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Benefiting from external knowledge? A study of telecommunications industry cluster in Shenzhen, China

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Abstract

Purpose – External knowledge should not be limited in one zone or level. Researchers have paid more attention to the perspective of multilevel cluster networks. However, little research has empirically studied the various dimensions of external knowledge. The purpose of this paper is to study different levels of external knowledge, their relation with trade and non-trade interdependence and their relation with different kinds of innovations, namely, exploitation and exploration.

Design/methodology/approach – Both quantitative and qualitative research methods were adopted in this study. In terms of the quantitative research method, data were collected from 168 companies in the Shenzhen Hi-Tech Industrial Park of China using convenience sampling. As for the qualitative research method, a total of 35 interviews were carried out in this study.

Findings – The quantitative results indicate that different levels of external knowledge in the Shenzhen Hi-Tech Park have different effects. First of all, the results indicate that cross-national connections have a positive influence on trade interdependence, which helps firms to produce exploration. Second, cross-regional connections have a positive influence on both trade and non-trade interdependence, which further help firms to create innovative exploitation and exploration. Third, inter-regional connections have a positive influence on non-trade interdependence, which helps firms to increase innovative exploitation. The qualitative result makes a plausible explanation for the quantitative results. The interview results indicate that as the telecommunications industry has so much to do with China's national security, there are several initiatives of market protection strategies and political interventions, which help firms to form different levels of knowledge flow in Shenzhen.

Research limitations/implications – There are several limitations of this study which primarily relate to the case study method. The results can be contextually generalized to the domestic-oriented cluster in developing countries.

Practical implications – This study has several managerial implications. First, this research ensures that it is important to consider the multilevel nature of external knowledge before starting with the decision-making process of a firm in a cluster. Second, all levels of administrators and managers in a company should investigate what kinds of involvement and innovation are needed and most highly valued for organizational development. Third, the research framework of this study can be applied to understand which level of external knowledge influences organizational performance.

Originality/value – This study is an initial attempt to provide an examination of external knowledge, organizational involvement and innovation performance of an industrial cluster via a mixed method.

Keywords Innovation performance, Knowledge flow, External knowledge, Industrial cluster, Involvement

Paper type Research paper

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1. Introduction

An industrial cluster has been considered to have the ability to increase innovation capability for firms. Since the 1990s, the management and policy-making of industrial clusters have opened up numerous discussions (Porter, 1990; Giuliani and Bell, 2005;

Lei and Huang, 2014; Expósito-Langa *et al.*, 2015). An industrial cluster is widely defined as a geographic agglomeration or hot spot that attracts firms to look for the cooperation in the same or interconnected sector (Krugman, 1995; Giuliani and Bell, 2005). Several researchers argue that the competitive edge of a firm in an industrial cluster results from networking that provides innovation-boosting knowledge flows for firms (Uzzi, 1996; Somsuk *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; otherwise, the lock-in effect may take place. This effect can hinder the cluster development (Grabher, 1993; Yeung *et al.*, 2006). The openness to external knowledge has become an important issue due to globalization (Cooke *et al.*, 2004; Isaksen and Kalsaas, 2009). The development of information and communications technology makes geography no longer important (Bojnec and Fertő, 2010), indicating "the ending of geography" (Castells, 1996). However, external knowledge is fundamental to the development of an industrial cluster. Thus, an open system is required to elaborate different levels of knowledge links in a cluster (Schiele and Ebner, 2013; Yu and Lee, 2013; Lei and Huang, 2014).

However, what kinds of network connections do external knowledge help firms to enhance innovation? Several studies emphasize that the advanced companies of developed countries enable the companies in developing countries to upgrade their knowledge and techniques (Qu and An, 2003; Humphrey and Schmitz, 2004; Martins and António, 2010). The companies in developing countries are able to upgrade their knowledge and technology through foreign direct investment and the cooperation involved in the investment (Bojnec, 2011). However, many of these studies have often been conducted based on the socio-cultural background in developed countries (Fan, 2011). Therefore, more and more researchers have been increasingly paying attention to the development in developing countries (Prajogo *et al.*, 2007), and 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; Freeman, 2002; Isaksen, 2009; Sotarauta *et al.*, 2011; Schiele and Ebner, 2013).

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 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). Second, cross-regional knowledge implies that external knowledge comes from outside the cluster but still within the nation (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; Humphery and Schmitz, 2004; Gereffi *et al.*, 2005).

The second objective of this study is to explore the relation between external knowledge and organizational involvement inside the cluster. In the development of industrial clusters, not only is the source of external knowledge important, but also the organizational involvement inside the cluster is crucial. The involvement of industrial clusters can be considered to be trade and non-trade interdependence (Cheng *et al.*, 2014).

Tallman *et al.* (2004) indicate that trade interdependence means that the firms in the economic environment have commercial cooperation and technical exchanges. In contrast, non-trade interdependence is created through culture, customs and beliefs (Cooke, 2001). On one hand, trade interdependence has been spread to a long distance since explicit knowledge was easily transferred (Nonaka, 1994; Bierly *et al.*, 2009). On the other hand, several researchers suggest that non-trade interdependence is a short distance relationship (Camagni, 1991; Oinas, 1997; McGrath and Macmillan, 2000; Tushman and Smith, 2002; Bierly *et al.*, 2009). Camagni (1991) proposes the term "cafeteria effect," which is an idea that is similar to cultural and social habits of the vendors in an industrial cluster (Cai *et al.*, 2014). Nevertheless, few studies focus on different levels of external knowledge and their relation with trade and non-trade interdependence. Therefore, this study attempts to explore the relationship between external knowledge and organizational involvement of a cluster.

