobile phone companies are in charge of software parts. Mobile phone companies should also create the operating system on the platform of cell phones, thus combining hardware and software together to accomplish the functions of mobile phones (Ai and Wu, 2015). "That is the reason why the first image users can see on the screen is the logo of mobile phones instead of IC chip companies once they turn on their mobile phones" (source: interviewees).

In the beginning, the companies in Shenzhen cooperate with overseas companies because their products have combined the hardware and software parts together. The overseas companies also create the operating system on the platform of cell phones. Therefore, mobile phone companies in Shenzhen can simply purchase overseas products to make mobile phones function (Fan, 2011). In other word, the companies in Shenzhen do not have to create the software parts and the operating system on the platform of mobile phones.

However, developing IC chips with software and hardware at the same time has two shortcomings. On one hand, the chips are expensive. In order to combine software with hardware, firms are required to have in-house hardware and software engineers, increasing the cost. On the other hand, the functions of the IC chips are fixed. Therefore, the mobile phones companies in Shenzhen cannot add additional functions. In other words, "overseas IC chip firms control the entire manufacturing sector from development and integration to production of the circuit boards independently" (source: interviewees).

Under this situation, the firms in Zhangjiang are aware of the limitation of overseas IC chips. In order to reduce the cost and meet the demand of companies in Shenzhen, the firms in Zhangjiang change the production process of overseas companies, which originally integrates hardware parts with software ones together at the same time. They are encouraged to cooperate with other firms by revealing products which are specific to them and ask for their help. For example, in order to develop Bluetooth and screen control chips, Spreadtrum cooperates with RDA Microelectronics and Telegent. This production model helps the companies in Zhangjiang to respond to the market demand with low cost. An interviewee indicated that "the chips from overseas firms cannot change the standardized functions of the chip. Therefore, these chips are difficult to respond to all the demand of the market. If compared to the cooperation with foreign companies, domestic firms can easily communicate and negotiate with each other. That is the main reason why the firms in Zhangjiang have dynamic connections with the firms in Shenzhen because the companies in Shenzhen acquire the need of the market while the firms in Zhangjiang fabricate chips according to the market demand".

According to Ji (2007), in 2005, 93 percent of the companies in Shenzhen used the chips from overseas companies. However, in 2007, the number of them decreased to 15 percent, as local firms adopted the modified production process to increase the market share.

5.1.2 Governmental support to promote cross-regional interactions and market knowledge and improve innovation. The telecommunication industry has much to do with the national security in China. In order to avoid the monopoly of foreign investment, the government promotes the cross-regional integration using through market protection strategies and political intervention.

With a funding of 600 million RMB, the China Mobile Limited promotes the cooperation among different domestic companies. In terms of the funding bidding, the China Mobile Limited asked the equipment manufacturers and chip designers to join the bidding and encourage the cooperation between upstream and downstream companies of the production chain. The bidding winners were mostly pairs of equipment manufacturers in Shenzhen and chip designers in Zhangjiang, respectively. In the "Broadband Internet Phone Joint Research and Development Project," the companies winning the project are Yulong Coolpad (Shenzhen)-Leadcore Technology (Zhangjiang), ZTE (Shenzhen)-Leadcore Technology (Zhangjiang), and Spreadtrum (Zhangjiang)-Hisense (Beijing). As for "United Research Project on Low Price 3G Mobile Phones," the company pairs like Leadcore Technology (in Zhangjiang) with ZTE Corporation (in Shenzhen), Spreadtrum (in Zhangjiang) with Hisense (in Beijing), and Spreadtrum (in Zhangjiang) with New Postcom (in Shenzhen) received the funding grants from the China Mobile Limited as well (Zhang, 2005). Through collaborative projects, the mobile phone chip manufacturers in Zhangjiang have established cross-regional learning relationships with other domestic companies.

