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Knowledge and Information Acquisition of Cluster Firms through Personal Networks and Value-Chain Linkages: A Case Study of China's Mobile Phone Manufacturing Industry

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Abstract

This article investigates how heterogeneous firms in China's industrial clusters (ICs) acquire the external knowledge and information necessary for their businesses. We developed an empirical analysis of a sample of 107 firms in China's mobile phone industry to determine how different types of knowledge and information are conveyed through a variety of conduits, particularly personal network and value-chain linkages. We find that personal networks played important roles when firms gathered a variety of knowledge and information, whereas firm heterogeneity mattered when they gathered core technological knowledge and information. Larger firms tended to depend more on vertical linkages with suppliers, particularly platform vendors, whereas smaller firms relied more on personal networks when they obtained core technological knowledge and information. Several academic and policy implications are derived from the findings.

Keywords: cluster; knowledge, personal network, value-chain, China
JEL classification: O14, O18, O53

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1. Introduction

The rise of China has been prominent in global high-tech industries. A report by the Asian Development Bank noted that China's share of Asia's exports of high-tech products increased to 43.7% in 2014 from 9.4% in 2000. As a result, China surpassed Japan as the champion high-tech exporter in Asia (Bloomberg 2015). Given that such a rapid catch-up was achieved by a developing country, a series of questions naturally arises: How have local firms achieved technological and managerial learning during such a short period? How have local firms been acquiring external knowledge and information indispensable to the learning process? The latter question, to which the present study aims to answer, is also relevant to the important academic debates that have been held in industrial clusters (ICs).

The long-term innovativeness of clustered industries has been attributed to localized knowledge spillovers (LKSs) among cluster firms, whereas a series of subsequent empirical studies have attempted to modify this previous view. In the early view that emphasized the existence of spatially mediated spillovers, proximity among cluster entities was widely believed to facilitate frequent face-to-face communications, thus enabling the diffusion of tacit knowledge to all cluster entities. However, extra-cluster firms cannot share such knowledge because they are set aside from dense communication network within clusters (e.g., Saxenian 1994). In addition, horizontal interactions among cluster entities (e.g., interfirm informal contacts of employees within clusters) play an important role in the LKS process (Dahl and Pedersen 2004). In this manner, knowledge can be assumed to be a local public good that is shared pervasively. However, a series of subsequent empirical studies emphasized that knowledge is diffused in ICs in highly selective ways; in other words, knowledge is similar to club goods that are shared only with subgroups of eligible cluster entities (e.g., Giuliani

2007; Morrison 2008). Asking which is more appropriate in the case of high-tech clusters in developing countries such as China—in which knowledge distribution within clusters is quite different from that of developed countries—is appropriate.

Given that the knowledge base of domestic cluster firms in developing countries such as China is relatively scarce in general, asking whether cluster firms have acquired advanced knowledge or information from entities with a sufficient knowledge base, such as global suppliers, is also worthwhile. Certain studies proclaimed the role of extra-cluster linkages in maintaining ICs' long-term innovativeness (Bell and Alubu 1999). Empirical studies on Chinese high-tech industries partly revealed the contribution of global linkages on the upgrading and innovation outcomes of domestic firms (Sun and Zhou 2011). However, questions on the inter-relatedness of the role of ICs and extra-cluster linkages in the acquisition of knowledge and information still remain obscure. Worthwhile questions to ask include: Which is more important for knowledge acquisition by cluster firms in developing countries, horizontal knowledge exchanges (e.g., knowledge exchange through personal networks within clusters), or vertical learning of knowledge (e.g., acquiring knowledge from knowledgeable entities such as suppliers with a global origin)? Do these two channels work as substitutes or complements when local firms acquire the necessary knowledge or information?

The article aims to answer these questions by analyzing how Chinese cluster firms acquire a variety of knowledge and information through diverse channels, with special attention paid to the role of the personal network within clusters and vertical linkages with global suppliers. For this purpose, we conduct an empirical analysis of a sample of 107 firms in China's mobile phone industry. Our analysis finds: (1) personal networks inside clusters play a very important role in acquiring a variety of knowledge and information, which is consistent with Dahl and Pedersen (2004); (2) firm

heterogeneities make a difference in the choice of conduit when cluster firms gather core technological knowledge. Larger local firms can acquire more core technological knowledge through vertical linkages with suppliers, particularly platform vendors having global origins. The latter finding has an important policy implication: the early formation of assets by local firms facilitates knowledge transfers from global suppliers to local firms in developing countries.

This article is organized as follows. The second section briefly reviews literature reports that explain the role of ICs and value chains in gathering knowledge and information. The third section introduces the method and data used for this research. The fourth section reports our empirical results and relevant discussion. Finally, the fifth section presents salient conclusions derived from this study.

2. Literature review and hypotheses

For decades, Chinese high-tech industries have achieved remarkable growth. As an example, the volume of domestic production in China's mobile phone industry increased considerably to 1.63 billion units in 2014 from 5.25 million units in 2000, with annual growth up to 41% (NBSC 2016). Domestic brands' competitiveness has also been significantly strengthened, as demonstrated in the increasing market shares of China's national brands. According to a report released by International Data Corporation, the top three Chinese brands—OPPO, Huawei, and VIVO—grabbed a total of 48% of the Chinese smartphone market in 2016. In contrast, Apple's shares fell to 9.6% in 2016 from 13.6% in 2015 (China Daily 2017). If it were 10 years ago, the mobile-phone-made-by-China might remind many of the Shanzhai cell phones, which were low-end (or in many cases, counterfeit) phones produced by unauthorized firms, often with minor differentiation in product appearance and that were sold at an

extremely low price (Ding and Pan 2014). However, the golden age of Shanzhai cell phones gradually faded as the pace of China's industrial upgrade accelerated.

Given that China's mobile phone industry has made vast improvements through this rapid pace, we cannot but pose a question: How do Chinese local firms obtain the knowledge and information that is indispensable—by any criterion—to the mobile phone business that belong to high-tech products? Given that Chinese local mobile phone manufacturers, on average, have accumulated scanty knowledge and other managerial resources to date, with the exception of a few national champions such as Huawei and ZTE, assuming that the most novel knowledge and information necessary to them is produced mainly in-house is unrealistic. Rather, inferring that Chinese local firms have upgraded through constant learning is more reasonable. This learning process invariably involves the ceaseless acquisition of necessary knowledge and information from external sources, along with making investments to accumulate knowledge capital in-house. To further understand the upgrading process of China's high-tech industries, elucidating how Chinese firms obtain knowledge and information that are indispensable to their business is imperative.

The discussion related to LKSs in ICs is a proper starting point when one regards the research question previously stated. A body of empirical studies on modern ICs such as Silicon Valley showed broad existence of LKSs in ICs and their contributions to innovativeness. People engaging in the same business or closely related activities inside a cluster naturally share common sets of values and codes of rules, and similar social backgrounds. This type of social proximity, along with spatial proximities, helps them engage in intensive face-to-face communication (e.g., informal personal contacts) and mutual cooperation. Frequent face-to-face communications and close collaboration enable people and firms in the same cluster to more easily share valuable

information and tacit knowledge. Valuable information and tacit knowledge become "public goods" as a result of LKS in ICs, facilitating improved innovativeness of cluster firms (e.g., Saxenian 1994).

