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Domestic firm innovation and networking with foreign firms in China's ICT industry

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Abstract. This study systematically analyzes the impacts of supplier – client and technological linkages with foreign firms on domestic firm technological innovation, based on a unique dataset that was collected through a survey of over 600 firms in China's information and communication technology industry. The results revealed that Chinese firms were engaged in extensive supplier – client relationships with foreign firms, although their technological collaborations with foreign firms were very limited. It was found that firm innovation benefited significantly from technological relationships with foreign firms. However, the results also suggest that, although export/import did contribute to domestic firm innovation, supplier – client relationships with foreign-invested enterprises in China did not show positive effects on domestic firm innovation. The analyses further suggest that such market transactions between domestic and foreign firms helped building technological linkages between domestic firms and foreign firms. These results clearly demonstrate the value of networking in enhancing firm innovation in developing countries.

1 Introduction

Developing countries, particularly the newly industrializing economies, have benefited greatly from their participation in the global economy. Most of these economies have actively promoted export and have attracted foreign investments based on their initial advantage of cheap costs. However, an economy built upon cheap costs will be unsustainable. With growing costs, the attractiveness of these countries as manufacturing sites of standard commodities will decline: foreign investments will move to other locations with even lower costs and the export-oriented firms will gradually lose their cost-based advantages. This is clearly demonstrated by the shift of foreign investment from Southeast Asian countries to China since the late 1990s (Felker, 2003; Lall and Albaladejo, 2004). One path towards more sustainable development in developing countries is through innovation: developing countries have to upgrade and move to more sophisticated products with more advanced technologies. Nevertheless, upgrading is very challenging for developing countries, given the shortage of resources, capital, experiences, and their immature institutions. Hence many have argued that participation in global value chains (GVCs) or global production networks (GPNs) provides great opportunities for firms in developing countries (Bathelt et al, 2004; Coe et al, 2004; 2008; Ernst and Kim, 2002; Gereffi, 1999; Gereffi et al, 2005; Gertler and Levitte, 2005; Simmie, 2004; Sturgeon, 2002; Sturgeon et al, 2008; Yeung, 2007; 2009). It is hoped that domestic firms can learn from their traded and nontraded relationships with foreign suppliers, buyers, and competitors. It is in this hope that many developing countries have energetically promoted export and foreign investment.

Such theoretical arguments are attractive and compelling and empirical works on international knowledge transfer are extensive (Altenburg, 2000; Giroud, 2000;

Ivarsson and Alvstam, 2005; Lall, 1980; Lim and Fong, 1982; Scott-Kennel and Enderwick, 2005). However, we argue that the benefits of connections with foreign firms/markets need to be further scrutinized as many studies have found that firms in developing countries are often locked into the lower end of the international division of labor or the global value chains (Altenburg et al, 2008). We still have only limited understanding of knowledge transfer and local capability building (Ernst and Kim, 2002), particularly in developing countries.

In this paper we use a unique dataset that was collected through a survey of over 600 firms in China's information communication technology (ICT) industry, focused on the impacts of supplier – client and technological linkages with foreign firms on domestic firm technology innovation. Supplier-client linkages include export – import and buying – selling transactions with foreign-invested enterprises (FIEs) in China. Domestic firms can act as suppliers or as clients in such relationships. Technological linkages include technology, information, and personnel interactions between domestic and foreign firms. Specifically, we address three sets of questions. (1) How extensive and intensive are supplier – client and technological linkages between foreign firms and domestic firms? (2) To what extent do such supplier – clients and technological networking activities with foreign firms help domestic firms build up technological competence? (3) How do supplier – client and technological networking relationships interact with each other; and do supplier – client relationships help domestic firms build technological linkages with foreign firms?

The remainder of the paper is divided into five sections. In section 2 we review the literature on the relationship between networking with foreign firms and domestic firm innovation. In section 3 we describe our data and methodology. In section 4 we examine the impacts of supplier – client linkages and technological networking with foreign firms on domestic firm innovation; in section 5 we analyze the impact of supplier – client relationships on technological networking between domestic and foreign firms. In the last section we provide a brief discussion of the implications for firms and policy makers in China, as well as other developing countries.

2 Learning by participation in global production networks

2.1 Supplier – client relationships

'Supplier – client relationships' refer to business transactions between firms. In this study we focus on the supplier – client relationships between foreign firms and domestic firms. In such relationships, foreign firms act either as suppliers or as clients for domestic firms. It has been argued that linkages between clients and suppliers provide critical insights for firm innovation. This is clearly demonstrated by the research pioneered by von Hippel (1978), who argued for a 'customer-active' paradigm which better fits the inherent requirements of the industrial idea-generation process for industrial new-product development. For firms in developing countries it has been argued that close linkages with foreign markets and foreign suppliers are particularly important (Altenburg, 2000; Aw and Hwang, 1995; Berger and Revilla Diez, 2008; Bernard and Bradford Jensen, 1999; Giroud, 2000; Scott-Kennel and Enderwick, 2005; van Biesebroeck, 2005). As suppliers, foreign firms can sell their capital goods and components to domestic firms in developing countries (*backward linkages*). Through such transactions, particularly in selling capital goods, foreign firms can teach domestic firms how to run and maintain the equipment, and local firms may also learn to develop new process technologies through their experience of using the equipment and components. As buyers, foreign firms can procure goods manufactured by domestic firms (*forward linkages*): either through direct export from domestic firms to firms

in foreign countries or through sales from domestic firms to FIEs within developing countries. As highlighted in the literature on international business, linkages are the key mechanism for knowledge and technology to transfer from foreign direct investment (FDI) to developing countries. Without linkages, FDI may create an "economic enclave" (Hansen et al, 2009) or "Cathedrals in the desert" (Hardy, 1998), which exploit the advantage of low costs and resources, and have very limited sustainable positive impact on the local economy in developing countries (Altenburg, 2000; Giroud, 2000; Gorg and Strobl, 2001; Hardy, 1998; Scott-Kennel and Enderwick, 2005). As suppliers to foreign firms, domestic firms are able to better understand the trend of market demand and are subject to more demanding requirements. Consequently, domestic firms which are embedded into the supplier networks of foreign firms should benefit from such relationships.

Empirical studies on these supplier–client relationships and domestic firm capability building are extensive. Many studies have found positive impacts of exporting on firm performance, including innovation (Aw and Hwang, 1995; Baldwin and Gu, 2004; Bernard and Bradford Jensen, 1999; Salomon, 2002). Others have revealed positive impacts of forward and backward linkages of FIEs in host economies (Altenburg, 2000; Hansen et al, 2009; Ivarsson and Alvstam, 2005; Lall, 1980; Lim and Fong, 1982; Scott-Kennel and Enderwick, 2005; Zhou and Tong, 2003). We argue that the discussion on impacts of supplier–client connections with foreign firms on domestic firms in developing countries is incomplete without a consideration of the international division of labor. The long-standing new international division of labor (NIDL) theory, for example, argues that global core countries are the sources of advanced technology, organizational leadership, and the main consuming market in the global production system while peripheral and semiperipheral regions participate by providing low-cost human resources, either unskilled or skilled labor, in a global system that is designed to benefit disproportionately the core countries (Froebel et al, 1980; Hymer, 1976). Innovation activities are drawn to the core regions because innovation and product development require close management and research and technical involvement which can be achieved most easily in advanced regions (Sayer, 2004). As a result, firms in developing countries are trapped into the low end of global value chains, unable to upgrade, and capture only a declining share of value in the global economy (Gibbon and Ponte, 2005; Phelps et al, 2009). Sample empirical studies include those of Grabher (1994) and Hardy (1998) on Central and East Europe, Lowe and Kenney (1999) on Latin America, Poon and Thompson (2003) on East Asia, and Phelps et al (2009) on Africa.