The interviews show that in order to maintain the control over the domestic mobile phone and the telecommunication market, the Chinese Government acquires knowledge from local companies that collaborate with foreign companies in the first place. After local firms reach a certain level of technical proficiency, the Chinese Government subsidizes local firms and asks them to build inter-regionally mutual cooperation. The goal of cross-regional cooperation between local upstream and downstream companies is to satisfy the domestic market demand. Therefore, cross-regional cooperation not only mitigates potentially technical gaps but also accelerates the knowledge spillover within two regions that cooperate with each other. The companies in Shenzhen gain market shares and knowledge and share the knowledge with downstream companies in Zhangjiang. During the process of knowledge absorption, companies can upgrade their technical capabilities. Besides, local companies can have a higher level of problem-solving efficiency than multinational companies. The cross-regional network is a geographical blessing that benefit the manufacturers in Zhangjiang.

5.2 Why do cross-national connections help firms to obtain technical knowledge and improve innovation performance?

A government often plays a crucial role in local development, which is the same as the case in the development of clusters and local industries in developing countries (Johnson, 1982; Amsden, 1989; Wang, 2010). Through various interventions, the government helps to introduce local companies to the global market, sets preferential regulation, increases R&D funding and attracts talents in order to increase the national capacity for development (Weiss and Hobson, 1995; Schneider, 1998; Weiss, 2003; Haggard, 2004). Because the USA, as the center for the industrial development, builds industrial networks, there is a dynamic talent flow between Zhangjiang and the USA. Of 110,700 employees in Zhangjiang, 8,000 have overseas working experiences, mostly in the USA. Many engineers working in the Silicon Valley come from India and China, which are often referred to as "IC" (the first letters of India and China and ICs). These engineers owning overseas working experiences and acquiring knowledge in the USA desire to start with their own business in their home country. Therefore, many of them return to Zhangjiang where the companies of the IC industry agglomerate (Hu and Gang, 2005). The movement of talents accelerates cross-national network and becomes a vital element within the cluster (Wan and Gao, 2000; Saxenian, 2004).

In addition, the cross-national connection helped firms to obtain technical knowledge, and the knowledge-obtaining process had been accelerated after China adopted the 3G communication standard in 1998. China was different from the USA and European countries, which had already owned a certain level of technology when the 3G was adopted and could be commercialized immediately. When the 3G standard came out in the market, the Chinese still considered it to be a future concept. Therefore, there was still a huge distance between the technology standard and the market (Ernst, 2011).

This situation was dubbed "Valley of Death" (Lu, 2003), implying that if the innovative technology was unable to enter the market, it would be difficult to generate the profit. At that time, there were doubts about the Chinese communication capability as some people found it unstable and consumers were reluctant to use communication technology in China. This is why Chinese companies need to cooperate with foreign companies to upgrade their technology for new standards (Ernst, 2011).

In order to promote its telecommunication technology, therefore, the Chinese Government initially opens up the telecommunication industry to foreign investors, hoping that it can bring about mutual cooperation. Indeed, there were some cooperation examples, including the cooperation between the China Datang Corporation and Siemens from 2001 to 2004, the teamwork of ZTE and Ericson in 2004, and the pairing of Potevio and Nokia in 2004 (Cai, 2012). On the other hand, the Chinese Government also sought to improve the technology level of domestic products using the market protection and government interference. For example, the National Development and Reform Commission ruled that the manufacturing of mobile phones should be carried out with a license. The purpose of such regulation is to curb the development of mobile phone manufacturing abroad, forcing companies to produce mobile phones domestically with proper licenses. These restrictions resulted in the cooperation among Huawei, Texas Instruments and Motorola, and even the alliance between ZTE and Japanese Kyocera (Liu, 2008). This might be the reason why cross-national connections help firms to obtain technical knowledge and improve innovation performance.

6. Conclusion and implications

The purpose of this study is to examine the source of external knowledge and analyze different types of knowledge and their influences on innovation performance. Cross-national, cross-regional and inter-regional connections are considered in this study. This study also attempts to investigate different types of knowledge flow and their relationships with innovation performance. A mixed method that combines the quantitative and qualitative methods is adopted in this study. The quantitative method is adopted to explore the source of external knowledge at various levels. The qualitative method is then used to further elaborate the influence of knowledge flow.

The results of this study indicate that the source of external knowledge in the Zhangjiang Hi-Tech Park comes from cross-regional and cross-national connections.

