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R&D of Multinationals in China: Structure, Motivations and Regional Difference

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R&D of Multinationals in China: Structure, Motivations and Regional Difference[1]

By Kazuyuki Motohashi[2]

Abstract

In this paper, the motivations of R&D by multinationals are investigated by using a large firm level dataset from Chinese official statistics on science and technology activities. Growing intensity of R&D activities is found both for foreign owned and domestic firms. But, it is also found that the R&D intensity at foreign owned firms is relatively smaller. This may be due to the fact that foreign owned firms are operating by relying of technological capabilities at home.

Statistical analysis confirms that the major motivation of foreign R&D in China is "market driven" instead of "technological driven" or "human resource driven". However, there is a great variation of foreign R&D strategy across regions. Market driven R&D is found mainly in Guangdong, which is called a world IT factory, and does not have strong universities or PRIs. In contrast, R&D strategy in Beijing is oriented toward technology driven approach, because we can find a cluster of scientific institutions there. Shanghai, with both a large industrial base as well as strong science sector, is in-between.

JEL Classification: O31, O32

Keywords: Globalization of R&D, China, Regional Differences

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1. Introduction

During his southern visit in 1992, Deng Xiaoping called for speeding up economic reform and economic growth in order to bring about a boom in the inflow of FDI. With open door policy for foreign direct investment as well as strong competition among local governments trying to attract foreign capital, the FDI achieved remarkable expansion, raising the amount from US$4.4 billion (actual amount used) in 1991 to US$53.5 billion in 2003. Major motivations behind this surge of FDIs include using cheap labor for offshore production facilities and exploiting large market backed by the world largest population. However, at the same time, China started attracting foreign investors as a host of international R&D. Now, Beijing becomes to be a city of international R&D centers, including ones by Intel, Microsoft, Nokia and Siemens.

International R&D can be a natural extension of international production and marketing. Each country has a different taste, and R&D for localization of home market product is an important element of international marketing. Since China is a large developing country with substantial difference in consumer tastes from developed economies, substantial efforts of product localization R&D need to be provided for market penetration. At the same time, the level of scientific research at Chinese university has been improving due to the strong government policy for S&T promotion and high-tech developments. Therefore, there may be some scientific area where multinationals have a good incentive work with Chinese universities as technology sources. Furthermore, China is an attractive country for cheap but high quality S&T human resources. The number of engineering and science students is now greater than that of Japan, and second to the United States, and ample S&T labor supply makes it possible for multinational to hire well qualified Chinese students for reasonable wage.

These motivations for international R&D in China can be broadly categorized into (1) market driven R&D, (2) technology driven R&D and (3) human resource (HRST) driven R&D. In this paper, we analyze R&D activities of multinationals by using a large dataset from Science and Technology Survey conducted by National Bureau of Statistics of PRC. In this dataset, detail variables on S&T activities are available both for foreign owned companies and domestic ones. Therefore, activities at multinationals can be compared with those of domestic firms to understand which motivation among the three above is relevant.

In addition, regional differences of the motivations for international R&D are investigated in this paper. There are three major regions which host substantial amount

of FDIs, Beijing, Shanghai and Guangdong. Beijing is a city of scientific sector, where major universities and substantial number of public research institutes are located. Zhongguancun in Haiden district is called China's "silicon valley" as a cluster of scientific institutes and tremendous number of high-tech start-up companies. Shanghai is a large industrial base with manufacturing firms, and S&T activities are mainly conducted by such private sector. Finally, Guangdong province is a world center of electronics components firms. Although there are a few universities and PRIs, a substantial number of multinationals set up a production facility in the "IT factory of the world". Motivations of international R&D must differ substantially by these regional specific factors.

This paper is organized as follows. In next section, the dataset used for this study is explained and descriptive statistics on the differences of R&D activities between foreign owned companies and domestic ones. Then, a section of quantitative analysis on the motivation on R&D by multinationals in China is provided. This is followed by a section for describing regional differences of this motivation, focusing on Beijing, Shanghai and Guangdong, the three major regions for hosting FDIs. Finally this paper concludes with summary of findings and unexplained questions for further research.