We further argue that the impacts of supplier–client connections on domestic firms are affected by the state. In the global economy many governments in developing countries have actively promoted export and inward foreign investment through tax rebates and other measures. It is undeniable that export has afforded many benefits for developing countries through providing employment and increasing their foreign currency reserve. China's foreign reserve has reached more than US$2 trillion dollars through the efforts of three decades. Nevertheless, the Chinese government has actively promoted export through heavy subsidies—without which many manufacturers can barely survive. We argue that such a policy also lessens the pressure on domestic firms to become more competitive through innovation and other capability building. Consequently, domestic firms are less likely to benefit technologically through their export activities.

Concerning inward foreign investment, the majority of FIEs in developing countries are branch factories which are thinly integrated with the local economy (Firn, 1975; Hood and Young, 1982; Phelps, 1996; Phelps et al, 2009). Recognizing the potential

problem of economic enclaves (Hansen et al, 2009), the Chinese government has enacted a number of policies promoting local linkages through a requirement for 'local content' in exchange for granting FIEs access to the huge domestic market. Liu and Dicken (2006) have argued that such policies have created "obligated embeddedness" for FIEs, which are forced to buy from local suppliers in exchange for access to China's domestic market. It is commonly recognized that markets in China generally are more price sensitive and less quality demanding than markets in advanced economies. As such, FIEs in China are less strict with their local suppliers than with their suppliers in advanced economies. We argue that such obligated embeddedness of FIEs will weaken the potential impacts of their linkages on domestic firms.

To summarize, we hypothesize that suppliers–client linkages with foreign markets or FIEs do not necessarily help technological innovation of domestic firms in developing countries such as China.

2.2 Technological networking

Technological linkages between foreign firms and domestic firms are more crucial than supplier–client networks for domestic firm technological upgrading since such networks enable more direct exchanges of information and knowledge through formal and informal channels. In such relationships, foreign firms act as *technology providers* (licensing) and as *partners*. It is in such close technological relationships that domestic firms are most likely to receive tacit knowledge from foreign firms (Andersson et al, 2002; Antoncic and Prodan, 2008; Huggins, 2001). Many studies have examined firm-level technological interactions (Ahuja, 2000; Liefner and Zeng, 2008; Liefner et al, 2006; Revilla Diez and Berger, 2005; Revilla Diez and Kiese, 2006; Yeung and Olds, 2000) and revealed the positive impacts of interfirm technological interactions on firm innovation (Ahuja et al, 2008; Andersson et al, 2002; Antoncic and Prodan, 2008; Baum et al, 2000; Gemünden et al, 1992; Huggins, 2001). However, the opposite has also been reported: for example, Kotabe and Swan (1995) found that firms engaging in collaborative arrangements with other firms produced innovations that were less creative and had less impact; Stuart (2000) found no effect of the number of alliances on a firm's patenting activity.

Furthermore, whether or not and how much developing countries can benefit from technological networking with foreign firms is still an open question. First, as many studies have documented, a major problem in developing countries is that domestic firms have failed to master imported technologies due to their weak absorptive capabilities and institutional problems. They have fallen into a trap of "importing—out of date—importing again—out of date again" (Liu, 2008, page 11). In addition, in order to engage in collaborative technological relationships, domestic firms need to have strong internal R&D capabilities (Ahuja, 2000; Yeung and Olds, 2000). Otherwise, foreign firms will be unwilling to engage in such relationships as they have nothing to gain. Unfortunately, most domestic firms' capabilities are weak. As a result, we do not expect such technological relationships with foreign firms to be common and we do not expect that technological linkages with foreign firms will exert strong impacts on domestic firm innovation.

Third, if technological linkages with foreign firms are considered so important for domestic firm capability building, the next question is how to build such relationships. Many studies have found that prior collaborative experience (Sampson, 2005), internal technological capability (Ahuja, 2000; Gulati, 1999), firm size (Angel, 2002; Arku, 2002), and the complementaries of their capabilities as well as their status similarity (Chung et al, 2000), help firms to create collaborative relationships. In this study we analyze whether supplier–client relationships help build technological relationships

between domestic firms and foreign firms, since such supplier–client relationships are common in developing countries and should provide opportunities to develop deeper technological collaborative relationships.

3 Data and methodology

Data for this study came from a unique dataset that was collected through a large-scale survey of over 1000 firms in China's three major city regions—Beijing, Shanghai–Suzhou, and Shenzhen–Dongguan—which together account for half of China's ICT manufacturing employment and close to 60% of its ICT manufacturing output and export (Zhou et al, 2011, page 2). The survey was conducted by a firm affiliated with the Chinese National Statistics Bureau and was completed in late 2006 and early 2007. Before the survey, questionnaires were designed by a team of researchers who had rich experience in China. The researchers had intensive communications with the survey firm, which has standard procedures in place for quality control. Subject firms were chosen through a database based on the 2004 Economic Census with annual updates. The surveyors phoned the firms from the database one by one until the required number of firms had agreed to participate in the survey.[1] In principle, 5% of firms in four sectors were selected from each region, with at least thirty firms in each sector of every region included. In total, 1023 firms participated in the survey. In this study we focus on the 633 hardware firms, since software firms may follow different paths of innovation. Surveys were carried out either through telephone interviews or through site visits. Among the 633 hardware firms, 322 were FIEs, which included wholly foreign-owned enterprises as well as joint ventures between foreign investors and Chinese partners. The 309 domestic enterprises belonged to three subsectors: 104 firms were in computer/communication equipment manufacturing; 161 firms were in electronic parts manufacturing and 41 in semiconductor manufacturing (table 1). We were informed that the survey firm's supervisors would telephone the interviewed firms afterwards to ensure that the surveys had indeed taken place. We also had investigators accompanying staff from the survey firm to conduct surveys with selected firms. Based on our preliminary analyses, we are very satisfied with the overall quality of the survey.

Table 1. Firm sample distribution.

	Region					
	Beijing	Shanghai	Suzhou	Shenzhen	Dongguan	total
Total	280	230	177	221	115	1023
Software manufacture	180	120	20	70	0	390
Hardware manufacturer hardware total	100	110	157	151	115	633
computer/communication equipment manufacturing (401 and 404)	40	30	47	55	40	212
electronic parts (405 and 406)	30	50	80	96	75	331
semiconductor (4052 and 4053)	30	30	30	0	0	90

[1] Ideally, one would select the firms randomly from the database. Since the firms in the database are organized alphabetically, not by other attributes, we may assume that selected firms in this study are largely 'randomly' selected. Comparison of the selected firms with others did not reveal significant differences in size or a number of other dimensions.

Table 2. Definitions of the variables and their descriptive statistics.