The third objective of this research is to understand how different levels of external knowledge influence internal networks and innovations. The development of an industrial cluster can foster different innovations for firms. March (1991) uses two terms to distinguish two different kinds of innovations: exploitation and exploration. Exploitation is mostly derived from existing knowledge, and then used in other fields of business activities. Exploration mostly involves new knowledge and processes of production activities (Bierly *et al.*, 2009). However, many studies have provided a different perspective of whether exploitation and exploration are distinct or complementary (Gupta *et al.*, 2006). Some studies indicate that exploitation and exploration have different characters, which may produce different effects (McGrath and Macmillan, 2000; Tushman and Smith, 2002; Bierly *et al.*, 2009). Other studies mention that complementary exploitation and exploration help firms to succeed in acquiring advantages (Knott, 2002; He and Wong, 2004; Smith and Tushman, 2005; Bierly *et al.*, 2009). However, few studies focus on discussing how both kinds of innovations develop, respectively. Therefore, this study attempts to explore the interrelationships among different levels of external knowledge, internal network and different kinds of innovations.

In order to achieve aforementioned research objectives, the quantitative and qualitative research methods are combined in this study. First, the quantitative research method used to explore the source of external knowledge in various levels, types of knowledge inflow and their impacts on firms' innovations is studied. Second, the qualitative method is used to further elaborate the results of sources of knowledge flow.

This study adopts a case study design. There are two reasons to explain why this study focusses on the Shenzhen Hi-tech Park. The first one is to have easy access to the data collection. The second one is to study a domestic-funded cluster because Shenzhen represents one of the industrial clusters that is mostly domestically funded in China. In 2013, the amount of domestic and foreign capital in the Shenzhen Hi-Tech Park was 23.5 billion and 7.8 billion RMB, respectively (Shenzhen Bureau of Statistics, 2013).

The reason why this study chooses a domestic-funded cluster is because previous studies have indicated that a foreign-funded cluster is more likely to turn into a satellite platform. The satellite platform represents that the affiliated companies have a strong connection with their parent firms. However, these affiliated companies have relatively weak connections with other firms in the same zone. Therefore, attracting foreign firms settling in developing countries helps little cluster development. Nevertheless, many studies of Chinese industrial clusters have found the phenomena of satellite platforms, such as Shanghai (Ai and Wu, 2015) and Wuxi (Jin and Zhou, 2009). More and more studies have been increasingly stressing the importance of domestic companies because

local firms are willing to cooperate with each other, therefore increasing the development of zones (Amsden and Chu, 2003; Jin and Zhou, 2009). Domestic-funded clusters may possibly create different methods of development (Saxenian, 2004). Therefore, domestic-funded clusters have been considered an interesting subject to investigate.

In this study, there are four possible theoretical contributions. First, previous studies put emphasis on the perspective of local-global relationship dichotomy in studying the industrial cluster of developing countries (Freeman, 2002; Sotarauta *et al.*, 2011). To have a fresh new angle, this study uses a case study in a developing country and tries to understand different levels of external knowledge and their influences in a cluster. Second, numerous previous studies have focussed on the role of foreign firms in clusters (Henderson *et al.*, 2002; Coe *et al.*, 2004; Humphery and Schmitz, 2004; Gereffi *et al.*, 2005; Wu *et al.*, 2015). This study focusses on the role of domestic firms. In addition, it suggests that industrial cooperation and exchange among local manufacturers in a cluster may bring about different knowledge networks and innovations (Jin and Zhou, 2009), which are considered to be a different way based on the existing literature. Third, earlier studies of industrial clusters adopt a quantitative or qualitative method. However, few studies use a mixed method to improve research validity (Miles and Huberman, 1994).

2. Theoretical framework and hypothesis development

The purpose of this study is to examine the source of external knowledge and analyze different types of connections among firms 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 trade and non-trade interdependence for firms and their relation with exploitation and exploration. Therefore, this study develops its hypotheses using different levels of connections.

In respect of cross-national connections, numerous previous studies have mentioned that the technology transfer from developed firms to latecomer firms brings about technical upgrades (Gereffi, 1994; Henderson *et al.*, 2002; Coe *et al.*, 2004; Humphrey and Schmitz, 2004; Gereffi *et al.*, 2005). Therefore, cross-national connections give domestic firms to upgrade technologies. The relationship between local and foreign firms is crucial for local firms because the companies in developing countries can improve their capacity through the cooperation with foreign companies in developed countries (Henderson *et al.*, 2002; Coe *et al.*, 2004; Humphrey and Schmitz, 2004; Gereffi *et al.*, 2005; Wu *et al.*, 2015). The development of an industrial cluster needs trade and non-trade interdependence in clustering network. Under this circumstance, linking local manufacturers and multinational companies can build trade and non-trade relationships, leading companies to innovate and promote local development (Tallman *et al.*, 2004; Cheng *et al.*, 2014; Wu *et al.*, 2015). Trade and non-trade interdependence positively stimulate different types of innovations. Both exploitation and exploration are necessary to ensure the advantage of a firm (Bierly *et al.*, 2009; Cheng *et al.*, 2014). Accordingly, the following hypotheses are proposed:

H1a. Cross-national connections have a positive effect on trade interdependence.

H1b. Cross-national connections have a positive effect on non-trade interdependence.

H1c. Cross-national connections have a positive effect on the increase of a firm's innovative exploitation.

H1d. Cross-national connections have a positive effect on the increase of a firm's innovative exploration.