A series of subsequent empirical studies has added various new findings on knowledge diffusions in ICs. (1) Knowledge is diffused in ICs in highly selective ways (Giuliani 2007; Morrison 2008; Morrison and Rabellotti 2009). Cluster firms are not homogeneous in many respects, such as knowledge bases and capabilities. Consequently, thinking that the knowledge network of each cluster firm is highly idiosyncratic is natural. Providing valuable knowledge and information to other firms can be regarded as reciprocal behavior. Therefore, that knowledgeable firms are unwilling to share a knowledge network with a number of non-knowledgeable firms in the cluster is natural; instead, they are willing to share with only a few knowledgeable firms from which they can expect to obtain valuable knowledge in exchange. In this respect, knowledge should be regarded as a type of club goods that is shared only with a few fully qualified cluster firms. (2) Informal contact among employees working in a cluster plays an important role not only in interfirm diffusion of generic information but also interfirm knowledge diffusion of important knowledge (e.g., know-how). However, knowledge diffusion is affected by the firm's policy toward such knowledge diffusion (Dahl and Pedersen 2004). (3) Along with "local buzz," which facilitates actors co-locating in a cluster to engage in active interactions and knowledge creation, global-pipelines or external linkages bring knowledge and information into the cluster (Bathelt et al. 2004). So-called gatekeepers play important roles in this process. They have strong traded or non-traded linkages with global actors outside the cluster and accumulate knowledge through these linkages. They possess a knowledge base and absorptive capabilities that are sufficiently strong to assimilate new knowledge and

transmit it to various local actors in the same cluster. However, the strategy of these gatekeepers might affect knowledge diffusion in the cluster (Morrison 2008; Morrison and Rabellott 2009).

Another line of study explained in the literature that is useful to our analysis is those using the global value-chain (GVC) perspective. Certain studies have acknowledged the crucially important role of external linkages in conveying valuable knowledge and information to firms in a cluster. Previous studies using a GVC perspective pointed out the following generalizations: (1) The power relationship between global lead-firms and developing countries' suppliers in a value chain is asymmetric; (2) Global lead firms generally adopt the leadership of chain governance by which transactions among firms are coordinated; (3) However, local firms in developing countries can obtain knowledge and information from global lead-firms, enabling them to upgrade; and, (4) The pattern of upgrade is affected by the type of chain governance, which is presumed to be a function of various factors that include the transaction complexity, the characteristics of the knowledge involved, and the level of local suppliers' capabilities (Gereffi 1994, 1999; Schmitz 1995b; Humphrey and Schmitz 2002; Gereffi et al. 2005; Kawakami 2011; among others).

Although these existing studies serve as useful references, empirical studies that examined high-tech industries in developing countries, particularly those that specifically examine the knowledge and information acquisition of local firms, are still inadequate to elucidate this subject. To fill this gap left by inadequate results from empirical studies, we decided to analyze how local firms in high-tech industries obtain the necessary knowledge and information using a case study that examined China's mobile phone manufacturers, most of which are located in the high-tech cluster of Shenzhen in China's Pearl River Delta.

This study specifically examines the role of ICs in diffusing knowledge and information to local firms, drawing on existing studies that have been overviewed to date. However, we must be highly aware of differences in high-tech clusters between developed and developing countries.

The following two points are noteworthy: (1) the importance of the platform vendor and (2) the typically insufficient knowledge base of local manufacturers. Mobile phones typically have a modular product architecture. Platform vendors (i.e., suppliers of baseband ICs, a core component of mobile phones) play important roles in the product's value chain. Because of the modularity, even local firms with only a slight stock of knowledge can participate in the production of mobile phones using a turnkey solution provided by platform vendors (Brandt and Thun 2011; Imai and Shiu 2011; Ding and Pan 2014). In the case of the Shanzhai cell phone, its value chain was driven by MediaTek (MTK), a Taiwanese platform vendor. MTK succeeded in providing to its underserved customers a turnkey solution that includes a platform (baseband IC) that conducts most of the system design and part of the software design, and a reference design that makes most phone components easy to use. This turnkey solution has significantly reduced the technological barriers to entry in the feature phone sector. However, only marginal autonomous innovations were made to the platform (Ding and Pan 2014), which leads us to the first hypothesis.

> Hypothesis 1: Chinese local manufacturers mainly acquire core technological knowledge from platform vendors that provide local phone manufacturers with core components (e.g., baseband ICs) and related services.

This hypothesis holds that the platform leaders in mobile phone value chains are main channels of technological knowledge for developing countries' firms with a small knowledge base.

However, we must consider that firm heterogeneity matters in this proposition. In the 4G era, which is far more technologically complicated than 3G, Qualcomm has become increasingly prominent in Chinese markets. Qualcomm, as the developer of the world's first smartphone and the largest owner of 3G and 4G technology patents, entered the smartphone baseband IC market soon after Apple released the iPhone. Qualcomm adopted a strategy that enables platform users to conduct product differentiation at a deep level, whereas MTK, with few technological capabilities, had to continue its turnkey solutions that were intended to lower technological barriers and enable more underserved mobile phone firms to enter the market. These circumstances demonstrate that China's current local mobile phone manufacturers are extremely heterogeneous: groups of famous brand companies now have large market shares. They are eager to make major innovations to their products and services to meet the rapidly upgrading needs of the Chinese domestic and global markets. For this purpose, they are likely to have closer relations with platform vendors that have higher technical standards. The denser interexchange of knowledge and information that exists between big brand companies and platform vendors such as Qualcomm is natural. In contrast, small firms with inferior technological capabilities (such as Shanzhai producers) rely on turnkey solutions that are less demanding in terms of user knowledge and capabilities. Only sparse knowledge and information exchanges possibly occur between this type of firm and platform vendors that provide turnkey solutions. The products of such platform vendors tend to be fairly standardized and use common turnkey platforms with slight differentiations. The products are sold mainly in the low-end markets in China or other

developing countries. Consequently, that they need abundant and dense knowledge and information exchanges with platform vendors is not plausible. Most technically minor problems that they often encounter might be solved by knowledge and information exchanges through personal contacts. This consideration leads us to the second hypothesis.

> Hypothesis 2: Firm heterogeneity makes a difference. Local firms with different levels of assets and capabilities tend to use different channels when they gather highly technical knowledge, know-how, and information. Firms with larger assets and absorptive capabilities tend to use value-chain channels when they collect such knowledge and information. However, firms with fewer assets or lower weaker capabilities tend to use personal networks embedded within clusters.

As we have surveyed to date, numerous reports in the literature described analyses of modern clusters in developed countries. They revealed the critical importance of ICs as knowledge and information systems. This importance also holds for developing countries, but with some modifications. One can plausibly assume that local firms in ICs of developing countries have only a small knowledge base. If local firms' knowledge bases are weak, then shared knowledge and information may not contribute in any significant way to enhancing collective learning (Morrison et al. 2013). If so, how should we regard the role of ICs in diffusing knowledge and information? For this purpose, we distinguish technical knowledge from more generic information. The former relates to core technology and embodies some degree of tacitness. Know-how and solutions that firms encounter in the R&D process might be good examples. However, the latter relates to various information or codified knowledge, such as price information of core components, reputation of supplier capabilities, and

information on human resources. We assume that local firms obtain the latter type of information or codified knowledge (generic information) mainly through various types of traded or non-traded relationships embedded in ICs. Given that "Guanxi" networks play important roles in the present Chinese business context, horizontal information exchanges, particularly those through personal networks webbed over the cluster, are expected to play important roles when local firms gather various types of generic information. This consideration leads us to the third hypothesis.