Variable	Definition	Average
Innovation outputs		
AnyPatent	Whether or not a firm obtained any patent (domestic or foreign)	0.32
InvPatent	Whether or not a firm obtained any invention patent (domestic or foreign)	0.24
NewProduct	Whether or not a firm developed a new product during the two years before the survey	0.64
NewProcess	Whether or not a firm developed new process-technologies	0.54
Com_Innov	Whether or not a firm obtained any patent, developed a new-product or new-process technology	0.77
Linkage and control variables		
Exports	Percentage of exports out of revenues	14.98[a]
Imports	Percentage of imports in total purchases	23.37
SalesToFIEs	Percentage of revenues from sales to FIEs in China	14.55
BuyFromFIEs	Percentage of purchases from FIEs in China in total purchases	22.20
FTel_Link	The factor score measuring technological linkages with foreign firms	0.00
FTekAlliance	The importance of foreign technology alliance (0: not exist—4: very important)	0.71
FTekCoop	The importance of foreign technology cooperation (0: not exist—4: very important)	0.87
FTekLicensing	The frequency of foreign technology licensing (0: not exist—4: very frequent)	0.50
FTekAdvice	The frequency of technical advising from foreign firms (0: not exist—4: very frequent)	0.76
FPersonEx	The frequency of personnel exchange with foreign firms (0: not exist—4: very frequent)	0.82
FinfoEx	The frequency of information exchange with foreign firms (0: not exist—4: very frequent)	0.87
Yes_FBizLink	Whether or not a firm has supplier–client relationships with foreign firms	0.92
Yes_FTekLink	Whether or not a firm has technological linkages with foreign firms	0.45
NoLinks	Whether or not a domestic firm has neither technological linkages nor supplier–client relationships with foreign firms	0.03
FTekLinkOnly	Whether or not a domestic firm has technological linkages but no supplier–client relationships with foreign firms	0.05
FBizLinkOnly	Whether or not a domestic firm has supplier–client relationships but no technological linkages with foreign firms	0.51
BothLinks	Whether or not a domestic firm has both technological linkages and supplier–client relationships with foreign firms	0.40
RDExp	Percentage of R&D in total budget	18.85
Years	Years since establishment	9.0
Emp	Number of employees	245
PVE	Whether or not a firm is privately owned	0.89

[a] This refers to the average rate of sales out of exports for *all* the domestic firms included in the sample. When we limit the firms to those with exports, the average rate of export out of revenue would be raised to 35.88%.

The questionnaire contained more than 200 questions on issues related to firm innovation and linkages (table 2). We measured firm innovation through a number of indicators from inputs to outputs: R&D input measurements included number of R&D employees, percentage of R&D employees of the total employees, percentage of R&D expenditure in total budget, number of employees with BA or above degrees, and percentage of R&D employees with overseas experience, and whether or not the firm has an R&D facility. Innovation outputs included three types of indicators: patent grants, new-product development, and new-process technology development during the two years prior to the survey. The survey asked the firms to report the total number of domestic as well as foreign patent grants, the number of new products, and whether or not new-process technology was developed. However, only 32% of the firms reported having any patents; 64% and 54% of the firms reported developing new products or processing technologies, respectively. Because the dependent variables do not follow a normal distribution, we used the binary format of the data in the modeling analyses: AnyPatent (whether or not the firm had any patent grant), NewProduct (whether or not the firm had developed any new-product technology during the two years before the survey), and NewProcess (whether or not the firm had developed any new-process technology during the two years before the survey). We also included InvPatent (whether or not the firm had any invention patent), since invention patents need to go through stricter scrutinization by the national intellectual property rights office and they often indicate more advanced technologies than do designs or utility models—the other two types of patents in China. Finally, we constructed a composite variable (Com_Innov) that combines AnyPatent, NewProduct, and NewProcess; the Com_Innov variable has the value 1 as long as at least one of the three innovation indicators shows nonzero values. As a result, the new composite innovation variable designated more firms as innovative. Based on the new composite innovation variable, we found that 73.8% of firms could be classified as 'innovative'.

For supplier–client relationships, we included the following indicators: percentage of exports in total revenues (Exports), percentage of sales to FIEs in China (SalesToFIEs), percentage of imported components (Imports), and percentage of components purchased from FIEs in China (BuyFromFIEs). One may expect that such measures of linkages between domestic firms and foreign firms are strongly correlated. Interestingly, the correlation coefficients among the four supplier–client linkages are not as large as expected (table 3). We include all the four variables in the models. We also constructed a composite binary variable, Yes_FBizLink, which indicates whether or not a firm had any of the four types of supplier–client relationships with foreign firms.

For technological network relationships, we included a variety of indicators of interaction between domestic and foreign firms, such as the frequency of foreign technology

Table 3. Correlations among the variables of business linkages between domestic firms and foreign firms.

	Exports	Imports	SalesToFIEs	BuyFromFIEs
Exports	1			
Imports	0.105			
SalesToFIEs	−0.099	−0.002	1	
BuyFromFIEs	0.137*	−0.083	0.168**	1

** Correlation coefficient is significant at the 0.01 level; * correlation coefficient is significant at the 0.05 level.

licensing (FTekLicensing), importance of technology collaboration (FTekCoop) and technology alliance (FTekAlliance), and the frequency of technical advising (FTekAdvice), and personnel and information (FPersonEx and FInfoEx) exchanges with foreign firms. Firms were asked to rank the frequency/importance of such relationships from 0 (nonexistent) to 4 (very frequent/important). As all the measurements of technical interactions between domestic firms and foreign firms were strongly correlated (table 4), we first crated a new binary variable (Yes_FTekLink) to measure whether a firm had any technological linkages with foreign firms—this new variable has a value 1 if the firm showed some linkages with foreign firms through the different mechanisms listed above. In addition, we conducted factor analyses and found that one common factor can be extracted: FTek_Link. This factor explained 81.66% of the variances in the six original measurements of the technological linkages with foreign firms (table 5). Such results demonstrate that the different measurements of technological linkages with foreign firms were consistent and the extracted factor was used in the further modeling analyses.

To investigate the relationships between domestic firm innovation and various global linkages, we first examined the simple relationships between the five measurements of innovation (AnyPatent, InvPatent, NewProduct, NewProcess, and Com_Innov) and the linkages variables. We used logistic regression to model the relationships between innovation and the linkages, because of the binary nature of the innovation variables. The key independent variables included the different measurements of supplier–client relationships as well as the extracted technological linkage factor (FTek_Link), as specified above. In addition, five variables were included as controls: percentage of R&D expenditure in total budget (RDExp), the number of years since the firm was established (Years), number of employees (Emp), and whether or not the firm was privately owned (PVE). RDExp, representing firm internal R&D efforts as well as the firm's innovative capability, has been found to be critical for innovation. Years and Em represent firm age and size, respectively. Such control variables have been found to be

Table 4. Correlations among the variables of technological linkages between domestic firms and foreign firms.

	FTekAlliance	FTekCoop	FTekLicensing	FTekAdvice	FPersonEx	FInfoEx
FTekAlliance	1					
FTekCoop	0.761**	1				
FTekLicensing	0.656**	0.655**	1			
FTekAdvice	0.743**	0.820**	0.761**	1		
FPersonEx	0.757**	0.853**	0.728**	0.855**	1	
FInfoEx	0.778**	0.816**	0.730**	0.856**	0.900**	1

** Correlation coefficient is significant at the 0.01 level.

Table 5. Factor analyses of the technological linkages between domestic and foreign firms.