Several researchers focus on domestic manufacturers which play a key role in enhancing cross-national connections (Zheng and Sheng, 2006). Qu and An (2003) argue that domestic manufacturers promote the inside-outside relationship of a cluster, including cross-cluster linkages. The cross-regional connections represent an important source of knowledge for the development of cluster (Sotarauta *et al.*, 2011). The source of knowledge can be received not only from foreign firms but also from local companies (Malmberg and Maskell, 2003). Through organizational interactions, companies can build trade and non-trade interdependence. Both of the interdependence is important in cross-regional development. By linking cross-regional connections and satisfying demands of local markets, technical levels in an organization can be significantly improved and innovations can be stimulated (Pietrobelli, 2008). Through cross-regional connections, companies may exploit and explore strong demands of domestic markets and have opportunities to upgrade their technologies and obtain innovative exploitation and exploration. Accordingly, the following hypotheses are formulated:

H2a. Cross-regional connections have a positive effect on trade interdependence.

H2b. Cross-regional connections have a positive effect on non-trade interdependence.

H2c. Cross-regional connections have a positive effect on the increase of a firm's innovative exploitation.

H2d. Cross-regional connections have a positive effect on the increase of a firm's innovative exploration.

In the level of inter-regional connections, the firms in the same area should interact with each other for innovative achievement in order to have sustainable cluster development. In these inter-regional connections, both trade and non-trade relations are important. The knowledge network can promote knowledge flow. The knowledge flow can successfully help firms to produce innovative exploitation and exploration (Camagni and Maillat, 2006; Castells, 1996). Both of them can be increased through the interaction of knowledge within a cluster (Cheng *et al.*, 2014). Accordingly, the following hypotheses are formulated:

H3a. Inter-regional connections have a positive effect on trade interdependence.

H3b. Inter-regional connections have a positive effect on non-trade interdependence.

H3c. Inter-regional connections have a positive effect on the increase of a firm's innovative exploitation.

H3d. Inter-regional connections have a positive effect on the increase of a firm's innovative exploration.

With the help of trade and non-trade interdependence, an industrial cluster becomes an environment where knowledge flows freely. The free flow of knowledge can further produce innovations (Fang and Guo, 2013; Ferreira Peralta and Francisca Saldanha, 2014). As mentioned previously, innovations can be divided into exploration and exploitation. Accordingly, the following hypotheses are formulated:

H4a. Trade interdependence has a positive effect on the increase of a firm's innovative exploitation.

H4b. Trade interdependence has a positive effect on the increase of a firm's innovative exploration.

H4c. Non-trade interdependence has a positive effect on the increase of a firm's innovative exploitation.

H4d. Non-trade interdependence has a positive effect on the increase of a firm's innovative exploration.

The hypotheses of this study are presented in Figure 1.

3. Research methodology

This study adopts a mixed method that combines qualitative and quantitative approaches because both of them have shortcomings. The data generated through the quantitative research can explain a certain phenomenon directly even though the reasons behind certain facts cannot be found. 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). Therefore, the mixed method may generate a flexible result for the study (Miles and Huberman, 1994).

3.1 Quantitative method

3.1.1 Design of the questionnaire. In all, 15 questions referring to the studies of Tabata (2007), Chen (2008) and Sotarauta *et al.* (2011) were designed to measure the scales of inter-regional, cross-regional and cross-national connections. Eight items based on Niu (2010), Niu *et al.* (2014) and Tallman *et al.* (2004) were developed to assess trade and non-trade interdependence. In all, 15 questions referring to the study of Cheng *et al.* (2014) were used to measure exploitation and exploration.

Due to the newness of the survey questionnaire, an exploratory factor analysis (EFA) was conducted using the Statistical Package for Social Science 21.0 before the hypotheses were tested. The EFA results suggested that three factors derived from different levels of external knowledge, two factors from industrial cluster involvement and two factors from innovation performance, respectively. In the beginning, this study developed a questionnaire which comprised of 41 items. In order to confirm the validity of the questionnaire, a pre-test was conducted to expose the weaknesses in the questionnaire design and instrumentation (Hair *et al.*, 2010). The researchers held a

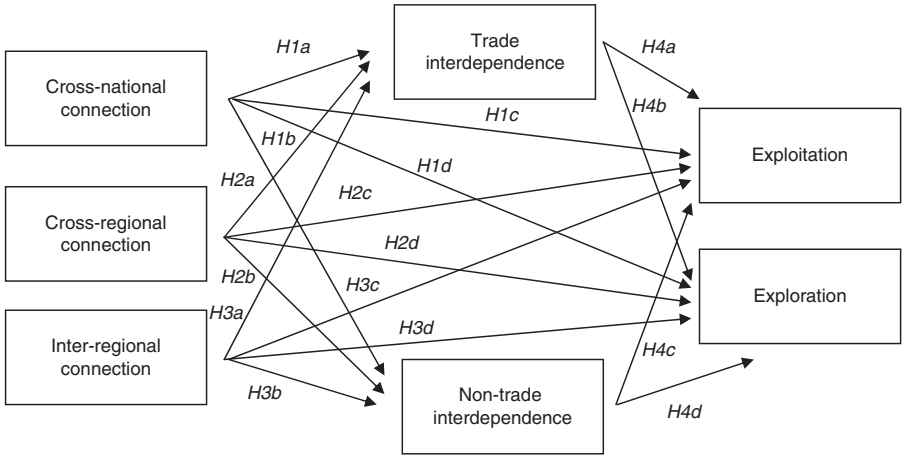

Figure 1.
Research framework

discussion which was composed of five managers from the telecommunications industry, and three engineers and three managers from the telecommunications industry associations in Shenzhen, respectively. All of them specialized in the telecommunications industry. During the pre-test procedure, some minor changes were made to the survey questions (Cooper and Schindler, 2006). As a result, three items were removed from the measurement items of trade and non-trade interdependence and innovation performance, leaving a final 38-item set to form a complete scale for this study. As for the hypothesis questions, the respondents were asked to respond to the statements using a seven-point Likert scale with the anchors ranging from strongly disagree (1) to strongly agree (7).