Through the connection with global companies, the firms in Zhangjiang acquire technical knowledge. Also, through the interaction with cross-regional companies, the firms in Zhangjiang absorb market knowledge. The result of the study is different from the concepts such as global production network (Henderson *et al.*, 2002), global commodity chains (Gereffi, 1994), and global value chains (Gereffi *et al.*, 2005), which all indicate that the introduction of technology from advanced companies to latecomer companies helps the technical upgrade of the latecomer developing countries (e.g. Gereffi, 1994; Henderson *et al.*, 2002; Coe *et al.*, 2004; Humphrey and Schmitz, 2004; Gereffi *et al.*, 2005). This study shows that while Zhangjiang may be considered to be a latecomer cluster in the ICT industry, the connection with foreign companies is not the only solution for obtaining external knowledge and innovation. Different perspectives for acquiring knowledge need to be considered.

The result of this study stresses the important role of local companies. Many previous studies have argued that in order to achieve sustainable development in industrial clusters, local companies should achieve modernization on their own, since the manufacturing sector in the latecomer industrial clusters is mostly owned by local firms rather than foreign firms, such as the automobile industry in India (Richet and Ruet, 2008) and the memory chip industry in South Korea (Wang, 2010). The global competition landscape can be altered by local companies. If the latecomer countries are controlled by multinational companies, the global economic competition will never be changed (Amsden and Chu, 2003).

The result of this study indicates that the national-level interaction may also encourage local manufacturers to absorb knowledge and boost innovation performance. Knowledge is not limited to the local, global or cross-regional boundaries. All knowledge exchange is equally important. In addition, local companies can enhance their capacity by satisfying the demand of requirement of local markets (Pietrobelli, 2008).

The results correspond with the industry feature of the Zhangjiang Hi-Tech Park. The ICT industry for mobile phones is important, as mobile communication has much to do with national security and the whole economy of China. In order to avoid the control of foreign investment, the Chinese Government should cooperate with foreign investors to promote the technical exchange and facilitate the interaction between the companies of mobile phone chips in the Zhangjiang Hi-Tech Park and the mobile phone companies in Shenzhen, respectively, right after the 3G Global Standard for Mobile Communication was adopted in China. Through the market protection strategy and political intervention, the government facilitated cross-national and cross-regional cooperation.

Moreover, the result of this research also corresponds with several studies of industrial clusters in China, indicating that the situation in China is not like the development of industrial clusters in developed countries (Yeung *et al.*, 2006; Jin and Zhou, 2009). While the clusters in the Silicon Valley are formed naturally, the industrial cluster in China is often created by the initiative of the government. The government relocates companies into the same area and gives the tax advantage and policy preference of a firm (Ai and Wu, 2015). Therefore, the weakness of knowledge flow in an industrial cluster of China can be easily found (Yeung *et al.*, 2006; Wei *et al.*, 2009; Fan, 2011). The weakness of knowledge flow in the industrial cluster of China may be the reason to explain why none of the *H3a*, *H3b* and *H3c* are supported.

In terms of theoretical implications, this study is different from previous studies which focus on the dichotomy of the local and global relationships (Oinas, 1997; Malmberg and Maskell, 2003; Bathelt, 2007). As indicated by Fan (2011) and Schiele and Ebner (2013), this study not only focusses on local and global relationships

(Oinas, 1997; Malmberg and Maskell, 2003; Bathelt, 2007), but also indicates that the national and domestic aspects are important in terms of knowledge acquisition. In addition, whether different types of knowledge may act as a mediator between different levels of external knowledge and innovation performance, different types of knowledge are discussed in this study. The discussion may help fellow researchers to understand different knowledge flows in a cluster and their influences on cluster development. As for managerial implications, the findings of this study provide business executives and policymakers with a new way of thinking about the development of industrial clusters and local firms. Firms may be able to find out new ways to raise innovation performance using different external knowledge.