	Factor loading matrix	Extracted variance
FTekAlliance	0.865	0.747
FTekCoop	0.907	0.823
FTekLicensing	0.831	0.691
FTekAdvice	0.931	0.866
FPersonEx	0.943	0.889
FInfoEx	0.940	0.883

Note: factors with eigenvalues greater than 1 were extracted.

important in explaining the differences in innovation among firms [see a recent review on this topic by Ahuja et al (2008)]. Finally, we included regional dummies since the five cities differ from each other significantly. For example, the recent study by Zhou et al (2011) has revealed that firms in Suzhou and Dongguan are most export oriented and least R&D intensive among the five cities in China—Beijing, Shanghai, Suzhou, Shenzhen, and Dongguan—while firms in Beijing are more oriented towards the domestic markets and are R&D intensive. In the models, we chose Dongguan as the default location and the other cities (Beijing, Shanghai, Suzhou, and Shenzhen) were included as the regional dummies.

For the logistic regression the following model was used

$$Y = \mathrm{F}(\boldsymbol{X}, \mathrm{Years}, \mathrm{Emp}, \mathrm{RDExp}, \mathrm{PVE}, \mathrm{Regions}), \quad (1)$$

where Y is the indicator of innovation and $\boldsymbol{X}$ refers to a vector of linkage variables between domestic and foreign firms, Emp, RDExp, PVE, and Regions refer to number of employees, percentage of R&D expenditure in total budget, whether or not the firm was privately owned, and the regional dummies, respectively (table 2).

We conducted analyses with different specifications of the linkage variables. In the first set of models, we examined how the presence of supplier–client linkages (Yes_FBizLink) and technological linkages (Yes_FTekLink) with foreign firms helped domestic firm innovation. We also conducted analyses to investigate the interactions between supplier–client linkages (Yes_FBizLink) and technological linkages (Yes_FTekLink) with foreign firms and their impacts on domestic firm innovation. As table 6 demonstrates, theses two composite variables are strongly correlated. On the basis of these two variables, we classified the firms into four categories: with both technological linkages and supplier–client linkages with foreign firms (BothLinks), with neither technological linkages nor supplier–client linkages with foreign firms (NoLinks), with technological linkages but no supplier–client linkages with foreign firms (FTekLinkOnly); and with no technological linkages but with supplier–client linkages with foreign firms (FBizLinkOnly) (table 2). The results showed that among the 306 valid firms, only 8.2% did not have supplier–clients linkages with foreign firms (either firms in foreign countries or FIEs in China) while more than half (54.9%) reported no technological linkages with foreign firms. Among the four categories, the leading group consisted of those firms with supplier–client relationships but no technological relationships with foreign firms and the second largest group consisted of firms with both supplier–client and technological linkages with foreign firms. We examined the effect which different combinations of such technological and supplier–client linkages with foreign firms had on domestic firm innovation. In the third set of logistic regressions we included the four original supplier–client relationships (Exports, Imports, BuyFromFIEs, and SalesToFIEs) as well as the extracted technological linkage factor (FTek_Link).

Table 6. Interactions between supplier–client linkages and technological linkages.

		Whether or not a firm has any technological linkages with foreign firms (Yes_FTekLink)		
		no	yes	total
Whether or not a firm has supplier–client relationships with foreign firms (Yes_FBizLink)	no	NoLinks: 10 (40%)	FTekLinkOnly: 15 (60%)	25 (100%)
	yes	FBizLinkOnly: 158 (56.2%)	BothLinks: 123 (43.8%)	281 (100%)
	total	168 (54.9%)	138 (45.1%)	306 (100%)

Finally, to see if supplier–client relationships affected technological networking, we used linear regression models, which can be summarized in equation (2). The dependent variable was the various measurements of technological linkages between domestic firms and foreign firms (table 4) as well as the extracted factor scores based on technological linkages with foreign firms (FTek_Link). The key independent variables were the four variables measuring supplier–client relationships between domestic and foreign firms. Also included in the models were age of establishment (Years), number of employees (Emp), whether or not the firm was privately owned (PVE), the percentage of R&D expenditure in the total budget (RDExp), and the regional dummies. Table 2 includes the detailed definition of the variables included in these models.

$$Z = \mathrm{F}(\boldsymbol{T}, \mathrm{Years}, \mathrm{Emp}, \mathrm{RDExp}, \mathrm{PVE}, \mathrm{Regions}), \quad (2)$$

where Z refers to technological relationships with foreign firms, vector $\boldsymbol{T}$ refers to various measurements of supplier–client relationships between domestic firms and foreign firms, and Years, Emp, RDExp, PVE, and Regions have the same definitions as in equation (1).

4 Learning from linkages with foreign firms

We report the results of the analyses in this section. As reviewed above, forward and backward market linkages with foreign firms provide potential learning opportunities for domestic firms in developing countries. Our survey showed that Chinese domestic firms enjoyed extensive supplier–client relationships with foreign firms: on average, about 40% of domestic enterprises exported and among the exporting firms, exports accounted for one third of their revenues. If one includes the sales to FIEs in China's domestic market (14.55%), then foreign clients (exports and sales to FIEs in China) accounted for 50% of the revenues of Chinese domestic firms. Similarly, Chinese domestic firms sourced a significant portion of their inputs (nearly 50%) from foreign firms: 22.20% from FIEs in China and 25.35% from imports.

From the perspective of FIEs in China, our survey showed that they were more reliant on export: more than 80% of FIEs reported exporting, and exports on average accounted for 66% of the sales for these exporting firms. As a result, their linkages with domestic firms were much weaker: both sales to and purchase from domestic firms were around 20%—much lower than the level reported by domestic firms in such linkages with their domestic counterparts. Such results confirmed the sourcing patterns found in foreign-owned multinational subsidiaries in Europe (Tavares and Young, 2006).

Table 7 reports the frequency/importance of various technological interactions between domestic firms and foreign firms. Among the Chinese domestic firms, about 60% reported having no technological relationships with foreign firms, and less than 15% of Chinese domestic firms considered their interactions with foreign firms frequent/very frequent or important/very important in their technology development. When all six types of technological linkages with foreign firms were considered, more than half of the surveyed domestic firms reported no such linkages at all. For FIEs in China more than 60% did not report any technological relationships with Chinese domestic firms, and less than 15% of them considered such linkages with Chinese domestic firms frequent/very frequent or important/very important. The results clearly show that technological linkages between domestic firms and foreign firms were very limited, similar to what Arku (2002) found among small electronic firms in Canada.

The regional differences in linkages with foreign firms are also clear (table 8). Among the five cities, firms in Beijing were the least export oriented or FIE oriented: only 32% of domestic firms in Beijing reported exports; and for exporting firms

Table 7. Technological networking between domestic and foreign firms (percentages shown in parentheses).