2. Data and Recent trend of international R&D

The dataset used in this paper is based on the Survey on Science and Technology Activities, an annual survey conducted for all large- and medium-sized enterprises (LMEs)[3] in manufacturing sector, conducted by National Bureau of Statistics (NBS). There are about 22,000 samples for each year from 1998 to 2002.[4] The scope of the survey is quite broad, and in addition to the variables commonly found in regular R&D surveys, such as R&D expenses and staffs, it also covers innovation output variables, such as sales of new products and the number of patent applications. In this survey, some survey items are based on the concept of S&T (Science and Technology), which is broader than that of that of R&D by the Frascati Manual (OECD, 2002). For example,

[3] LMEs are defined as firms at or above a certain production capacity threshold. This threshold varies by industry, and is defined in terms of units corresponding to the technical characteristics of each sector, such as 'ton' for chemicals and 'sheets' for textiles. Details of this definition can be found in Hu et. al (2004).

[4] In 2000, a census survey of S&T activities was conducted that included small firms (non LMEs) as well; in that survey, the share of S&T spending by LMEs in 2000 was about 67.3% of the total amount spent by all companies. As such, it is reasonable to say that annual data for LMEs is representative of overall S&T activity trends in the Chinese manufacturing sector.

S&T activities include implementation of R&D results in actual production facilities, which is not covered by the definition of R&D.

The patterns of R&D as well as S&T activities can be compared between foreign owned companies and domestic ones by firm ownership information. In this survey, the ownership structure of firm is categorized into (1) domestically owned, (2) Hong Kong, Macao and Taiwan (HKMT) owned and (3) Foreign owned. In addition, further distinctions within each type of ownership are provided. Domestically owned companies can be broken down into state owned, collectively owned, limited partnership, stock holding as well as privately owned. HKMT and foreign owned companies also have subcategories, such as joint ownership with domestic investors and wholly foreign owned companies.

In this paper, HKMT and foreign owned companies are separately compared to so-called privately owned domestic companies, which include limited partnership, stock holding and private companies.[5] The reason for excluding state owned and collectively owned enterprises is that their corporate governance mechanism is quite different from the rest of domestic firms as well as HKMT and foreign owned companies. The major motivation of this study is benchmarking R&D activities at multinationals to those of domestic firms. In this process, it is important to pick up comparing domestic samples with similar type of governance mechanism to HKMT and foreign owned companies.

Figure 1 and Figure 2 is the presence of HKMT and foreign owned companies in total output by year and by industry, respectively. We can find a growing share of these types of companies over time and the sum of these two shares becomes over 25% in 2002. However, this share varies substantially across industry, according to Figure 2, showing composition of industrial output by industry in 2002. In 'electronics and electronics' and 'fabricated metals', over 50% of output comes from HKMT or foreign owned companies. In contrast, the shares of them are quite small for 'mining', 'petrochemical', 'primary metals' and 'utilities'.

(Figure 1) and (Figure 2)

Figure 3 shows the ratio of R&D to total sales by type of firm ownership. Foreign and HKMT owned firms are broken down into wholly owned ones and jointly owned with

[5] Specifically, privately owned domestic companies include 150 (limited partnership), 160 (stock holding) and 170(private companies) except for 151 (wholly state owned limited partnership) and 171(individually owned private firm) by the ownership code of S&T Survey.

domestic investors ones. In general, a trend of intensifying R&D activities for both international and domestic firms can be found. It is also found that the ratios of domestic firms are higher than those of the others. This is consistent with the findings in Jefferson et. al (2004). This may be due to the fact that foreign and HKMT owned firms backed by technological capabilities of their parent firms outside of China does not need the same level of R&D activities as Chinese companies. Within the category of foreign and HKMT owned firms, the R&D to sale ratios in wholly owned ones are smaller than those of joint ownership ones. A further look into the data shows that the share of firms with no R&D (focusing on manufacturing and other activities) is substantially larger for wholly owned firms, and the R&D to sales ratio does not differ very much when it is compared only for R&D firms.

(Figure 3)

In Figure 4, the ratio of the amount of S&T outsourcing to total S&T (S&T outsourcing intensity) in 2002 is compared across the type of firm ownership. It also shows the breakdown of total S&T outsourcing intensity into ones by the type of counterpart, i.e., (1) domestic universities and PRIs, (2) domestic firms and (3) international counterparts, including firms, universities and PRIs. While the total S&T outsourcing intensity does not change very much between foreign owned and domestic firms, the composition is quite different. As for foreign owned firms, the share of international S&T outsourcing is very large, and this is supposed to be interactions with their parent company or related firms in home country. This finding can explain why R&D intensity at host country firms is low. In contrast, domestic firms are working more with domestic universities and firms.