The EFA results indicated three factors for the sources of external knowledge. Because of five items loading on each variable, the final measures labeled the source of external knowledge as inter-regional, cross-regional and cross-national connections, respectively. Eight items were included in the dimensions of trade and non-trade interdependence. The final measures were labeled as trade and non-trade interdependence. There are four items for trade interdependence and the same number of items for non-trade interdependence. As for the dimensions of exploitation and exploration, 15 items were included. The final measures were labeled as exploitation and exploration. All the questions can be found in Tables I-III.

3.1.2 Sampling and data collection. The data of this study were collected through the adoption of convenience sampling from companies in the Shenzhen Hi-Tech Park. The Shenzhen Hi-Tech Park was founded in 1996. Until 2013, up to 65 percent of companies in this park had been from the telecommunications industry and 38 percent from the manufacturing industry, respectively. There were a total of 241 domestic companies in the Shenzhen Hi-Tech Park (Shenzhen Municipal People's Government, 2009). The sample size was determined using the Mendenhall *et al.* (1993) formula. Applying this formula gave 148 as the minimum acceptable number of completed questionnaires (see the Appendix). Through the assistance from Shenzhen Incubator Center and the organizers of the Fifth China Hi-Tech Fair during the period from 16 to 21 November 2014, 300 questionnaires were distributed. Five students from the Department of Electronic Science and Technology in Shenzhen University were recruited to work as surveyors and then trained to randomly approach respondents, informing about the purpose of the survey in advance before they were given the questionnaire. Of the 228 questionnaires distributed, 214 (93.9 percent) were returned; 46 incomplete returned were discarded. The total usable sample of 168 represents an overall response rate of 78.5 percent. The usable response was above the minimum sample size of 148, as suggested by Mendenhall *et al.* (1993). Non-response bias was checked by comparing early to late respondents (Thompson and Daniel, 1996) and did not appear to be an issue in the analysis. The demographic profile of the respondents is shown in Table IV.

3.1.3 Validity and reliability of the questionnaire. Before the final version of the questionnaire was confirmed, the experts as mentioned previously were required to give advice to ensure validity. Therefore, the questionnaire had a good level of validity. The Cronbach's coefficient α estimates for seven variables ranged between 0.77 and 0.94, exceeding the minimum value of 0.70, as proposed by Nunnally (1978). Confirmatory factor analysis was applied to examine the validity using structural equation modeling (SEM) with analysis of moment structure 8.0. The results of Cronbach's α estimates, AVEs, CRs and correlations are presented in Table V.

Construct	Statement	Factor 1 inter-regional connections	Factor 2 cross-regional connections	Factor 3 cross-national connections
Inter-regional connections	1. Inter-regional knowledge flow: the knowledge that my company acquires mostly comes from inter-regional connections	0.692		
	2. Inter-regional activities: my company often participates in the seminars that are held in the park	0.561		
	3. Inter-regional connections with universities and research institutions: my company has a strong cooperation with universities and research institutions in the park	0.727		
	4. Inter-regional connections with other companies: my company has a good relationship with other companies in the same or different industries in the park	0.750		
	5. Inter-regional connections among employees: the employees in my company have a good personal relationship in the park	0.710		
Cross-regional connections	1. Cross-regional knowledge flow: the knowledge that my company acquires mostly comes from cross-regional connections		0.889	
	2. Cross-regional activities: my company often participates in the seminars that are held in China		0.818	
	3. Cross-regional connections with universities and research institutions: my company has a strong cooperation with Chinese universities and research institutions		0.816	
	4. Cross-regional connections with other companies: my company has a good relationship with other Chinese companies in the same or different industries		0.816	
	5. Cross-regional connections among employees: the employees in my company have a good personal relationship in other regions of China		0.788	
Cross-national connections	1. Cross-national knowledge flow: the knowledge that my company acquires mostly comes from cross-regional connections			0.750
	2. Cross-national activities: my company often participates in international seminars that are held outside of China			0.762

(*continued*)

Table I.
Factor analysis of sources of external knowledge

Construct	Statement	Factor 1 inter-regional connections	Factor 2 cross-regional connections	Factor 3 cross-national connections
	3. Cross-national connections with universities and research institutions: my company has a strong cooperation with foreign universities and research institutions			0.699
	4. Cross-national connections with other companies: my company has a good informal relationship with other international companies			0.723
	5. Cross-national connections among employees: the employees in my company have a good personal relationship around the world			0.710
Total variance explained		0.24	0.32	0.20

Table I.