> Hypothesis 3: Various relations in local clusters, particularly human networks, webbed inside the cluster at which local firms locate tend to convey generic types of knowledge and/or information (e.g., reputations of suppliers and customers, information related to human resources) to them.

3 Methodology and data

3-1. Research design

Simply stated, our hypothesis is that the most important channel through which local firms can acquire core technological knowledge and information is vertical linkages, particularly those with platform vendors. In contrast, the most important channel for local firms to gather various types of generic information is horizontal exchange, most typically those through personal networks inside ICs. Consequently, to test this hypothesis, we must categorize different types of knowledge and information. For this purpose, we classified the knowledge and information necessary to local firms into 21 categories using the opinion of experts who were very familiar with China's mobile

phone industry.[1] Table 1 presents 21 categories of knowledge and information, with an index number for each type.

One point with respect to our research design is particularly noteworthy. Dahl and Pedersen (2004), who provided the most important report on the literature for our research, asked employees in a high-tech cluster to analyze the importance of LKSs through informal networks. In contrast to this strategy, we preferred to ask managers of each sample firm to obtain a much broader picture of local firms' knowledge and information acquisition. In general, China's managers are quite familiar with the actual circumstances of every department in their firms, in contrast to employees who are not always familiar with other sections of their firms.

In our questionnaire research, we asked each sample firm to specify one most important channel when the respondent firm obtains each type of knowledge and information. Although we acknowledged that firms might use multiple channels to gather one type of knowledge and information, we asked respondents to choose only one to avoid excessive complications. Given what we learned from our interviews, we

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[1] In the questionnaire, we asked respondent firms to evaluate the importance of each type of knowledge and information on the basis of a 5-point Likert scale (1=not important at all; 3=moderately important; 5=very important). We calculated simple arithmetic means for all types of knowledge and information. We found that the means of all of the categories are larger than 4 and the modes are 5. Therefore, local mobile phone-set manufacturers, on average, view all such knowledge and information as highly important to their businesses, confirming that our classification of knowledge and information is valid for further analysis.

specified 10 alternative channels, from which each respondent firm was asked to choose the most suitable answer. We intentionally exclude the acquisition of knowledge embodied in goods, factors of production, or enterprise organizations (e.g., knowledge transfers through purchasing materials and capital equipment, hiring people, and M&A) again to avoid excessive complications. The 10 alternatives of knowledge and information channels are listed on the left side of Table 2 with an index number. When we present the results of our analyses in the next section, we aggregate "Colleagues in the past workplaces" (channel #1), "Friends and acquaintances engaging in the same business" (channel #2), and "Alumnus and landsman engaging in the same business" (channel #3) into one category, "Personal connection channel," for simplicity. One important object of our analysis is to elucidate the role of vertical linkages in diffusing necessary knowledge and information to local manufacturers. For this purpose, in the next section, we aggregated "Suppliers" (channel #4) and "Customers" (channel #5) into one category, "Value-chain channel."

In addition to the question about the channel, we asked firms where the most important relational network for each channel is located. We prepared eight alternatives, from which respondent firms were asked to select the most suitable one. The location alternatives are listed on the right side of Table 2 with an index number.

[Insert table 1 and table 2]

3-2. Empirical analyses procedures

The empirical analyses are organized in the next section according to the following structure: (1) analyzing the role of value chains as knowledge and information channels; and (2) analyzing the role of ICs as knowledge and information channels.

3-2-1. Role of value chains as knowledge and information channels

The results of our questionnaire research showed that we can understand the most important channel for local firms when they gather each type of knowledge and information. By analyzing the results, we can test our hypotheses related to the roles of the value chain in the diffusion of knowledge and information. In our research design, KI#3, KI#5, and KI#6 are regarded as types of core technological knowledge and information. KI#3 (i.e., knowledge and information pertaining to the product roadmap and the technological direction of baseband ICs by key platform vendors, such as MTK and Qualcomm, is crucially important technological knowledge and information for mobile phone manufacturers. For example, local mobile phone manufacturers that want to develop a new brand must typically closely consult with platform vendors; they must deeply understand the product roadmap of platform vendors (Ding and Hioki. 2017; Humphrey et al. 2017). The product roadmaps are so complicated that, in many cases, mobile phone manufacturers must engage in repeated communications with their platform vendors. For similar reasons, thinking of KI#5 and KI#6 is natural because innovations and solutions to technological difficulties are presumed to require a higher level of technical knowledge and know-how.

To test hypothesis 1, we checked whether local mobile phone manufacturing firms selected the value chain channel, especially suppliers, as the most important one for obtaining knowledge of these three types. One caveat existed in our original design of the questionnaire. That is, we did not specify the platform vendor as an independent alternative for the knowledge channel. To compensate for this point, we use the results of the other questionnaire that asked sample firms about the flow of technical knowledge between them and their key platform vendors. By connecting these two results, we can ascertain whether hypothesis 1a is supported or rejected.

When testing hypothesis 2, we run multi-nominal logit regressions in which the dependent variable (i.e., each firm's selection for the most important channel to acquire KI#3, KI#5, or KI#6) is regarded as a function of explanatory variables (i.e., each firm's characteristics, such as firm scale and R&D intensity) controlled by other firm-level factors, such as years in business and firm location. If we find a statistically positive correlation between the firm's choice of a "supplier" channel and explanatory variables, then hypothesis 2 is supported. The data for the explanatory and control variables are available from responses to other questions from our questionnaire.

3-2-2. Role of ICs as knowledge and information channels

To test hypothesis 3, we first determine whether respondent firms obtain various types of generic information mainly through the personal connection channel. This point can be confirmed using the same procedure adopted in section 3-2-1. Following this procedure, we analyze where the most important partner of the personal connection channel is located. If most of them are inside the cluster in which respondent firms are located, then we can infer that personal connections webbed inside the cluster might play important roles when cluster firms gather a variety of knowledge and information.

3-3. Data collection

We conducted two questionnaire studies during 2013–2015. In the first study, 172 valid answers were collected from mobile phone manufacturers and other types of firms, such as parts suppliers. The sample included 108 mobile phone manufacturers. The data for this subsample were used mainly for this study. The first questionnaire was designed to obtain sample firms' basic information and information related to their acquisition of knowledge and information. Through the second questionnaire, a sample of 56 mobile phone manufacturers was drawn. Most of the 56 firms had been included in the first sample. The second questionnaire was designed to elucidate knowledge and information

exchange between mobile phone manufacturers and their platform vendors. We commissioned the implementation of those two questionnaire studies to China's state-owned research institute specializing in the country's electronics industry. This commission significantly improved the reliability of our data. In line with questionnaire research, we also conducted a series of intensive interviews with managers and employees of local mobile phone companies and industrial experts who are very familiar with the local and national situations in China's electronics industries. These interviews greatly deepened our understanding of the relevant industries.