Technological linkages	Domestic firms reporting linkages with foreign firms		
	none	important/ very important	total
Technology alliance	187 (60.71)	31 (10.06)	308 (100)
Technology cooperation	174 (56.31)	49 (15.86)	309 (100)
Licensing	189 (61.17)	9 (2.91)	309 (100)
Technology advice	174 (56.31)	33 (10.68)	309 (100)
Personnel exchange	173 (55.99)	39 (12.62)	309 (100)
Information exchange	177 (57.47)	45 (14.61)	308 (100)
	Foreign-invested firms in China reporting linkages with domestic firms		
Technology alliance	242 (75.16)	40 (12.42)	322 (100)
Technology cooperation	232 (72.05)	44 (13.66)	322 (100)
Licensing	234 (72.67)	7 (2.17)	322 (100)
Technology advice	209 (64.91)	23 (7.14)	322 (100)
Personnel exchange	211 (65.94)	32 (10.00)	320 (100)
Information exchange	219 (68.01)	35 (10.87)	322 (100)

less than a quarter of sales were exports. The average percentage of sales to FIEs was merely 6.59% for firms in Beijing. Firms in Suzhou and Dongguan were most foreign-firm oriented (exports and sales to FIEs in China): more than 50% of domestic firms in Dongguan reported exports and the average percentage of export sales for exporting firms in Suzhou was more than 50%. While the average percentage of imports in total purchases was similar among the five cities, firms in Shenzhen and Dongguan purchased much more from FIEs in China than did firms in other cities. Concerning technological linkages with foreign firms, firms in Beijing stood out again from the other cities and enjoyed the strongest linkages with foreign firms: more than 80% of firms reported both technological and supplier–client relationships with foreign firms, whereas the majority of the firms in the other four cities reported having supplier–client relationships but no technological linkages with foreign firms.

Did such linkages with foreign firms help domestic firms to build up their technological competence? Before reporting the results of the logistic regressions, we show the reports from the bivariate analyses (table 9). The results showed unmistable connections between technological linkages with foreign firms and domestic firm technological innovation: the average FTek_Link score was significantly and consistently higher for innovative firms than for noninnovative firms. Innovative firms were also more likely to have technological linkages with foreign firms. For example, among the firms with patents, 58% reported having technological linkages with foreign firms, while only 38% of the noninnovative firms so reported. Regarding the impacts of supplier–client relationships with foreign firms on domestic firm innovation, however, no consistent patterns emerged: it was not clear whether or not innovative domestic firms had more intensive backward or forward business relationships with foreign firms than did non-innovative domestic firms. First, innovative firms did seem to report slightly more supplier–client relationships with foreign firms; however, most of these relationships are not statistically significant. Moreover, the differences between innovative and noninnovative firms showed mixed results when the four different measures were compared. On the one hand, innovative Chinese firms seemed more likely to engage

Table 8. Regional differences of domestic firms' linkages with foreign firms.

Linkages	Region					Total
	Beijing	Shanghai	Suzhou	Shenzhen	Dongguan	
Percentage of domestic firms with exports	31.71	49.09	33.33	47.47	52.00	41.75
Average % of sales out of exports[a]	23.42	35.70	50.75	39.77	28.85	35.88
Average % of imports in total purchase of raw materials and components	22.46	21.27	23.48	24.92	24.44	23.37
Average % of sales to FIEs[b] in China	6.59	10.75	20.92	11.98	46.98	14.55
Average % of purchases of raw materials and components from FIEs in China	16.12	20.73	18.50	27.78	29.78	22.20
Average FTek_Link score	0.76	−0.09	−0.37	−0.30	−0.43	0.00
Percentage of domestic firms with neither technological nor supplier–clients relationships with foreign firms	0.00	1.82	14.58	1.01	4.00	3.24
Percentage of domestic firms with technological linkages but no supplier–client relationships with foreign firms	17.28	0.00	2.08	0.00	0.00	4.87
Percentage of domestic firms with supplier–client relationships with foreign firms but no technological linkages with foreign firms	0.00	69.09	58.33	73.74	79.17	51.30
Percentage of domestic firms with both supplier–client and technological linkages with foreign firms	82.72	27.27	25.00	25.25	16.67	40.07

[a] Only exporting domestic firms are included in the calculations.
[b] FIE—foreign-invested enterprises.

in export. On the other hand, among those who did export, noninnovative Chinese firms seemed to exhibit a higher degree of reliance on export than did innovative firms. Innovative firms also imported more components than noninnovative firms, although they did not necessarily buy more from FIEs in China. In most cases, the differences are statistically insignificant.

The positive impacts of technological linkages with foreign firms on domestic firms are further confirmed when the interactions between technological linkages and supplier–client linkages are examined (table 9). Innovative firms were much more likely to report both technological and supplier–client relationships with foreign firms than were noninnovative firms. For example, 53% of the firms with patents reported having both types of linkages with foreign firms, although only 33% of noninnovative firms so reported. However, the relationship between firm innovation and supplier–client relationships with foreign firms did not seem to be positive: 40% of the innovative firms reported maintaining supplier–client relationships with foreign firms while 57% of the noninnovative firms so reported. For firms with only technological linkages with foreign firms, however, we could not draw definite conclusions since only fifteen firms belong to this category (table 6).

Table 9. Comparison of innovative and noninnovative Chinese firms.[a]

	AnyPatent		InvPatent		NewProcess		NewProduct		Com_Innov	
	no	yes	no	yes	no	yes	no	yes	no	yes
Percentage of firms with exports[a]	36.76	52.13**	38.86	51.39*	32.39	49.70**	33.93	46.19**	28.57	45.61**
Percentage of sales out of exports in 2006	39.51	28.39**	39.10	25.51**	43.61	31.60**	41.11	30.93	53.75	31.51**
Percentage of sales to FIEs in China	15.65	13.06	15.82	11.69	15.50	13.74	17.24	13.02	17.65	13.97
Percentage of imported parts	20.80	26.69**	20.84	28.69**	20.76	25.58**	20.99	24.75**	15.73	24.83**
Percentage of purchase from FIEs in China	22.11	22.10	23.27	19.19	21.84	22.50	22.21	22.20	24.96	21.22
FTek_Link	−0.19	0.33**	−0.17	0.43**	−0.26	0.22**	−0.41	0.24**	−0.63	0.16**
Yes_FBizLink	0.90	0.95	0.91	0.93	0.88	0.94*	0.90	0.93	0.87	0.93*
Yes_FTekLink	0.38	0.58***	0.39	0.63***	0.30	0.58***	0.22	0.58***	0.32	0.49**
NoLinks	0.04	0.01	0.04	0.01	0.06	0.01	0.04	0.03	0.07	0.02
FTekLinkOnly	0.05	0.04	0.05	0.06	0.06	0.04	0.05	0.04	0.06	0.05
FBizLinkOnly	0.57	0.40	0.57	0.35	0.64	0.40	0.73	0.39	0.81	0.43
BothLinks	0.33	0.53	0.34	0.57	0.24	0.54	0.17	0.54	0.06	0.50
χ^{b}	12.86**		13.93**		30.21**		40.50**		45.26**	

*** Difference is significant at the 0.01 level, ** 0.05 level, * 0.10 level.

Note. 'Innovative firms' are defined as firms which reported owning patents (AnyPatent), invention patents (InvPatent), or having developed a new-product (NewProduct) or process technology (NewProcess) during the two years before the survey. Com_Innov shows whether or not a firm is innovative in any measure of the four innovation variables. Numbers in the table report the average statistics of the corresponding variables among the different categories of firms. For example, in the first row under the heading for AnyPatents, 36.76 refers to the percentage of firms with no patents that report having exports, 52.13 refers to the case for firms with at least one patent.