7. Research limitations and future research directions

Although this study provides important contributions to the understanding of cluster development and the concept of geographical economy, there are some limitations. First, this study was built upon a case study in Zhangjiang of China and only a specific industry was chosen. Thus, the findings might not be applicable to other countries or regions in China. Future studies can compare this study with similar studies of other industries or with other case studies. Second, many studies about the development of industrial clusters discuss the formal and informal knowledge flow. However, this study neglected the informal knowledge flow deriving from former colleagues, classmates and friends. Future studies can add the informal knowledge flow into the research by investigating its impacts on cluster development. Third, this study only focusses on local companies in the ICT industry of Zhangjiang and neglects the role of foreign companies. Future studies should increase the research targets, including both local and foreign companies. Fourth, this study did not adopt control variables. Future studies may increase control variables, such as different sizes of companies and different investment companies. Finally, the development of a cluster depends on the interaction among different actors, such as universities, rival companies, research institutions, etc. However, this study focusses only on the role of firms and neglects the knowledge source from others. Future studies may increase the influences of different actors on the cluster and investigate the relation of knowledge among organizations or institutions.

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(The Appendix follows overleaf.)

Appendix 1. The interview questions

Dear Sir/Madam,

There are three purposes in this interview. The first one is to understand why the manufacturer chooses to station in the Zhangjiang Hi-Tech Park. The second one is to investigate the source of innovation knowledge in your company. The third one is to understand the reason why you think about the source of knowledge in your company.

1. What is the major business in your company?
2. In your opinion, what is the competitive advantage of your company?
3. Why is your company chosen to station in the Zhangjiang Hi-Tech Park?
4. Where does the innovation knowledge in your company come from? Is it cross-national, cross-regional or just within Zhangjiang?
5. Why do you think the innovation knowledge in your company comes from cross-national and cross-regional connections or just within Zhangjiang?
6. According to our quantitative results, some companies in Zhangjiang think that cross-regional connections help their firm to acquire market knowledge and improve innovation performance. In your opinion, how do you explain this result?
7. According to our quantitative results, some companies in Zhangjiang believe that cross-national connections help their firms to obtain and acquire technical knowledge and thereby improve innovation performance. In your opinion, how do you explain this result?
8. In terms of development and operation, how have they been done in your company?
9. What is the prospective development and operation goal in your company?
10. In your company, where are R&D talents and people found or recruited mostly?

Appendix 2

	Date	Location	Name of organizations	Number of interviewees	Record number
1.	December 2011	Shanghai	Micro One Electronics Inc.	2 (IC design company); CEOs	2011-12-14
2.	December 2011	Shanghai	Xingtera China	2 (IC design company); top managers	2011-12-15
3.	December 2011	Shanghai	B-1	2 (IC design company); senior managers	2011-12-16
4.	December 2011	Shanghai	Shanghai integrated circuit industry association	2 (Other industries related to the IC industry); directors	2011-12-17
5.	March 2012	Shanghai	B-3	5 (IC design company); senior managers	2012-03-22
6.	March 2012	Shanghai	B-4	4 (IC design company); senior managers and CEOs	2012-03-23
7.	March 2012	Shanghai	Spreadtrum	2 (IC design company); senior manager and CEO	2012-03-26
8.	September 2012	Shanghai	Fival Technology	2 (IC design company)-; senior managers	2012-09-35
9.	September 2012	Shanghai	Brite Semiconductor	1 (IC design company); senior manager	2012-09-36
10.	September 2012	Shanghai	ACM Research (Shanghai), Inc.	1 (IC equipment supplying)-; senior manager	2012-09-37
11.	September 2012	Shanghai	B-7	1 (IC manufacturing); senior manager	2012-09-40
12.	September 2012	Shanghai	B-8	2 (IC design company)-; senior managers	2012-09-41
13.	June 2013	Shenzhen	C-1	2 (China's domestic mobile phone manufacturing sector); senior manager and CEO	2012-06-50
14.	June 2013	Shenzhen	C-2	4 (China's domestic mobile phone manufacturing sector) CEO and three managers	2012-06-51
15.	June 2013	Shenzhen	C-3	6 (Knock-off mobile phone manufacturing market); CEOs and senior managers	2012-06-52

Table AI.
A list of interviewees

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