(Figure 4)

3. Motivations of International R&D

There are numerous papers analyzing globalization of R&D, while most of studies are addressing developed countries, instead of developing countries. It is found that FDIs in R&D are concentrated in small number of higher industrialized countries (Floroda, 1997). However, China is one of exceptions and there is an increasing attention toward this large and fast growing country. Recently, substantial numbers of multinationals have set up R&D centers in China, and their activities are analyzed by interview and mailing surveys (Xue and Wang, 2001; Walsh, 2003). Wu and Callahan (2005) used the data on international R&D alliances in China, and analyzed the relationship between motivations, forms and functions. In addition, there are some studies focusing on

Taiwanese firms' activities in mainland China, and linkages between them (Chen, 2004).

All of these existing studies are based on the information only on multinational's activities in China, which is collected by ad-hoc surveys. In contrast, in this paper, the data for both foreign owned and domestic firms from an official statistics in China are used for an analysis. Domestic firms' information can be used as a benchmark to be compared with R&D activities at foreign owned firms. Both types of firms in the same industry and firm size are operating in a similar manner in China, except for the fact that foreign owned firms have its parent at home as a source of technological capabilities. Multinationals set up foreign subsidiaries for various purposes, such as exploiting market and exploiting technology at host country. A whole idea of quantitative analysis in this section is comparing the activities and focuses of R&D of foreign owned companies with the same kind of domestic firms. By conducting this comparison, we can make some inferences on the motivations of multinational's R&D in China, whether it is market driven or technology driven[6].

"Market driven R&D" and "technology driven R&D" are two major motivations in international R&D. Zedtwitz and Gassman (2002) show that the choice between two strategies by multinationals is determined by relative scarcity of research (R) to development (D) inputs. Similarly, Kuemmerle (1999) presents the dichotomy of FDI in R&D between Home Base Exploitation (HBE) and Home Base Augmentation (HBA). HBE is exploiting home base technological capability, while HBA R&D is augmenting home base technological capability. The former activities at host country R&D site are mainly driven by host market, while the latter activities are for absorption of host country's technology. In addition to these two types of motivations for international R&D, we would propose the third type, "human resource driven R&D". This factor is particularly relevant to China, where a large pool of well educated talented people lives (Wu and Callahan, 2005).

A quantitative analysis in this section is provided for identifying the motivations in R&D activities by foreign owned enterprises in China out of three types, (1) market driven R&D, (2) technology driven R&D and (3) human resource driven R&D. In order to conduct such identification, the following four types of indicators based on S&T Survey data are used.

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[6] Another approach is using a dataset for activities of parent company and its foreign subsidiaries. Examples include Iwasa and Odagiri (2004) and Belderbos (2001)

(1) Intensity of R&D activities

- STR: Ratio of S&T expenses to sales
- RDR: Ratio of R&D expenses to sales

(2) Focus of R&D (R or D)

- DEVRD: Share of development R&D in total R&D[7]

(3) Type of S&T outsourcing

- U_PRI: Share of S&T outsourcing to universities and public research institutes (PRIs) in China
- INTER: Share of S&T outsourcing to international counterparts

(4) Human Resource for Science and Technology

- STER: Share of S&T employees to total employees
- HSTER: Share of high level S&T employees to total employees[8]
- STW: Average wage of S&T employees (1000 RMB)

Each of these indicators for foreign (as well as HKMT) owned enterprises is compared with that of the same kind of domestic firms. More precisely, each of these indicators is regressed with dummy variables for foreign and HKMT owned enterprises after controlling for industry, firm size and firm age.

Expected signs of foreign (as well as HKMT) owned enterprise dummies are difference, depending on the motivation of international R&D. Table 1 shows the differences.

Table 1: Expected Sign of Foreign Owned Dummies

	Market Driven	Tech Driven	HR Driven
(Intensity of R&D)			
STR, RDR	-	+	+
(Focus of R&D)			
DEVRD	+	-	0,-
(Type of S&T outsourcing)			
U_PRI	-	+	?
INTER	+	-	-
(HRST)			
STER, HSTER	-	+	+
STW	-	+	?

[7] Total R&D can be divided into (1) Basic R&D, (2) Applied R&D and (3) Development R&D. Therefore greater DEVRD means that more development (D) oriented R&D, instead of more research (R), is conducted.

[8] In S&T Survey, the number of high level S&T employee is separately collected. Examples of high level S&T employees are high level engineers, high level economists, high level statisticians, professors and associate professors.