Construct	Statement	Factor 1 trade interdependence	Factor 2 non-trade interdependence
Trade interdependence	1. Engagement in collaboration: my company has a strong cooperation with other companies in the same or different industries	0.804	
	2. Widespread production information: my company can acquire knowledge of product development	0.813	
	3. Development of core capability: can your company easily develop core capability?	0.661	
	4. Technical competence: my company can easily absorb technical knowledge	0.740	
Non-trade interdependence	1. Social networks: the labors and colleagues in my company can easily communicate with other organizations outside the company		0.731
	2. Cultural backgrounds: my company and labors share similar cultural backgrounds		0.844
	3. Non-official relationships: My company has a good informal relationship with other organizations		0.799
	4. Supportive organizations: my company can easily receive support from governments, universities and research institutions		0.760
Total variance explained		0.35	0.43

Table II.
Factor analysis of trade and non-trade interdependence

Construct	Statement	Factor 1 exploitation	Factor 2 exploration
Exploitation	1. Efficiency at work: the production efficiency of my company has increased	0.797	
	2. Refinement of business strategies: the business strategies of my company have been refined	0.879	
	3. Improvement of engineering function: the engineering function of my company has been improved	0.906	
	4. Improvement of product quality: the product quality of my company has been improved	0.876	
	5. Improvement of customer service: my company has improved customer service	0.844	
	6. Prolonging the profit from existing products: the product of my company has prolonged the profit from existing products	0.763	
	7. Improvement of technologies and techniques: my company has significant progress in terms of technologies and techniques	0.731	
	8. Improvement of financial strategies: my company has a significant improvement for financial strategies	0.761	
Exploration	1. New patents: my company has new patents		0.901
	2. New product introduction: my company has been increasingly producing new products		0.861
	3. New market entry: my company has new market entry		0.808
	4. New ways to manage business strategy: my company has new ways to manage business strategy		0.798
	5. Sales from new services/products: my company has sales from new services/products		0.765
	6. Functions of new supply chains: my company has functions of new supply chains		0.790
	7. Introduction of new technologies: my company has new technologies		0.800
Total variance explained		0.45	0.35

Table III.
Factor analysis of exploitation and exploration

The χ^2/df ratios (1.82), the root mean square error of approximation (0.06), the standardized root mean residual (0.04) and other indices (e.g. CFI, GFI, IFI, NNFI) can be seen in Table VI.

3.2 Qualitative method

This study adopted the purposive sampling and snowball sampling methods. During the period from January to June, 2015, 35 interviews were carried out using the qualitative research method. In order to collect more information, other sources are used in this study. The source included the official websites of the firms, the annual reports of companies, and the annual reports from the Shenzhen Hi-Tech Park.

In order to increase the validity of qualitative data, at least two experts joined the interview. Moreover, all the interviewees received the interview questions in advance. As a result, the interview had a relatively smooth process, ensuring that key information was received.

	Options	Frequency	%
Age (years)	20-30	8	4.8
	31-40	35	20.8
	41-50	68	40.5
	51-60	52	31.0
	61-70	5	3.0
	Over 71	0	0.0
Seniority (years)	0-5	8	4.8
	6-10	37	22.0
	11-15	70	41.7
	16-20	23	13.7
	21-25	18	10.7
	25-30	12	7.1
	Over 31	0	0.0
Number of employees	10	10	6.0
	11-50	68	40.5
	51-250	85	50.6
	More than 251	5	3.0
Position	Senior engineers	93	55.4
	Senior managers	40	23.8
	General managers	25	14.9
	CEOs	10	6
Types of companies	Electronic component manufacturing	31	18.5
	Computer industry	5	3.0
	Optical product manufacturing	2	1.2
	Telecommunications	125	74.4
	IT industry	5	3.0

Note: $n = 168$

Table IV.
Demographic profile of the respondents

	Trade interdependence	Non-trade interdependence	Exploration	Exploitation	Inter-regional connections	Cross-regional connections	Cross-national connections
Trade interdependence	1.00						
Non-trade interdependence	0.13*	1.00					
Exploration	0.27**	0.23**	1.00				
Exploitation	0.24**	0.18**	0.17	1.00			
Inter-regional connections	0.26**	0.17**	0.12	0.28**	1.00		
Cross-regional connections	0.29*	0.24**	0.24	0.31**	0.13	1.00	
Cross-national connections	0.42**	0.09	0.35**	0.07*	0.23*	0.30*	1.00
Cronbach's α	0.80	0.85	0.86	0.94	0.86	0.90	0.77
AVE	0.69	0.71	0.71	0.62	0.66	0.65	0.76
CR	0.90	0.92	0.95	0.92	0.91	0.90	0.94

Notes: CR, composite reliability; AVE, average variance extracted. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table V.
Descriptive statistics and correlation matrix of latent variables

4. Findings

The main purpose of this study is to examine different levels of external knowledge and their relation with trade and non-trade interdependence, exploitation and exploration. In order to test the hypotheses in the conceptual research model (see Figure 1), this study applies SEM. The results are given in Table VI.

H1 predicts that cross-national connections have a positive effect on trade and non-trade interdependence and on the increase of exploitation and exploration for firms. The results support *H1a*, suggesting that cross-national connections help firms to build trade interdependence ($b = 0.27$, $p < 0.05$). Moreover, the results support *H1d*, indicating that cross-national connections help firms to create exploration ($b = 0.44$, $p < 0.01$). However, *H1b* and *H1c* are not supported. Cross-national connections have no significant positive effects on non-trade interdependence ($b = 0.11$) and exploitation ($b = 0.25$).

H2 postulates that cross-regional connections have a positive effect on trade and non-trade interdependence and on the increase of exploitation and exploration for firms. The results fully support *H2a* ($b = 0.38$, $p < 0.01$), *H2b* ($b = 0.24$, $p < 0.01$), *H2c* ($b = 0.26$, $p < 0.01$) and *H2d* ($b = 0.18$, $p < 0.05$), indicating that cross-regional connections positively help firms to create trade and non-trade interdependence, exploitation and exploration.

H3 assumes the positive effect of inter-regional connections. The results support *H3b* and *H3c*, suggesting that inter-regional connections help firms to build non-trade interdependence ($b = 0.17$, $p < 0.05$), and indicating that inter-regional connections help firms to create exploitation ($b = 0.17$, $p < 0.05$). However, the results do not support *H3a* and *H3d*, showing that inter-regional connections do not help firms to create trade interdependence ($b = 0.13$) and exploration ($b = 0.22$).