The term "mobile phone manufacturers" includes three types of firms (i.e., independent design houses [IDHs], system integrators [hereafter, "integrators"], and vertically integrated firms [VIFs]) constituting mobile phone value chains in China (see Figure 1). The platform vendors or platform leaders (e.g., MTK, Qualcomm, Spreadtrum) provide baseband ICs—core components of mobile phones—to IDHs VIFs. Then, the IDHs engage in the design and provision of core intermediate components, such as printed circuit board assemblies (PCBA), to integrators that produce a final mobile phone and that sell them under their own brand name. VIFs are firms in which functions fulfilled by IDHs and integrators are vertically integrated. The first sample comprises 108 mobile phone manufacturers and 64 firms engaging in sectors related to mobile phone production. The second sample of 56 mobile phone manufacturers was mostly drawn from firms in the first sample. Data related to mobile phone manufacturers were used for this research.

[Insert Figure 1]

China's ICT industries including the mobile phone manufacturing sectors are highly clustered to the Pearl River Delta (PRD) region, the Yangtze River Delta (YRD)

region, and the northern region surrounding Beijing (Wang and Lin 2009). Therefore, many of our samples were drawn from the PRD region, including Shenzhen in China's Guangdong province. Among the 108 mobile phone manufacturers in our sample, 78, 19, and 11 firms were located in the PRD region, the YRD region, and the rest of mainland China, respectively. Shenzhen is the largest industrial cluster for cell phone and other electronic products throughout the world. As China's first special economic zone, significant foreign investments have flowed into Shenzhen since the 1980s. These companies have fostered numerous local suppliers, which have formed the most comprehensive electronics-supportive industrial area in the world. A company can purchase all of the necessary parts to produce a cellular telephone within a mere two hours' distance. Moreover, North Huaqiang Market, a huge specialized market for electronics, is located in the center of Shenzhen. A cell phone company can trade directly with buyers from domestic and emerging markets merely by operating a booth in this market. These production and distribution advantages stimulated an increasing number of startups to emerge in Shenzhen. In 2015, 1.12 million companies existed among a total population of 11.38 million.

4. Results

4-1. Role of value chains as knowledge and information channels

4-1-1. Testing Hypothesis 1

Table 3 presents the distribution of the most important channels for each type of knowledge and information. Shaded numbers in the second and sixth columns mean that they gain equal to or greater than 34% in the total. In other words, when the total frequency of a channel—such as the personal connection channel for a type of knowledge and information—surpasses one-third of the total frequency, then we infer

that the personal connection channel plays an important role in gathering this type of knowledge and information.

Regarding KI#3, more than half of the sample firms regarded the value-chain channel—particularly the supplier channel—as the most important channel when they obtain this type of knowledge and information. Therefore, it can be concluded safely that hypothesis 1 is supported with respect to KI#3.

However, matters differ with respect to KI#5. Regarding this type of knowledge and information, only 25 firms (approximately 23% of the total) selected the value-chain channel as the most important channel for obtaining this type of knowledge and information. In contrast, the personal connection channel gained a larger share, at 40%. This result demonstrates that the value-chain channel, on average, is of only secondary importance when local firms gain this type of knowledge and information. Therefore, we conclude that hypothesis 1 is rejected with respect to KI#5.

[Insert Table 3]

Regarding KI#6, 44 firms replied that the value-chain channel is the most important when they obtain this type of knowledge and information. Although the personal connection channel has the largest share (47%) of the total, the share of the value-chain channel (41%) is quite large. Moreover, almost all firms selected the supplier channel as the most important one for acquiring this type of knowledge. This result is quite compatible with our expectation, leading us to the next procedure.[2]

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[2] Another interesting finding is that research institutes such as universities do not play a very important role in acquiring core technological knowledge, such as KI#3, 5, and 6, as shown in column for C#9 in Table 4. Possible reasons that explain this finding are: (1) not many

The results of the second questionnaire research showed intensive mutual exchange of technological knowledge and information between platform vendors and their users, convincing us that the value chain, particularly that with platform vendors, is the main conduit through which they obtained KI#3 and KI#6. We addressed questions on 56 sample firms' relationship with platform vendors. The 56 firms comprised 22 IDHs, 23 VIFs, and 11 integrators. Because integrators usually do not directly purchase baseband ICs from platform vendors but purchase PCBAs from IDHs, whereas IDHs and VIFs purchase baseband ICs from platform vendors (see Fig. 1), the trade linkage of integrators with platform vendors differs from that of IDHs and VIFs. For this reason, integrators were asked different questions from those of IDHs and VIFs. To IDHs and VIFs, we posed two questions: "Does your company ask platform vendors to provide related knowledge, information, or solutions when it engaged product development based on the platform and confronts technological problems?" and "Are platform vendors proactive at providing technological knowledge and information to your company related to their IC products?" The responses are summarized in Tables 4 and 5. These two tables make it apparent that frequent mutual exchanges of technological knowledge and information occur between manufacturers and their platform vendors.

[Insert Table 4 and Table 5]

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good universities exist in PRD regions, from which many in our sample were drawn; and (2) industry-academia collaboration is not pervasive in present China relative to vertical inter-firm collaborations.

We asked integrators about the existence and frequency of information exchanges with platform vendors. All of the 11 integrators in our sample replied that technological information exchanges occur. This evidence taken together is sufficient to confirm that the value-chain channel, particularly business relationships with platform vendors, is an important channel through which local manufacturers obtain core technological knowledge and information. We conclude that hypothesis 1 is supported with respect to KI#3 and KI#6.

4-1-2. Testing Hypothesis 2

The results showed that both personal connection channels and the value-chain channel are regarded as important in acquiring KI#6. This finding naturally leads us to ask about the factors that can explain the split in a firm's choice regarding this type of knowledge. As explained in relation to hypothesis 1, we assume that this split is a function of firm attributes related to its assets and capabilities. To test this hypothesis, we attempted to run a multi-nominal logit regression model, which is specified as

$$\ln \frac{\Pr(y_i = vcc)}{\Pr(y_i = pcc)} = X_i' \beta_{vcc|pcc}$$

where y = vcc denotes the choice of the value-chain channel as the most important one and y = pcc denotes the personal connection channel as the most important one. Also, X is a vector of firm-specific explanatory and control variables (subscript i represents each firm) and β represents a vector of coefficients to be estimated. If the coefficients of firm scale and R&D intensity are significant and positive, then hypothesis 1 is supported. When we conducted regression analyses, we set the personal connection channel as the base category, as expressed in the previous equation. Regressions were done only for KI#3 and KI#6 because hypothesis 1was rejected with respect to KI#5.