As for market driven R&D, major activities at R&D sites at host country is product localization and process engineering, so that the intensity of R&D should be lower and the development portion of R&D should be higher. In terms of S&T outsourcing, the share with universities and PRIs is expected to be lower. But S&T outsourcing with international counterparts (the companies at home) would be higher, reflecting exploitation of home base technological capabilities. Finally, the share of S&T employee should be lower due to lower S&T intensity.

If FDI in R&D is driven by technology, the expected signs are basically opposite to those of market driven R&D. Higher S&T intensity and S&T employee intensity are expected. In addition, R&D is oriented toward research (R), instead of development (D) and more S&T collaborations with university and PRIs are expected (Kuemmerle, 1999). Finally, a HR driven R&D site hires more S&T people in China, which pushes up S&T intensity share, but an average wage does not always higher than that of the same kind of domestic firms. Another difference from technology driven R&D is that R&D orientation may be development (D), instead of research (R), because major incentives for FDI is cost saving of product development, instead of research. Unknown sign of U_PRI comes from the fact that they may want to collaborate with universities in order to attract good students, even though the technology over there is not so attractive.

The results of regression analysis are presented in Table 2. As well as dummy variables for foreign owned enterprises (FOREIGN) and HKMT owned ones (HKMT), the following controlling variables are included in order to make a fair match between foreign owned and domestic samples.

- WHOLLY: dummy for wholly owned for foreign and HKMT owned enterprise (base: jointly owned with Chinese investor)
- LAGE: log of firm age
- LEMP: log of firm employment size
- LEMP2: square of LEMP
- Industry dummies for 4 digit industrial classification (561 categories)
- Survey year dummies

(Table 2)

First, negative and statistically significant signs are found in R&D intensity indicators for both foreign and HKMT owned enterprises. In addition, positive and statistically significant sign to DEVRD means development (D) focus of R&D activities at international R&D sites in China. As for S&T outsourcing variables, negative signs to

U_PRI and positive signs to INTER are found. All of these findings suggest that R&D activities by foreign and HKMT enterprises are market driven. There is one indicator, STW, showing an opposite sign to the expected by market driven R&D. Higher average wages for S&T workers at foreign and HKMT may be explained by rent sharing of value added as a result of higher labor productivity at these firms[9]. This may not contradict with market driven hypothesis.

Market driven international R&D is dominant for both foreign owned and HKMT owned enterprises. When comparing the value of coefficients with dummy variables between them, foreign owned enterprises uses parent technological capability more extensively (greater coefficient with INTER), while NKMT owned firms tend to focus more on development (greater coefficient with DEVRD) than foreign owned ones.

4. Regional Variation: Beijing, Shanghai and Guangdong

Regression analysis of the previous sections shows that international R&D in China is driven more by market, as compared to technology or human resource in general. However, a significant variation of international R&D strategies must exist. Gerybadze and Reger (1999) show that the type of global R&D depends on the relative size of home country as well as whether type of innovation is science based or market driven. Kuemmerle (1997) argues that the type of global R&D is evolving over time so that it depends on the firm's experience on business operations in host country as well. All of these findings suggest firm level heterogeneity of motivations and styles of global R&D.

A great variance in global R&D strategies can be also expected by region. Market driven R&D can be expected in an area with relative large market, while technology driven R&D cannot be happen without substantial concentration of universities and research institutes. Human resource driven R&D needs an ample supply of HRST, which also requires regional proximity with higher educational institutes. In addition, business strategy might be affected by local government policies (Siegal, 2002). In this section, the motivations of international R&D are compared across three regions hosting substantial amount of FDIs in China, Beijing, Shanghai and Guangdong.

In Figure 3, the share of number of firms across regions is compared by type of firm's ownership. About half of foreign and HKMT owned enterprises are located in the three regions, while the share of domestic firms located there is only about 12%. HKMT

[9] It is confirmed that the productivity level of foreign and HKMT owned enterprises is higher than those of Chinese firms (OECD, 2005).

owned firms favor Guangdong, while the share of foreign owned firms is relatively large in Shanghai, but nobody can deny the importance of these regions in terms of host of FDI.

(Figure 3)

The same type of regression analysis as is in the previous section is conducted for the samples in Beijing, Shanghai and Guangdong, respectively. In order to make easier comparison of the results across regions, only the signs of statistically significant coefficients are displayed for the foreign owned enterprise dummy and for HKMT owned enterprise dummy in Table 3 and Table 4, respectively.[10] The column of "all regions" shows the results in the previous section.