H4 predicts that trade and non-trade interdependence positively influence exploitation and exploration. The hypotheses are partially supported. In addition to *H4a* ($b = 0.13$) and *H4d* ($b = 0.06$), the results support *H4b* ($b = 0.17$, $p < 0.05$) and *H4c* ($b = 0.21$, $p < 0.05$), indicating that trade and non-trade interdependence help firms to increase exploration and exploitation, respectively.

Overall, the quantitative research results reveal that not all sources of external knowledge have a positive influence on trade and non-trade interdependence. Only cross-regional connections have a positive influence on both trade and non-trade interdependence (*H2a* and *H2b*). Only cross-national connections (*H1a*) have a positive influence on trade interdependence. Inter-regional connections have a positive influence on non-trade interdependence (*H3b*).

Both exploitation and exploration derive from cross-regional connections (*H2c* and *H2d*) while exploration and exploitation come from cross-national connections (*H1d*) and inter-regional connections (*H3c*), respectively. In addition, the results show that by

Model	χ^2/df	*p*	RMSEA	SRMR	CFI	GFI	IFI	NNFI	AGFI
Structural model – overall model	1.822	0.000	0.062	0.040	0.911	0.922	0.942	0.936	0.887
Recommended value	< 5.0	–	< 0.08	⩽0.08	> 0.90	> 0.90	> 0.90	> 0.90	⩾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

Table VI. Results of the measurement and structural model tests

building trade interdependence, the exploratory innovation of a firm can be increased (*H4b*). The non-trade interdependence can increase the exploitation innovation of a firm (*H4c*). In other word, trade interdependence is a stimulant for exploration while non-trade interdependence is a facilitator for exploitation. Different types of external knowledge result in the creation of different types of connections.

However, cross-national connections do not have a positive influence on non-trade interdependence (*H1b*). In addition, inter-regional connections do not have a positive influence on trade interdependence (*H3a*). Also cross-national connections do not positively influence exploitation (*H1c*) and inter-regional connections do not positively influence exploration (*H3d*). Moreover, trade interdependence does not positively influence exploitation (*H4a*) while non-trade interdependence does not positively influence exploration (*H4d*). The relative data of the hypotheses are shown in Table VII.

The findings of this research partially agree with the propositions of several studies. First, the aforementioned review has revealed a sequence of knowledge flow which first starts acquiring knowledge from global pipelines, and then spreading knowledge to clusters. Yet, the results of this study show that knowledge can be obtained from various external locations at the same time. Meanwhile, the findings concur with the propositions of Pietrobelli (2008) and Sotarauta *et al.* (2011) that cross-regional collaboration among firms in the same country can be a source of knowledge for firms in technology parks that attempt to improve the capacity for both exploitation and exploration.

Second, knowledge networks can be divided into long and short distance networks since different types of knowledge can be transmitted through different distances (Oinas, 1997). The result of this study is coherent with the propositions of Camagni (1991), Oinas (1997), McGrath and Macmillan (2000) and Bierly *et al.* (2009) that non-trade interdependence has been considered to play a key role in building an atmosphere for innovations. Since informal communication is "in the air," the transmission distance is relatively short. Hence, informal communication cannot be easily replicated, and only be spread through inter-regional connections. On the

Hypothesized path		Structural coefficients	Hypothesis supported
H1a	Cross-national connections→trade interdependence	0.27*	Yes
H1b	Cross-national connections→non-trade interdependence	0.11	No
H1c	Cross-national connections→exploitation	0.25	No
H1d	Cross-national connections→exploration	0.44**	Yes
H2a	Cross-regional connections→trade interdependence	0.38**	Yes
H2b	Cross-regional connections→non-trade interdependence	0.24**	Yes
H2c	Cross-regional connections→exploitation	0.26**	Yes
H2d	Cross-regional connections→exploration	0.18*	Yes
H3a	Inter-regional connections→trade interdependence	0.13	No
H3b	Inter-regional connections→non-trade interdependence	0.17*	Yes
H3c	Inter-regional connections→exploitation	0.17*	Yes
H3d	Inter-regional connections→exploration	0.22	No
H4a	Trade interdependence→exploitation	0.13	No
H4b	Trade interdependence→exploration	0.17*	Yes
H4c	Non-trade interdependence→exploitation	0.21*	Yes
H4d	Non-trade interdependence→exploration	0.06	No

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

Table VII.
Hypothesis test results

contrary, trade interdependence is more specific and can be formed through commercial transactions (Tallman *et al.*, 2004). Thus, firms can easily spread farther distance using cross-national and cross-regional connections.

Third, this study agrees with the proposition of Cheng *et al.* (2014) that trade and non-trade interdependence may result in different kinds of innovations. This research provides an empirical support for theories, indicating that trade interdependence is important when a firm is attempting to acquire exploration while non-trade interdependence is trying to create exploitation. Numerous studies have noted that when a company enhances its competitive advantage, it needs to look for explicit and transparent knowledge (Colovic and Lamotte, 2014). The formal relationship is created among businesspeople, buyers and sellers. When companies create their techniques, they need to collect new ideas (Tallman *et al.*, 2004; Cheng *et al.*, 2014). This can be achieved by operating in an area where the surroundings are good for innovation production. This then requires informal relationships, which cannot be easily copied or learned. Hence, informal relationships make firms easy to form intra-regional competitive advantage (McGrath and Macmillan, 2000; Tushman and Smith, 2002).