Summary statistics of the explanatory variables are presented in Table 6. The results of the regression analysis are reported in Table 7. Both results show that firms' scale is positive and statistically significant, as expected. However, the estimated coefficient regarding R&D intensity in the regression for KI#3 is not significantly different from zero and that in the regression for KI#6 is positive and significant at a 10% level. Thus, we conclude from this result that a larger firm views the value-chain channel as more important than the personal connection channel as the channel of KI#3 and KI#6.[3]

[Insert table 6 and Table 7]

4-1-3. Roles of the value-chain channel to obtain generic types of information

Table 3 indicates that the value-chain channel also plays an important role in gathering various types of information, such as KI#4, KI#10, KI#14, KI#15, and KI#17. Broadly, these types of information are mostly associated with products or materials provided by suppliers (e.g., development trends and price trends of key parts and components, how to address material input inventory, and reputations of key parts and components suppliers). Information on other types is related to end-user demands or preferences (e.g., changes in product needs and purchasing behavior of end users and trends in phone appearances). For mobile phone manufacturers to gather information on these types mainly from their suppliers and customers is quite natural.

One finding is noteworthy. The value-chain channel does not dominate outstanding shares as the conduit of these types of information, with the exception of

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[3] We conducted a robustness-check by excluding influential outliers and estimating using differently specified equations, which showed that this finding is quite robust.

KI#4. In most cases, many firms also regard the personal connection channel as the most important one, whereas another group of firms prefers the value-chain channel. This finding acknowledges the importance of the personal connection channel, as discussed in the next section.

4-2. Testing hypothesis 3

Table 3 clarifies that the personal connection channel, particularly friends and acquaintances in the same business, is regarded as the most important channel by respondent firms when they obtain a variety of generic information. The types of information covered are as follows: information on general product fashion and outlook trends (KI#13), information on trends of rival companies (i.e., KI#2 and KI#7), information on marketing and supply chain management (i.e., KI#9, KI#16, KI#17, and KI#18), information on inputs and suppliers (KI#14 and KI#15), information on human resources and their management (KI#19 and KI#20), and information-related risk management (KI#21), among others. In general, many belong to declarable and factual knowledge (or know-who type of knowledge), although some are similar to procedural types of knowledge. In addition, we did not anticipate another finding, which is that the personal network plays a very important role in conveying a part of core technological knowledge, such as KI#5 and KI#6.

[Insert Table 8]

Of each sample firm, we further inquired about the location of the most important relational network belonging to C#2 (i.e., friends or acquaintances in the same business). In doing this, we again allow a firm to select only one location to grasp the basic feature of geographical distribution of the important relational network. The results are tabulated in Table 8. We believe that the North Huaqiang district (A), the

Chegongmiao district (B), and Nanshan Science Park (C) in Shenzhen, suburbs of Shenzhen, and other regions in the PRD region together constitute a huge cluster of the electronics industry, including mobile phone manufacturing sectors. Shanghai (E) and its surrounding region (F), such as Kunshan city, also comprise a cluster. Table 8 clearly presents that the important relational network belonging to friends and acquaintances currently engaging in the same business is located within the cluster in which a firm is located. More than 97% and 72% of sample firms located in the PRD and YRD clusters, respectively, replied that the most important relational networks belonging to the C#2 category are inside their cluster. The stickiness of the important personal connection sources to the nearby locality might be readily apparent relative to the case of the value-chain channel.

From the results stated thus far, we conclude that hypothesis 3 is supported, but with some modification: personal networks within clusters play a very important role in conveying a variety of knowledge and information, including not only generic types of information but also core technological knowledge.

This finding shows that the LKSs through personal informal networks within clusters play an important role in the learning of local firms in Chinese high-tech clusters such as Shenzhen. This result is consistent with Dahl and Pedersen (2004), who reported that engineers working in a high-tech cluster share valuable technical knowledge and generic information with informal contacts. We also confirmed the important role of information exchange through personal networks from our interviews in Shenzhen. According to one interviewee, informal contacts are frequently made in groups of, say, seven to eight individuals, including one staff member from the platform vendor, three to four staff members from the design house, and two to three staff members as integrators. Typically, all or some members regularly meet for meals or

hold meetings. Because each firm specifically examines a different market, they are not concerned that such communications will provoke intense competition.

However, according to our interviewees, such communications in many cases are concentrated on issues related to fundamental, open, and standardized technological information, as well as market and technology trends throughout the industry. This concentration provokes consideration of the quality or level of technological knowledge conveyed through personal networks in Chinese clusters. We return to this point in section 4-3-2.

4-3. Comparison between value-chain and personal networks

4-3-1. Comparison of spatial distribution

First, differences in the spatial distribution of relational networks deserves analysis.

Table 9 indicates that approximately 21% and 50% of sample firms in the PRD and YRD clusters, respectively, responded that the most important suppliers are outside the cluster in which they are located. The stickiness of the important supplier network to the PRD cluster might still be readily apparent, but is mainly the result of the huge presence of electronics industries in this region. As Table 10 shows, C#5 has much more outward origins. Approximately 60% and 80% of sample firms in the PRD and YRD clusters, respectively, replied that their most important customers are outside their own clusters.

[Insert Table 9 and Table 10]

Given the findings stated to this point, we naturally conclude that the personal connection nested mainly inside the cluster is one of most important channels through which various types of knowledge and information are diffused to cluster firms. Our empirical evidence firmly supports hypothesis 3. A comparison to the personal

connection channel shows that the value-chain channel plays an important role when local firms acquire core technical knowledge and information, along with other types of information closely related to the product or services provided by suppliers or that meet end-user demands. The important source of the value-chain channel is inside or outside the cluster. However, the value-chain channel has a much more readily apparent outward origin than the personal connection source. In other words, this channel functions more as a bridge over the cluster border through which many types of knowledge and information come into clusters.[4]

4-3-2. Relationship between firm attributes and channel preference in acquiring core technical knowledge

The test of hypothesis 2 shows that firm heterogeneity makes a difference in the choice of the most important channels when obtaining core technological knowledge, such as KI#3 and KI#6.

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[4] The value chain of China's mobile phone-set industry has marked global characteristics. Many important components are provided by companies of foreign origin. Most of those MNCs supplying critical components established local subsidiaries and R&D centers in China. In particular, as we have noted up to this point, the main platform vendors that provide important knowledge and information to local manufacturers are foreign or Taiwanese companies. More accurately, the value-chain channel should be interchanged to the *global* value-chain channel.