(Table 3) and (Table 4)

As for foreign owned enterprises (Table 3), the results for firms located in Guangdong show the similar pattern as those for all regions. This suggests that R&D activities at foreign owned enterprises located in Guangdong are driven by market, instead of technology or human resources. In contrast, firms in Beijing show substantially different pattern. Positive and statistically significant sign can be found to U_PRIs and the coefficients to DEVRD and INTER are not statistically significant. Positive coefficients with U_PRIs suggest technology driven R&D. Negative R&D intensity and S&T employment intensity contradict with this hypothesis, but it may be the case that tapping on technology at universities and PRIs in Beijing has just started and still in a small scale. Human resource driven hypothesis is not so relevant here, because STER and HSTER, key indicators for this hypothesis are negative and statistically significant.[11] In Shanghai, patterns of R&D activities by foreign owned enterprises are in-between those in Beijing and Guangdong.

It is natural that Beijing becomes to be a host of technology driven foreign R&D, because most advanced research facilities are concentrated in that place. In contrast, Guangdong is a place for industrial activities, without a strong science sector. Shanghai has also a strong industrial base, but there are also strong universities and public research institutes. The results in Table 3 suggest that multinationals locate their R&D

[10] Full regression results are available from the author by request.

[11] It may be the case that foreign owned firms in Beijing hire a small number of good scientists. However, it is very difficult to differentiate such motivation from technology driven hypothesis. Here, HR hypothesis is narrowly defined as an outsourcing of home country R&D to China by large amount.

activities across China, by reflecting each of regional characteristics.

Finally, R&D activities of HKTM owned enterprises in the three regions are not very different from privately owned domestic firms in the same area. In Guangdong, a tendency toward market driven R&D can be found, while most of coefficients in Beijing and Shanghai samples are not statistically significant. One problem is that the number of samples in Beijing and Shanghai is very small for statistical analysis. In addition, it is possible to interpret this result that the R&D activities of HKTM owned firms are very similar to those of domestic firms in these areas.[12]

5. Conclusion

In this paper, the motivations of R&D by multinationals are investigated by using a large firm level dataset from Chinese official statistics on science and technology activities. Growing intensity of R&D activities is found both for foreign owned and domestic firms. But, it is also found that the R&D intensity at foreign owned firms is relatively smaller. This may be due to the fact that foreign owned firms are operating by relying of technological capabilities at home.

Statistical analysis confirms that the major motivation of foreign R&D in China is "market driven" instead of "technological driven" or "human resource driven". However, there is a great variation of foreign R&D strategy across regions. Market driven R&D is found mainly in Guangdong, which is called a world IT factory, and does not have strong universities or PRIs. In contrast, R&D strategy in Beijing is oriented toward technology driven approach, because we can find a cluster of scientific institutions there. Shanghai, with both a large industrial base as well as strong science sector, is in-between.

The bottom line of our findings is that China is still in a stage of technological developments and foreign R&D is driven by Chinese market. However, at the same time, there is a sign of technology driven foreign R&D in particular area, such as Beijing. The next question is how to tap on technological resources in China. In order to answer this question, a more detail study is needed. There should be a great variety in firm level strategy for international R&D. It also depends on home country. For example, it is found that international R&D by multinationals in US and Japan, relatively large countries, are more centrally organized than that in small European countries.

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[12] Lai and Shyu (2005) present supportive evidences that innovative capacities of high-tech parks across Taiwan Strait (Zhangjiang High-Tech Park in Shanghai and Hsinchu Science Based Industrial Park in Taiwan) are in a comparable level.

Unfortunately, the dataset used for this study does not have home country identifier, and systematic quantitative analysis on detail analysis is very difficult. However, there are a number of studies based on literature survey (Gassman and Han, 2004; Zedtwits, 2004), and such detail information for specific firms should be combined with more general quantitative studies. This is our future work in order to come up with specific policy and managerial implications.