Fourth, the results indicate that different levels of external knowledge and different kinds of innovations are significantly associated. This study puts emphasis on cross-territorial interactions which have both trade and non-trade interdependence at the national level (Amsden and Chu, 2003; Jin and Zhou, 2009). On one hand, trade interdependence can be easily created because the government protects domestic markets and firms (Ernst, 2011). On the other hand, local companies have the same culture and language, therefore domestic firms can easily create cooperative networking (Amsden and Chu, 2003; Jin and Zhou, 2009). This national level can create trade and non-trade interdependence and then further foster innovative exploitation or exploration.

Nevertheless, this study partially disagrees with the proportions of several studies (Gereffi, 1994; Walck, 1995; Henderson *et al.*, 2002; Coe *et al.*, 2004; Humphrey and Schmitz, 2004; Gereffi *et al.*, 2005; Andersen and Bøllingtoft, 2011) that for latecomer countries, the upgrade of technology involves technology transfer and the introduction of production lines from developed countries. Globalization may affect local cluster-based knowledge which integrates global knowledge and increases innovations (Andersen and Bøllingtoft, 2011). The results of this study show that knowledge may not only come locally or globally, but also connect with other counterpart firms in the same country which helps firms to obtain market knowledge for further innovations.

5. Discussion

In order to further explicate the results of the quantitative research, several intriguing questions need to be answered and discussed. The first question focusses on why cross-regional connections can help firms to create trade and non-trade interdependence and then further foster innovative exploitation and exploration. Second, why are cross-national connections beneficial for firms to obtain trade interdependence and innovative exploration? Third, why can inter-regional connections have a positive influence on non-trade interdependence and innovative exploitation? This study, through qualitative interviews, attempts to make a detailed explanation.

5.1 Why can cross-regional connections help firms to create trade and non-trade interdependence and then further foster innovative exploitation and exploration?

From the in-depth interview, this study found two reasons used to explain the question: the increasing demand of the domestic market and the circulation of talent.

5.1.2 The increasing demand of the domestic market. Many manufacturers choose to station in Shenzhen because of the mobile phone industry. In the 1990s, China's mobile phone markets were dominated by foreign investment and international giants that had set up subsidiaries in China, such as Ericson, Nokia and Motorola. However, these companies solely aimed at the first-tier big cities such as Beijing and Shanghai. The market of secondary and tertiary cities was mostly ignored. Finding this opportunity, domestic manufacturers were thus established, as there was a great amount of China's domestic market demand, most of these domestic companies, without key communications technologies, had to station in Shenzhen. They manufactured low-tech parts of phones (such as mobile phone cases and keyboards) and imported high-tech wafers and chips, thereby reducing the cost:

> However, the cost of importing IC chip still remained relatively high, leaving room for cost reduction. In order to accomplish the manufacturing process of mobile phones, the companies 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 in the telecommunications industry (source: interviewees).

In general, the chips have two important parts: hardware and software. Hardware and software are manufactured separately by different companies. IC design companies are responsible for the hardware part while mobile phone companies are in charge of software parts. A brand of mobile phone companies (which sells complete mobile phone products to consumers) needs to look after not only the software system of the phones but also the integration of software and chips. Thus, hardware and software are combined together to fulfill 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 not only combined the hardware and software together, but also create the operating system of mobile phones. Therefore, mobile phone companies in Shenzhen can simply purchase overseas products to make the function of mobile phones (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 IC chips are fixed. Therefore, the mobile phones companies in Shenzhen cannot add additional functions. In other words:

> Overseas IC chip firms restrict and limit the phone functions available, and it is not viable to add or erase unwanted features (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 meet market needs promptly, products with flexibility are much required. Spreadtrum cooperates with RDA Microelectronics and Telegent. An interviewee indicates that:

> The chips from overseas firms cannot change the standardized functions of chips. 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), 93 percent of the companies in Shenzhen used the chips from overseas companies in 2005. However, in 2007, the number of them decreased to 15 percent, as local firms adopted the modified production process to increase the market share.

5.1.3 The circulation of talents helps firms to create non-trade interdependence. Due to production cooperation, Shenzhen and Zhangjiang form a cross-regional tie. The flow and exchange of talents can also be observed in Shenzhen. For example, during the interview, it is discovered that a majority of respondents have worked in Shenzhen as they are close to the market, and that some have come to Zhangjiang to establish companies due to the cooperation, such as Xue-Zheng Zhang, Chairman of Wingtech in Shanghai, Li Deng, General Manager of Dewav in Shanghai, and Wen-sheng Qiu, Chairman of Huaqin in Shanghai. These senior managers once worked in Shenzhen, and later they went to Shanghai:

> Shenzhen is the market center where we can receive a lot of market information. In contrast, Shanghai is the technology center where the information obtained in Shenzhen is combined with technology here and then sold. In addition, we have connections in Shenzhen and informal relationships can be helpful in business dealings.

In addition to the exchange and cooperation among manufacturers, academic exchange can also be found to be cross-regional. For example, Shenzhen Huaqiang Electronics Research Institute in Shanghai holds the mobile phone industry seminar every year. The seminar creates a platform for businesses, universities and other institutions. In addition, many top management talents of manufacturers in Shenzhen graduate from the School of Microelectronics, Fudan University, Shanghai IC design centers and Chinese Academy of Sciences. Their past relationship with colleagues, classmates and friends may also form informal connections between Shanghai and Shenzhen.