We infer that the preference for relying on personal connections by one group of firms embodies a kind of "mutual help among the weak." Small firms with few assets or capabilities, such as "Shanzhai" producers, specialize in low-end and highly standardized products. This group of firms cannot afford the large investments necessary to make major innovations. Rather, they are inclined to use "open source inputs" (e.g., common molds and PCBAs) to make minor changes for differentiation purposes (Ding and Pan 2014). Consequently, firms of this type do not often encounter fundamentally difficult technological problems. They are willing to exchange minor knowledge and information and help each other when encountering minor technological difficulties. The fact that this group of small firms uses similar turnkey solutions provided by the same platform vendors, such as MTK, might facilitate such mutual assistance because the use of common platform works similar to speaking a common language.[5] Weak motivation for platform vendors may also lessen the knowledge and information exchanges between platform vendors and small firms. The size of the entire group of these firms is quite large, but each firm is small. For platform vendors to provide premium knowledge and information to each of these small firms is not

[5] We asked 56 mobile phone manufacturers about their use of baseband ICs. On average, the share of MTK of the total of baseband ICs used by sample firms amounted to 64% . We also asked, "Did the selection of the baseband IC that your company currently uses have an influence on interactions between your company and peer companies?" To this question, 43 firms replied that there were "very important" or "important" beneficial influences. These results support our discussion.

worthwhile. In contrast to small firms, a smaller number of large companies often accumulate the sufficient technological capabilities and important assets (e.g., well-recognized brand name and extensive own sales networks) necessary to develop innovative products and sell them at a large scale. These large brand companies are more likely to develop smash-hit products that will eventually generate significant profits to platform vendors supplying baseband ICs to these companies. Therefore, platform vendors have sufficient motivation to provide core technical knowledge or information to large brand companies that need to learn the superior knowledge necessary for innovation. Large brand companies may possess advantageous positions, allowing them to draw useful knowledge and information from platform vendors because they exclusively own assets indispensable to realizing significant sales in Chinese domestic mobile phone markets. For these reasons, denser and more frequent exchange of core technological knowledge and information between platform vendors and large brand companies is more likely to occur than for small firms such as Shanzhai. Our regression analysis reveals that larger firms have a higher probability of selecting the value-chain channel as the most important one instead of the personal connection channel, and vice versa (Table 7). This result supports the previous explanation.

[Insert Table 11]

Table 11 shows the type of upgrading that was most important for respondent firms that selected the personal connection channel or the value-chain channel as the most important ones for obtaining a type of core technological knowledge, KI#6. We find that firms that selected the value-chain channel tended to achieve more upgrading of hardware functions, whereas firms that selected the personal connection channel tended to achieve less upgrading in hardware functions and more in product outlook and

cost savings. Realizing major innovations in hardware functions is necessary to penetrate higher consumer segments that demand high quality in exchange for paying higher prices. Large firms possessing well-recognized brand and financial resources can participate in this segment with the assistance of technological learning from global suppliers. In contrast, small firms mainly focus on lower market segments for which achieving low costs with slight product differentiation is important.

Roughly stated, two heterogeneous groups of firms exist and have different firm attributes (i.e., firm scale), different channels for acquiring core technological knowledge, and different target markets and outcomes. Large firms tend to possess more complementary assets (e.g., well-recognized brand, own sales and after-service networks), which are important to enable platform vendors to realize higher profits. In addition to relatively sufficient financial resources, this advantageous position of large firms in technological learning may partly explain the ongoing product consolidation occurring in the Chinese mobile phone manufacturing industry.[6]

5 Conclusion

This paper presents an investigation into how Chinese mobile phone manufacturers obtain the necessary knowledge and information. For this purpose, we classified 21 types of knowledge and information, ranging from key technical knowledge to varieties of more generic information. The most important channels through which firms obtain each type of knowledge and information and the geographical distribution of knowledge

[6] According to an interviewee, many small-scale IDHs have exited the industry and product concentration has progressed rapidly (Interview in Shenzhen on Oct. 10, 2016).

and information sources were identified through our questionnaire research and field interviews.

The results of our empirical analyses revealed the following. (1) Personal human connections networked within ICs play important roles when local firms gather knowledge and information of many types, mostly related to varieties of generic type of information. In other words, we found the importance of LKSs through personal contacts in China's high-tech cluster. (2) Vertical linkages within value chains, particularly those with platform vendors, serve as important conduits through which knowledge and many types of information, including core technical knowledge, are obtained by local manufacturers. (3) Local firms' preferences for the value chain or personal connection channel are partly explained by firm attributes of local manufacturers. Larger local firms assign greater importance to the value-chain channels for obtaining key technical knowledge and information relative to the importance of the personal connection.

The first finding on the importance of LKSs through personal networks inside China's high-tech clusters has important implications for the academic debates on the knowledge flows in ICs. Many empirical analyses suggest that the knowledge spillovers inside ICs take place in highly selective ways (Lissoni 2001, Giuliani and Bell 2005, Giuliani 2007, Morrison 2008, Morrison and Rabellotti 2009, Giuliani 2011 among others). However, our finding, which is fairly similar to the finding of Dahl and Pedersen (2004), indicates that the inter-firm personal contacts inside the cluster play highly important roles in the knowledge and information acquisition by local manufactures.

The difference in findings can partly be explained by the different research design with respect to the type of knowledge and information. Unlike with previous

studies which give only very rough knowledge classification, we attempted to make much finer grouping about the knowledge and information critical to the industry. This improvement leads to our new findings: (1) Not only core technical types of knowledge, but also a wide variety of generic knowledge and information related to whole range of functionalities within the mobile-phone value-chain are considered to be highly important by local firms; (2) Personal connection inside ICs is the most important channel for many local manufacturers to acquire externally a part of core technological knowledge and a wide variety of generic knowledge and information. It is common, in typical high-tech clusters in emerging countries such as China, that local firms gain their competitive advantages from capabilities to market a variety of slightly-differentiated products with low prices one after another in the short period of time. In such way of competition, obtaining a wide variety of knowledge and information regarding to functionalities in the entire local value-chain is of critical importance. In addition, inter-firm personal connection also facilitates a group of small firms sharing same technological platforms to exchange technological knowledge with each other. Our finer specification about knowledge and information leads to these new findings which are typical to ICs in emerging countries such as China. This study suggests that elaboration in classification of knowledge is crucial for future empirical analysis on the knowledge acquisition in ICs of emerging countries.

The second finding on the importance of vertical linkages for large local manufactures with absorptive capabilities in acquiring core technological knowledge also has important academic and policy implications. This finding is consistent with findings by previous empirical researches emphasizing the role of the vertical linkages with suppliers in knowledge circulation inside ICs (Guo and Guo 2011, Sohn et al. 2016), the role of gatekeepers or global pipelines (Bathelt et al. 2004, Giuliani and Bell

2005, Giuliani 2007, 2011, Morrison 2008, Morrision and Ravellotti 2009) and the role of lead-firms in global value chains (Gereffi, 1994, Humphrey and Schmitz 2002, Gereffi et al. 2005, Morrison et al. 2008).

An academic implication can be obtained from this study with respect to the knowledge spanning mechanisms inside ICs. Guo and Guo (2011) found that different leader-centered communities within the knowledge systems of ICs were inter-connected through the knowledge spanning mechanisms (e.g., knowledge diffusion from a leader-centered community to another community through common specialized suppliers). On the other hand, empirical literatures on gatekeepers in ICs emphasized the closed nature of knowledge circulation within small communities which are composed of gatekeepers and other knowledgeable cluster firms (Giuliani 2007, 2011, Morrison 2008, Morrision and Ravellotti 2009). Our finding fits more to the former's point of view emphasizing knowledge spanning via suppliers. Our analysis evidenced that there exists dense exchange of technological knowledge and market information between local mobile phone manufactures and platform vendors with global origins. It is without doubt that platform venders gradually accumulate knowledge and information inherent in their customers (i.e. local mobile phone manufactures) though such an exchange process. Due to the confidentiality obligation, it is impossible for platform venders to leak information of a customer to other companies. However, it is plausible that knowledge and information sunk in platform venders will be utilized in their product development and distributed to other entities in the long run. In this way, knowledge and information originally possessed by each local cluster firm will be spanned via platform venders to other cluster firms with which have no direct knowledge exchange relationship. The gap of views between two bodies of literatures can be largely attributable to the different nature of ICs analyzed (i.e. ICs of machine

building industries in the case of Guo and Guo [2011] and wine clusters in the case of gatekeeper literatures) .