[a] The relationship between percentage of firms with exports and AnyPatent/InvPatent/NewProcess/NewProduct/Com_Innov were tested through the χ^2 test. For the other variables, innovative and noninnovative firms were compared using the differences of means *t*-test.

[b] The χ^2 test was based on cross-tabulating the corresponding innovation variable and the four categories of linkages with foreign firms (NoLinks, TekLinkOnly, FBizLinkOnly, and BothLinks).

Table 10 reports the results from logistic regressions where the two composite binary variables were used to measure domestic firms' supplier–client linkages—(Yes_FBizLink) and technological linkages (Yes_FTekLink)—with foreign firms. The results show that Yes_FTekLink is the only variable that shows significant impact on innovation in all the models. This variable also shows the strongest impact on innovation in any of the models. However, in none of the models did the variable Yes_FBizLink show significant impact on innovation. These results offer further evidence to support our earlier argument that supplier–client linkages with foreign firms did not translate to technological competencies for domestic firms in China, whereas technological linkages with foreign firms did demonstrate positive impacts on domestic firm innovation. In addition, the variable EMP showed significant positive impact in three of the models, where patents and new-process innovation were the dependent variables. This is not surprising as larger firms have more resources and are more likely to have patents or to develop new products.

What is surprising is that R&D expenditure showed significant and positive impact in only two models (with new-product and the composite innovation variable as the dependent variables). Also surprising is that in the model with the composite innovation variable, all the regional dummies (Beijing, Shanghai, Suzhou, and Shenzhen) showed negative impacts on innovation. These results suggest that firms in the major cities (Beijing, Shanghai, Shenzhen) do not necessarily draw direct advantage from their locations in such cities, although firms in these major cities are more innovative than those in Dongguan.

In the next set of analyses (table 11), we examined the impacts of the possible interactions between supplier–client relationships and technological linkages with foreign firms on domestic firm innovation. As explained above, we constructed four binary variables based on the supplier–client (Yes_FBizLink) and technological (Yes_FTekLink) linkages with foreign firms. Ideally, we would include three of the binary variables in the models (NoLinks, FTekLinkOnly, FBizLinkOnly, BothLinks). However, as explained above (table 6), only ten firms reported no supplier–client or technological linkages with foreign firms (NoLinks). Meanwhile, only fifteen firms had technological linkages but no supplier–client relationships (FTekLinkOnly). The small numbers of firms in these two categories made comparison less meaningful.[(2)] In the end, we limited our analyses to the 281 domestic firms which had supplier–client linkages with foreign firms. The overall results are similar to those revealed in table 10. Both_Links showed consistently positive and significant impacts in all the models, and these results offer further support to our earlier argument that technological linkages with foreign firms do have positive impacts on domestic firm innovation.

In the third set of regressions (table 12), we included in the models all the four different measurements of supplier–client relationships with foreign firms as well as the extracted factor score (FTek_Link). On the one hand, the results showed that technological linkages with foreign firms had consistently positive and significant impacts on innovation in all the models, confirming what was revealed earlier. On the other hand, these models showed inconsistent results on the impacts of supplier–client relationships on domestic firm innovation. First, exports showed significant and positive impact in four out of the five models, and in only one (Com_Innov) the impact was not statistically significant. Also significant was the positive impacts of imports in three of the models. In comparison, neither SalesToFIEs nor BuyFromFIEs showed any significant impact on domestic firm innovation. Indeed, in most of the models,

[(2)] When we included three of the binary variables (FTekLinkOnly/NoLinks, FBizLinkOnly, BothLinks) in the model, none of the linkages variables was significant. To save space the results are not reported here.

Table 10. Results of logistic regressions: global linkages and domestic firm innovation 1.

	AnyPatent		InvPatent		NewProduct		NewProcess		Com_Innov	
	B	exp(*B*)[a]	*B*	exp(*B*)	*B*	exp(*B*)	*B*	exp(*B*)	*B*	exp(*B*)
Years	0.003	1.003	0.012	1.012	0.001	1.001	−0.004	0.996	−0.014	0.986
EMP	0.001	1.001***	0.001	1.001***	0.000	1.000	0.001	1.001**	0.000	1.000
Beijing	−0.087	0.917	1.171	3.226	−0.866	0.421	0.280	1.323	−1.737	0.176*
Shanghai	0.475	1.608	0.562	1.753	−0.138	0.871	−0.328	0.721	−0.530	0.589
Suzhou	−0.607	0.545	0.254	1.289	−0.535	0.586	−0.418	0.658	−1.055	0.348*
Shenzhen	−0.036	0.965	0.328	1.388	−0.394	0.675	−0.691	0.501	−0.807	0.446
PVE	0.140	1.151	0.644	1.904	−0.594	0.552	0.124	1.131	−0.884	0.413
RDExp	0.008	1.008	0.007	1.007	0.031	1.031***	0.012	1.012	0.050	1.051***
Yes_FBizLink	0.621	1.860	0.507	1.661	−0.078	0.925	0.831	2.296	0.461	1.586
Yes_FTekLink	0.995	2.706***	0.650	1.915*	1.663	5.273***	0.902	2.464***	2.687	14.686***
Correct percentage	28.65		76.30		72.40		65.20		81.30	
χ^2	69.40***		28.49***		53.57***		45.63***		69.39***	

*** Significant at the 0.01 level, ** 0.05 level, * 0.10 level.

[a] exp(*B*) refers to the exponential value of the *B* (regression coefficients). In logistic regressions, exp(*B*) values greater than 1 indicate the positive impact of the independent variable on the odds of the dependent variable (the ratio between the chance of the dependent variable being 1 over the chance to choose value 0).

[b] 'Correct percentage' refers to the percentages of observations that were correctly predicted by the models.

Table 11. Results of logistic regressions: global linkages and domestic firm innovation 2.

	AnyPatent		InvPatent		NewProduct		NewProcess		Com_Innov	
	B	exp(*B*)[a]	*B*	exp(*B*)	*B*	exp(*B*)	*B*	exp(*B*)	*B*	exp(*B*)
Years	0.009	1.009	0.018	1.018	−0.001	0.999	−0.008	0.992	−0.023	0.978
EMP	0.001	1.001***	0.001	1.001***	0.000	1.000	0.001	1.001**	0.000	1.000
Beijing	−0.107	0.898	1.213	3.362	−0.549	0.578	0.685	1.984	−1.138	0.320
Shanghai	0.534	1.705	0.670	1.954	0.137	1.147	−0.033	0.968	−0.217	0.805
Suzhou	−0.720	0.487	0.151	1.163	−0.501	0.606	−0.269	0.764	−1.091	0.336*
Shenzhen	−0.052	0.949	0.320	1.377	−0.296	0.744	−0.489	0.613	−0.743	0.476
PVE	0.196	1.217	0.782	2.185	−0.643	0.526	0.177	1.193	−1.443	0.236
RDExp	0.007	1.007	0.006	1.006	0.029	1.029***	0.009	1.009	0.051	1.052***
BothLinks	0.996	2.708***	0.641	1.898*	1.650	5.208***	0.826	2.284**	2.699	14.865***
Correct percentage[b]	67.60		75.80		72.30		64.90		82.10	
χ^2	25.67***		26.92***		53.13***		39.95***		69.11***	

*** Significant at the 0.01 level, ** 0.05 level, * 0.10 level.

[a] exp(*B*) refers to the exponential value of the *B* (regression coefficients). In logistic regressions, exp(*B*) values greater than 1 indicate the positive impact of the independent variable on the odds of the dependent variable (the ratio between the chance of the dependent variable being 1 over the chance to choose value 0).