5.2 Why are cross-national connections beneficial for firms to obtain trade interdependence and innovative exploration?

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 China and the USA. Of 123,400 employees in Shenzhen Hi-tech Park, 8,500 have overseas working experiences, mostly in the USA (Ji, 2007). 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 integrated circuits, IC). 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 3G was adopted and could be commercialized immediately. When the 3G standard came out in the market, the Chinese still considered it 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, the Chinese government initially opens up the telecommunications industry to foreign investors, hoping that it can bring about mutual cooperation. Indeed, there were some examples of cooperation, 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 mobile phone manufacturing 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 may be the reason why cross-national connections help firms to obtain technical knowledge and improve innovation performance.

5.3 Why can inter-regional connections have a positive influence on non-trade interdependence and innovative exploitation?

In the development of an industry cluster, the manufacturers in the same area share the same language and cultural background. Therefore, the cooperation can be easy for local firms to form informal relationships if compared with foreign firms (Pietrobelli, 2008). Based on our interviews, non-trade interdependence in the Shenzhen cluster can be formed through the collaboration within the industry associations.

An important channel to form non-trade interdependence in the Shenzhen High-tech Park is the Mobile China Alliance. Through this alliance, vendors can share their business information and the interoperability of patent pool. Especially, in this alliance, the membership is granted based on nationality rather than organizational capacity. Also, this regulation is much different from other coalitions in other countries. The main objective of the Mobile China Alliance is to promote non-official relationships

among firms. In the Chinese society, "Guanxi" is a Chinese term used to describe the inter-firm relationships with a broad social and cultural construct that reflects the Confucian tradition (Davies *et al.*, 1995; Park and Luo, 2001). Therefore, in the current state, the Mobile China Alliance has organized several activities to promote non-official relationships among firms. An interviewee indicates that:

> There are numerous associations in Shenzhen; for example, the members in the Mobile China Alliance have a good relationship. Through the help of the association, we can participate in different activities. These opportunities help us to create the interrelationships among different companies. I think that this non-official relation has been considered an important element which helps firms to foster innovations.

6. Conclusion

This study contributes to previous research in several ways. First, earlier studies related to industrial clusters focus on local-global relationship dichotomy (Oinas, 1997; Malmberg and Maskell, 2003; Bathelt, 2007). Therefore, this study adopts a multilevel perspective of external knowledge rather than only focusses on global and local levels. Second, only a few case studies in developing countries have been chosen to study the development of industrial clusters (Giuliani, 2013). Third, earlier studies of industrial clusters have seldom used mix methods to improve research validity (Miles and Huberman, 1994). Fourth, previous studies have rarely adopted a practical framework which can be used to determine different levels of external knowledge, organizational involvement and innovation performance (Fan, 2011; Schiele and Ebner, 2013).

The results corresponding with the industry feature the Shenzhen Hi-Tech Park. The telecommunications industry for mobile phones is important, as the mobile communications industry has much to do with national security and the whole economy of China. In order to avoid excessive foreign control, the Chinese government in early years cooperated with foreign investors to promote technical exchange. When the technology development reached a relatively mature level later, the government would protect domestic players via strategic and political interventions in the market. The government then promoted cross-national and cross-regional cooperation to further boost the development of inter-regional connectivity in the country. The government facilitated cross-national and cross-regional cooperation and further encouraged the development of inter-regional connections.

This study has managerial implications. First, this research reassures that it is important to consider the multifaceted nature of external knowledge before starting with the decision-making process of a firm in a cluster. Second, all levels of administrators and managers in a company should investigate what kinds of involvement and innovations are required and most highly valued for organizational development. Third, the research framework of this study can be applied to understand which level of external knowledge influences organizational performance. Fourth, the study aims to build a model for the development of industrial clusters in developing countries. The study results partially agree with other studies, suggesting that the regional development of China stresses the inter-regional integration, and that the flow of knowledge within the clusters is often somehow weak. Such findings can give companies which are willing to set up factories in China some insight into long-term development.

This study has several limitations. The first limitation is related to the case study method used in this study. However, the results may be contextually generalized to a domestically oriented cluster in a developing country. The second limitation of this study is the neglect of the role of foreign companies. Since there are more and more

domestic-funded clusters, such as Zhangjiang (Ai and Wu, 2015) and Zhejiang (Zheng and Sheng, 2006) in China, the importance of domestic-funded clusters has been raised. Those companies focussing on the domestic market can learn managerial and developmental lessons from this study. The last limitation focusses on the limited number of interviewees in this study, namely, only one respondent from each organization. However, this study interviewed all those whose views were relevant to the research question.

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Further reading

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Appendix. Sample size calculation

The sample size used in this research was determined using the following formula (Mendenhall *et al.*, 1993):

$$n = \frac{NZ^2_{\alpha/2}pq}{(N-1)e^2 + Z^2_{\alpha/2}pq}$$

where n is the sample size; $Z^2_{\alpha/2}$ the confidence interval estimate (expressed in standard normal variable form set at 95 percent); e the tolerable error level for estimation (5 percent); N the population; pq the component of sample proportion variance estimate (maximize 0.5).

As the variance of the population is unknown, this research assigned $p = 0.5$ and $q = 0.5$ to the equation above. Accordingly, pq equals 0.25. The purpose is to allow the maximum possible variation contained in the data set. Applying the Mendenhall *et al.* (1993) formula, the number of respondents will be:

$$n = \frac{241 \times (1.96)^2 \times 0.25}{(241)(0.05)^2 + (1.96)^2(0.25)}$$

$$n = \frac{231.4564}{0.6025 + 0.9604}$$

$$n = \frac{231.5064}{1.5629}$$

$$n = 148.$$

Therefore, 148 respondents are considered adequate as the formula provides a 95 percent of confidence level.

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