Our findings also have an important implication for the GVC research. Previous literatures using the GVC perspective tend to focus their attentions on the relationship between global lead firms and developing countries' suppliers participating in a GVC. Therefore, in the past GVC literatures, learning (thus obtaining from knowledge and information) from global lead firms, along with their strategic behavior for the upgrading and capability formations, has been a key to understand why and how local suppliers in developing countries can upgrade (Gereffi 1994, 1999; Humphrey and Schmitz 2002; Gereffi et al. 2005, Kawakami 2011 among others). However, our empirical results clearly show that China's cluster firms acquired a wide variety of important knowledge and information externally from other cluster firms through their personal connections inside the clusters. In this respect, along with vertical learning from global lead firms, horizontal learning from other cluster firms cannot be neglected to fully understand the mechanism of upgrading.

Our findings also has an important policy implication for development. Our analysis confirms that local firms with complementary assets can enjoy advantageous positions in technological learning because they can more easily accumulate technological knowledge from global suppliers. With reference to China's experience, acquiring deep knowledge of domestic markets at the early stage of development may be critical factors to facilitating domestic firms to accumulate complementary assets, which foreign competitors may lack. Policy assistance in this field, in line with ordinal policies such as training of technical personnel and promotion of inward FDI, is indispensable to upgrading high-tech industries in developing countries. Additionally, we can infer from this logic that, other things being equal, developing countries with

large domestic markets might have a greater advantage in developing high-tech industries relative to firms with small domestic markets.

A limitation of this study should be further considered in future research. In many high-tech clusters in developed countries, research institutes such as universities play crucially important roles in diffusing advanced knowledge to local firms in the same cluster. As described in this paper, we closely observed the relationship between platform vendors and local firms in diffusing higher levels of knowledge but not at their relationships with local and national research institutes. Devoting close attention to platform leaders is a valid strategy given the reality in China, particularly Shenzhen's mobile phone industry. However, circumstances might be somewhat different in Beijing or Shanghai, where China's top-level higher research institutes agglomerate. Consequently, further research on this topic is imperative.

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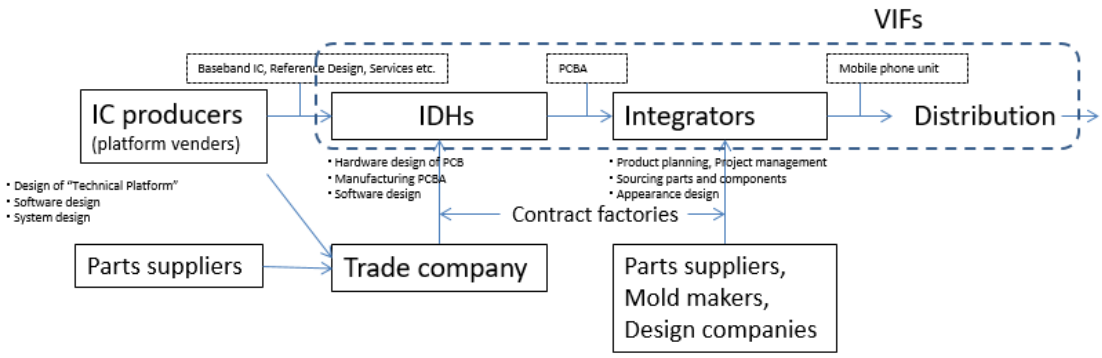
Figure 1 Value chains of China’s mobile phone-set industry.



Source: Ding and Pan (2014) with slight modification.

Table 1 Types of knowledge and information and their index numbers

Index	Definition of knowledge or information
KI#1	Direction of product development and product planning by global brand companies
KI#2	Direction of product development and product planning by Chinese domestic brand companies
KI#3	Product roadmap and technological direction of baseband ICs of Mediatek, Spreadtram, and Qualcomm, among others.
KI#4	Technology trends of hardware, such as screen, camera, touchscreen, and video, among others, and related software.
KI#5	Product innovation and product function definition
KI#6	Solutions to technical difficulties encountered in the product research and development process
KI#7	Product sales of brand companies' mobile phone sets and peer companies' products
KI#8	Changes in policies of telecommunications carriers
KI#9	Changes in marketing channels and marketing methods
KI#10	Changes in product needs or purchasing behavior of end users
KI#11	Changes in regulatory policies (e.g., customs regulation, trade protection, and IPR protection, among others) of each country
KI#12	Development of key customers, such as telecommunications carriers, large chain-stores, and others.
KI#13	Trends in mobile phone set appearance and related production technology
KI#14	Trends in price, demand, and supply of parts and components used in mobile phone set
KI#15	Reputations about key-component suppliers' capabilities
KI#16	Sharing of supply chain resources with peers, joint purchasing, and mutual adjustments of materials with peers
KI#17	Methods dearing with inventory shortage or glut of materials
KI#18	Selections of contract manufacturers, logistics companies, and trade companies
KI#19	Recruitment of key personnel in marketing, R&D, and project management
KI#20	Team building and the upskilling of company stuffs
KI#21	Risk management in the case of quality defections, good return, contract violations, and others.

Source: Authors' questionnaire survey data. The same below.

Table 2 Types of channels, varieties of locations, and their index numbers

Index	Channel	Index	Location
C#1	Colleagues in past workplaces	L#1	Huaqiangbei district in Shenzhen
C#2	Friends and acquitances engaging in the same business	L#2	Chegongmiao district in Shenzhen
C#3	Alumnus and landsman engaging in the same business	L#3	Nanshan science park in Shenzhen
C#4	Suppliers	L#4	Suburb of Shenzhen city and other area of Pearl River Delta region
C#5	Customers	L#5	Shanghai
C#6	Media, Web site, SNS (e.g., QQ, Weibo)	L#6	Yangtze River Delta region other than Shanghai
C#7	Exhibition and symposium	L#7	Beijing
C#8	Government authorities and industry groups	L#8	Rest of mainland China and overseas
C#9	Research institutes and consulting companies		
C#10	Other channels		

Table 3 Distribution of the most important channel for each type of knowledge or information