[b] 'Correct percentage' refers to the percentages of observations that were correctly predicted by the models.

Table 12. Results of logistic regressions: global linkages and domestic firm innovation 3.

	AnyPatent		InvPatent		NewProduct		NewProcess		Com_Innov	
	B	exp(*B*)[a]	*B*	exp(*B*)	*B*	exp(*B*)	*B*	exp(*B*)	*B*	exp(*B*)
Years	0.005	1.005	0.013	1.013	0.002	1.002	−0.007	0.993	−0.013	0.987
EMP	0.001	1.001***	0.001	1.001***	0.000	1.000	0.001	1.001**	0.000	1.000
Beijing	−0.015	0.986	1.018	2.768	−0.454	0.635	0.544	1.723	−1.369	0.254
Shanghai	0.353	1.423	0.431	1.538	−0.565	0.568	−0.453	0.636	−0.913	0.401
Suzhou	−0.605	0.546	0.224	1.251	−0.568	0.567	−0.382	0.683	−1.278	0.279*
Shenzhen	−0.119	0.888	0.233	1.262	−0.681	0.506	−0.802	0.448	−1.079	0.340
PVE	0.015	1.015	0.535	1.707	−0.641	0.527	−0.060	0.942	−0.859	0.424
RDExp	0.012	1.012	0.011	1.011	0.031	1.031***	0.020	1.020**	0.052	1.053***
Export	0.534	1.706*	0.572	1.773*	0.484	1.622*	0.656	1.928**	0.526	1.692
SalesToFIEs	−0.002	0.998	−0.003	0.997	−0.009	0.991	−0.002	0.998	−0.004	0.996
Imports	0.009	1.009*	0.012	1.012**	0.001	1.001	0.005	1.005	0.013	1.013*
BuyFromFIEs	−0.002	0.998	−0.010	0.990	0.001	1.001	0.002	1.002	−0.009	0.991
FTek_Link	0.472	1.603***	0.431	1.539***	0.667	1.949***	0.270	1.311*	1.569	4.802***
Correct percentage[b]	71.00		78.70		72.60		64.90		82.10	
χ^2	38.69***		42.46***		53.49***		49.58***		77.62***	

*** Significant at the 0.01 level, ** 0.05 level, * 0.10 level.

[a] exp(*B*) refers to the exponential value of the *B* (regression coefficients). In logistic regressions, exp(*B*) values greater than 1 indicate the positive impact of the independent variable on the odds of the dependent variable (the ratio between the chance of the dependent variable being 1 over the chance to choose value 0).

[b] 'Correct percentage' refers to the percentages of observations that were correctly predicted by the models.

these two variables showed negative rather than positive impact on domestic firm innovation. Direct supplier – client relationships with foreign markets through exports and imports seemed to be more beneficial than supplier – client linkages with FIEs in China. These results are contrary to the positive effects of supplier – client linkages with foreign firms on domestic firms that have been proposed in previous studies (Altenburg, 2000; Bernard and Bradford Jensen, 1999; Giroud, 2000; Scott-Kennel and Enderwick, 2005; van Biesebroeck, 2005).

To summarize, embeddedness into FIEs supplier – client networks does not guarantee benefit for domestic firms, although technological interactions with foreign firms do result in solid and positive impacts on domestic firm innovation.

5 Supplier – client relationships help build technological relationships

The above analyses have shown that technological linkages between domestic firms and foreign firms exerted a significant positive impact on domestic firm technological innovation, whereas the expected impacts of supplier – client relationships did not materialize. The remaining question is that of how to cultivate technological relationships between domestic firms and foreign firms. In particular, we need to know whether supplier – client relationships help build technological interactions between domestic and foreign firms.

The overall results of the analyses (table 13) suggest that nontechnological supplier – client relationships did seem to help build technological interactions between domestic firms and foreign firms. The results were consistent in most models where different measurements of the technological linkages with foreign firms were tested. Exports showed significant positive impacts in five of the seven models, and sales to FIEs and imports showed significant positive impacts in four of the models. However, BuyFromFIEs showed a significantly positive impact in only one model. Such findings are not surprising, since it is natural to expect that trade relationships provide opportunities for domestic firms to get to know foreign buyers, suppliers, and potential partners. Sustained trade relationships should also help build trust between foreign and domestic firms. It is particularly encouraging to see the positive impact of SalesToFIEs on domestic firm technological networking with foeign firms. As revealed above, supplier – client relationships with foreign firms did not seem to make a direct contribution to domestic firm innovation. However, their significantly positive impact on domestic firm technological networking suggests that supplier – client relationships with foreign firms can contribute to domestic firms indirectly — through technological networking.

Another consistent finding was that location in Beijing and Shanghai gave firms in these leading cities advantages in constructing technological linkages with foreign firms. It is important to note that a location in Beijing or Shanghai offered the strongest impact on the intensity of technological linkages between domestic firms and foreign firms, and such locational impacts were stronger than those of supplier – client relationships with foreign firms. Meanwhile, it is interesting to note that internal R&D, which has been critical in enabling firms to enter into technological cooperation with foreign firms (Ahuja, 2000; Gulati, 1999), showed neither significant nor consistently positive impact in any of the models. Indeed, in five of the seven models, R&D expenditure had a negative impact on the intensity of technological linkages between domestic firms and foreign firms. This is surprising, given that most foreign firms would not be willing to enter into such relationships with domestic firms which had nothing to offer. We argue that such surprising outcomes have resulted in part from the fact that impacts of firm R&D on technological linkages have been captured by the location variables Beijing and Shanghai. As found by Zhou et al (2011), firms in Beijing and Shanghai invest

Table 13. Impacts of suplier–client relationships on technological networking between domestic and foreign firms.

	FTek_Link		FTekAlliance		FTekCoop		FTekLicensing		FTekAdvice		FPersonEx		FInfoEx	
	β	sig.	β	sig.	β	sig.	β	sig.	β	sig.	β	sig.	β	sig.
Years	0.008	0.896	0.016	0.795	0.107	0.100	0.054	0.357	−0.008	0.901	0.002	0.978	−0.028	0.647
EMP	0.036	0.532	0.049	0.407	0.029	0.639	0.061	0.267	0.032	0.584	−0.005	0.926	0.028	0.620
Beijing	0.668***	0.000	0.398***	0.001	0.399***	0.001	0.704***	0.000	0.620***	0.000	0.693***	0.000	0.697***	0.000
Shanghai	0.235**	0.017	0.094	0.351	0.126	0.231	0.251***	0.008	0.213**	0.033	0.250**	0.013	0.239**	0.017
Suzhou	0.100	0.266	−0.126	0.171	0.046	0.631	0.143*	0.097	0.096	0.289	0.145	0.113	0.138	0.129
Shenzhen	0.157	0.153	−0.038	0.733	0.093	0.425	0.134	0.203	0.118	0.284	0.252**	0.024	−0.181*	0.101
PVE	0.045	0.467	0.013	0.842	0.055	0.400	0.011	0.854	0.030	0.634	0.079	0.211	0.071	0.248
RDExp	−0.010	0.874	0.017	0.782	0.020	0.754	−0.018	0.765	−0.020	0.744	−0.028	0.651	−0.022	0.718
Export	0.109**	0.048	0.066	0.245	0.119**	0.044	0.092*	0.085	0.071	0.202	0.148***	0.009	0.104*	0.061
SalesToFIEs	0.110*	0.071	0.091	0.151	0.130**	0.049	0.093	0.119	0.084	0.177	0.152**	0.016	0.112*	0.068
Imports	0.101*	0.060	0.078	0.155	0.104*	0.068	0.035	0.500	0.121**	0.026	0.064	0.244	0.123**	0.023
BuyFromFIEs	0.061	0.272	−0.031	0.589	0.055	0.356	0.106**	0.048	0.071	0.207	0.058	0.308	0.037	0.507
R^2	0.244		0.195		0.132		0.293		0.221		0.206		0.236	
F-statistic	7.42***		5.571***		3.511***		9.562***		6.560***		5.987***		7.112***	

*** Significant at the 0.01 level, ** 0.05 level, * 0.10 level.

Note. For all seven models, the independent variables are the same, and only the dependent variables differ.

significantly more on average in R&D than do those in other locations. Indeed, when we removed the regional dummy variables, RDExp became significant and showed the strongest impact on technological linkages with foreign firms. Therefore, we argue that the results here do not suggest that internal R&D was not important in helping firms to build technological linkages with foreign firms.

Meanwhile, we argue that the very fact that the two dummy variables Beijing and Shanghai, rather than R&D expenditure, showed the strongest impacts on technological linkages with foreign firms also demonstrates the leverage that these leading cities offer to firms. The power which such locations give to domestic firms is even stronger than that of internal R&D, because foreign firms were more likely and more willing to engage in technological linkages with domestic firms in such locations.

6 Conclusions and discussion

With the aid of a unique dataset from a large-scale survey of firms in China's ICT industry, we have revealed a number of interesting and important findings concerning the impacts of both supplier–client and technological linkages with foreign firms on domestic firm technological capability building. We have demonstrated that the Chinese domestic firms were engaged in extensive supplier–client relationships with foreign firms, through direct export/import or buying from/selling to FIEs in China. We also found that only a small percentage of domestic firms were engaged in technological networks with foreign firms. As expected, these domestic firms gained significant benefits from technological linkages with foreign firms (Andersson et al, 2002; Antoncic and Prodan, 2008; Gemünden et al, 1992; Huggins, 2001).

However, surprisingly, not all supplier–client relationships between domestic firms and foreign firms have shown positive impacts on domestic firm technology capability building. Although domestic firm technological innovation benefited significantly from export and import activities, forward and backward linkages with FIEs in China did not seem to have similar significant impacts. Earlier studies have been concerned about the 'economic enclave' (Hansen et al, 2009), where domestic firms could not benefit much when FIEs were isolated from the domestic economies in developing countries. The results of our study raise further questions on the positive impacts of FIEs on local economies, even when such FIEs do engage in backward/forward linkages with domestic firms (Altenburg, 2000; Bernard and Bradford Jensen, 1999; Giroud, 2000; Scott-Kennel and Enderwick, 2005; van Biesebroeck, 2005). The majority of foreign firms are initially attracted to developing countries such as China because of the low costs. Once there, their backward/forward linkages with domestic firms may be the results of so called 'obliged embeddedness' (Liu and Dicken, 2006); hence, their direct impacts on domestic firm innovation are limited. Domestic firms, when subject to the stricter requirements of the international markets, will experience stronger pressure and can benefit more from their direct contacts with the international markets through exports and imports than from their embeddedness into FIEs' supplier–client networks in their own developing countries.

Also surprising is the finding that R&D did not seem to result in much firm technological innovation as measured by patent grants in China, although it did show significant impact on new-product innovation. We suggest that this could call into question the usefulness of using patents to measure firm innovation in the context of China. It has been widely recognized that China offers weak intellectual property rights (IPR) protection, although significant progress has been made in this area during the last few decades (Sun, 2000). In such an environment, firms are less likely to protect their IPRs through patent application, but are more likely to rely on the concept of 'trade secrets' to protect their proprietary knowledge.

Furthermore, we found that market supplier–client relationships did help build technological linkages between domestic firms and foreign firms. Our analyses confirmed what Giuliani (2007) has revealed in the wine industry—that business networks and knowledge networks show different properties: knowledge is exchanged in a very selective and uneven manner, although the business networks are very pervasive.

Finally, it is also interesting to note that what mattered most in building such technological relationships with foreign firms was the domestic firms' location: a location in Beijing or Shanghai offered firms the strongest advantage in constructing technological linkages with foreign firms, and these effects of location were stronger than that of internal R&D (which did not show significant impacts). Many previous studies on interfirm technological collaboration (Ahuja, 2000; Gulati, 1999) have suggested that internal R&D and external technological networking are complementary. Our findings do not necessarily suggest that internal R&D does not help build external technological linkages. However, our findings do suggest that the power of location is stronger: firms in leading cities are privileged in constructing technological linkages with foreign firms.

The results of this study are partially disappointing and partially encouraging for Chinese policy makers. The results are disappointing for Chinese government and business from a number of perspectives. First, Chinese firms are engaged in extensive supplier–client relationships with foreign firms, although not all these linkages help domestic firms build technological capabilities directly. In particular, the supplier–client relationships with FIEs in China did not seem to help domestic firm innovation. This is disappointing because the Chinese government has hoped that the local-content requirement on FIEs will help domestic firms to learn from such interactions and so build up their technological capabilities. The results are also disappointing because Chinese firms' technological linkages with foreign firms are still very limited, although such linkages have proven to exert significant impacts on domestic firm capability building.

Nevertheless, the results could give Chinese policy makers some encouragement: at least some Chinese domestic firms were technologically advanced enough to be able to enter into deep technological relationships with more advanced foreign firms. The willingness of foreign firms to enter into such formal/informal technological relationships with Chinese firms is an indication of the technological sophistication of some domestic firms. The results are also encouraging in that the extensive supplier–client relationships between domestic firms and foreign firms did seem to help build technological collaborative relationships among them. Consequently, domestic firm innovation can benefit indirectly from supplier–client relationships with FIEs.

In this study we have focused on networking between domestic firms and foreign firms, and there are many other networks with domestic firms, universities, and governmental R&D laboratories which have not been examined. As revealed by previous studies, China's national innovation system was fragmented due to the legacy from the prereform command economy, and firms were not engaged in extensive networking, particularly technological networking, with other firms or other entities (Sun, 2000). It would be interesting to see what changes have occurred after decades of reform. Given that most Chinese firms are still weak in their technological capabilities, and the weak IPR-protection environment, we doubt that such technological networking among Chinese firms will be extensive or the impacts of such networking significant.

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