KI#	Personal connection channel				Value chain channel			Other channels					Total
	Total	C#1	C#2	C#3	Total	C#4	C#5	C#6	C#7	C#8	C#9	C#10	
kI#1	31	3	28	0	18	15	3	29	19	0	7	1	105
kI#2	66	4	59	3	13	10	3	13	8	1	3	2	106
kI#3	25	3	22	0	59	57	2	5	9	2	3	4	107
kI#4	23	0	19	4	69	66	3	7	5	0	1	1	106
kI#5	43	2	40	1	25	11	14	13	12	2	5	7	107
kI#6	50	4	46	0	44	43	1	2	4	0	3	4	107
kI#7	56	4	51	1	7	4	3	19	7	2	14	2	107
kI#8	25	3	18	4	9	4	5	15	3	45	4	5	106
kI#9	42	3	39	0	21	5	16	8	10	6	14	6	107
kI#10	15	2	11	2	38	2	36	12	17	2	15	7	106
kI#11	15	3	11	1	7	5	2	6	3	63	7	6	107
kI#12	34	4	27	3	23	8	15	9	11	15	2	13	107
kI#13	42	2	36	4	34	18	16	7	14	0	6	4	107
kI#14	41	3	36	2	52	45	7	3	5	0	1	5	107
kI#15	48	4	41	3	41	36	5	4	6	0	2	5	106
kI#16	68	6	60	2	26	21	5	2	5	0	0	6	107
kI#17	54	3	47	4	41	36	5	0	3	2	0	6	106
kI#18	67	2	59	6	14	9	5	2	5	1	4	14	107
kI#19	72	9	59	4	3	2	1	9	3	1	5	12	105
kI#20	38	2	35	1	6	2	4	2	8	0	14	39	107
kI#21	41	1	35	5	19	5	14	0	4	4	6	32	106
Average	42.7	3.2	37.1	2.4	27.1	19.2	7.9	8.0	7.7	7.0	5.5	8.6	106.5

(Note) C#1: Colleagues in the past working place, C#2: Friends and acquaintances in the same business, C#3: Alumnus and landsman in the same business, C#4: Suppliers, C#5: Customers, C#6: Media, Web site, and SNS, C#7: Exhibitions and symposium, C#8: Government authorities and industry groups, C#9: Research institutes and consulting companies, C#10: Other. Shaded numbers mean that those numbers surpass 34% of the total.

Table 4 "Does your company ask platform vendors to provide related knowledge, information, or solutions when it engaged product development based on the platform and confronts technological problems?"

	IDHs	VIFs	Total
Yes, we ask frequently.	18	20	38
Yes, we ask sometimes.	1	1	2
Yes, but occasionally.	3	2	5
No, we never ask.	0	0	0
Total	22	23	45

Table 5 "Are platform vendors proactive at providing technological knowledge or information to your company related to their IC products ?"

	IDHs	VIFs	Total
Yes, they provide frequently.	14	17	31
Yes, they provide sometimes.	5	4	9
Yes, but occasionally.	2	2	4
Not at all.	1	0	1
Total	22	23	45

Table 6 Descriptive statisitics of explanatory variables

Variable	Obs	Mean	Std. Dev.	Min	Max	Description
logEMP	108	5.68	1.94	2.30	11.92	Log of number of employee in 2012*
RAD_Share	108	0.41	0.27	0.00	0.83	Share of R&D personel in the total number of employee in 2012*
AGE	108	8.19	5.83	0	29	Years of operation at the end of 2014
Location Dummy	108	0.72	0.45	0	1	Dummy variable: value is 1 if the firm locates in PRD region, othewise 0.
Business type Dummy	108	0.49	0.50	0	1	Dummy variable: value is 1 if the firm is IDH,otherwise 0.

(Note) *: Nine firms established in 2013 and two firms established in 2014 reported data on 2013 and 2014, respectively.

Table 7 Results of multinominal regression analysis

	KI#3	KI#6
logEMP	0.532**(0.228)	0.386**(0.174)
RAD_Share	−0.349 (1.506)	2.275* (1.232)
AGE	0.031 (0.064)	−0.071 (0.051)
ZHUHAI (Location Dummy)	1.748**(0.638)	1.064* (0.561)
DH (Business-type Dummy)	0.749 (0.741)	−0.590 (0.590)
Constant	−3.627*(1.679)	−3.270*(1.324)
Observations	107	107
Log likelihood	−116.924	−105.188
LR chi2 (d.f.)	47.945 (30)	33.854 (25)

Standard errors in parentheses. * p<0.10, ** p<0.05, *** P<0.01

Table 8 Locations of sample firms and their most important relational network belonging in C#2 (friends or acquaintances in the same business)

Location of the most important network (C#2) / Location of respondent firm	A	B	C	D	E	F	G	H*	Total
A:North Qiangbei District, Shenzhen	1	0	0	1	0	0	0	0	2
B:Chegongmiao district, Shenzhen	3	5	4	1	0	0	0	0	13
C:Nanshan science park,Shenzhen	3	5	22	4	0	1	0	1	36
D:Suburb of Shenzhen and other regions in PRD	5	1	8	10	0	0	0	0	24
E:Shanghai	2	1	1	0	12	1	0	0	17
F:YRD region except Shanghai	0	0	1	0	0	0	0	0	1
G:Beijing	0	0	1	0	0	0	2	0	3
H:Rests of China mainland	1	1	2	2	1	0	1	0	8
Total	15	13	39	18	13	2	3	1	104

(Note)* Category H also contains overseas when it is used to show the location of relational networks.

Table 9 Location of sample firm and the most important relational network belonging in C#4 (suppliers)

Location of the most important network (C#4) / Location of sample firm	A	B	C	D	E	F	G	H*	Total
A:North Qiangbei District, Shenzhen	0	0	0	0	1	0	0	1	2
B:Chegongmiao district, Shenzhen	1	0	4	5	2	0	0	1	13
C:Nanshan science park,Shenzhen	2	1	17	11	3	0	0	2	36
D:Suburb of Shenzhen and other regions in PRD	1	2	9	11	0	0	0	1	24
E:Shanghai	2	1	0	3	7	2	0	2	17
F:YRD region except Shanghai	0	0	0	1	0	0	0	0	1
G:Beijing	1	0	1	0	0	0	1	0	3
H:Rests of China mainland	1	2	0	4	0	0	0	1	8
Total	8	6	31	35	13	2	1	8	104

(Note)*: Category H also contains overseas when it is used to show the location of relational networks.

Table 10 Location of sample firm and the most important relational network belonging in C#5 (customers)

Location of the most important informant (C#4) / Location of sample firm	A	B	C	D	E	F	G	H*	Total
A:North Qiangbei District, Shenzhen	1	0	0	1	0	0	0	0	2
B:Chegongmiao district, Shenzhen	3	0	0	3	0	0	0	7	13
C:Nanshan science park,Shenzhen	7	1	3	6	0	1	0	18	36
D:Suburb of Shenzhen and other regions in PRD	3	1	0	2	2	0	2	14	24
E:Shanghai	5	0	3	3	1	1	0	3	16
F:YRD region except Shanghai	0	0	0	0	0	1	0	0	1
G:Beijing	0	0	0	0	0	0	2	1	3
H:Rests of China mainland	1	1	0	0	0	0	0	6	8
Total	20	3	6	15	3	3	4	49	103

(Note)*: Category H also contains overseas when it is used to show the location of relational networks.

Table 11 The most important type of upgrading for two different types of respondent firms

	The most important realm of upgrading outcome within recent year								
	Hardware functions	Software functions	Product outlook	Product cost saving	Product marketing method	Improving brand image	Improving customer services	Other	Total
Suppliers #	6	5	7	2	2	2	1	0	25
Informal networks ##	1	5	9	4	0	2	0	0	21
Total	7	10	16	6	2	4	1	0	46

#: Firms replied that suppliers were the most important channels to acquire type 6 knowledge.

Firms replied that personal human connections were the most important channels to acquire type 6 knowledge.