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Figure 1: The output share of foreign and HKMT owned enterprises

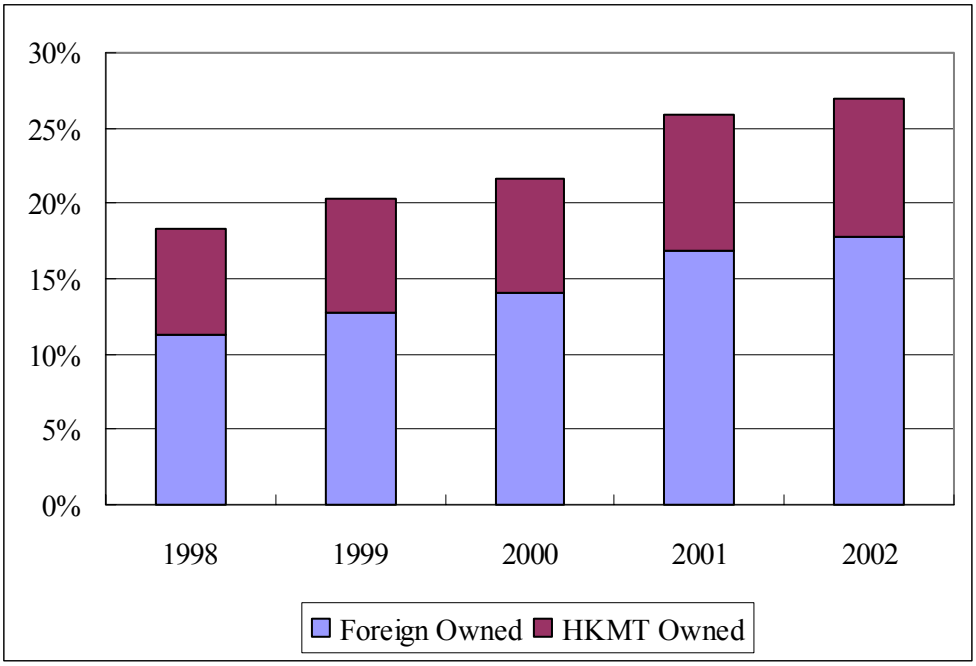

Figure 2: The output share by industry

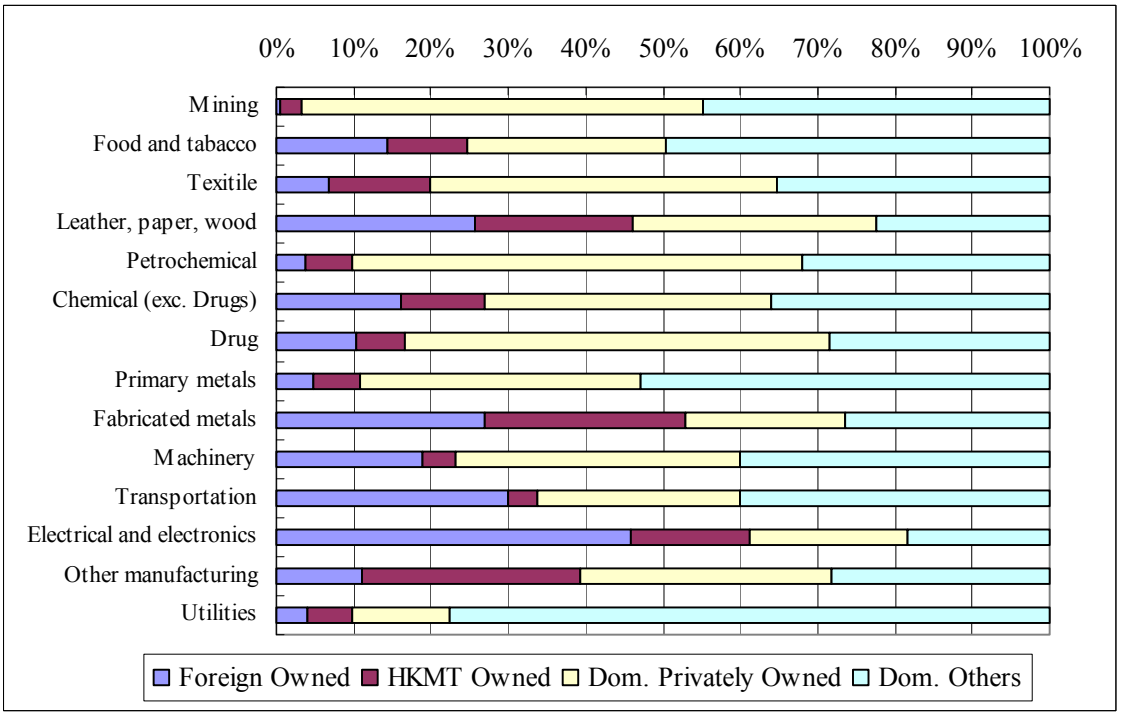

Figure 3: R&D/Sale by type of firm ownership

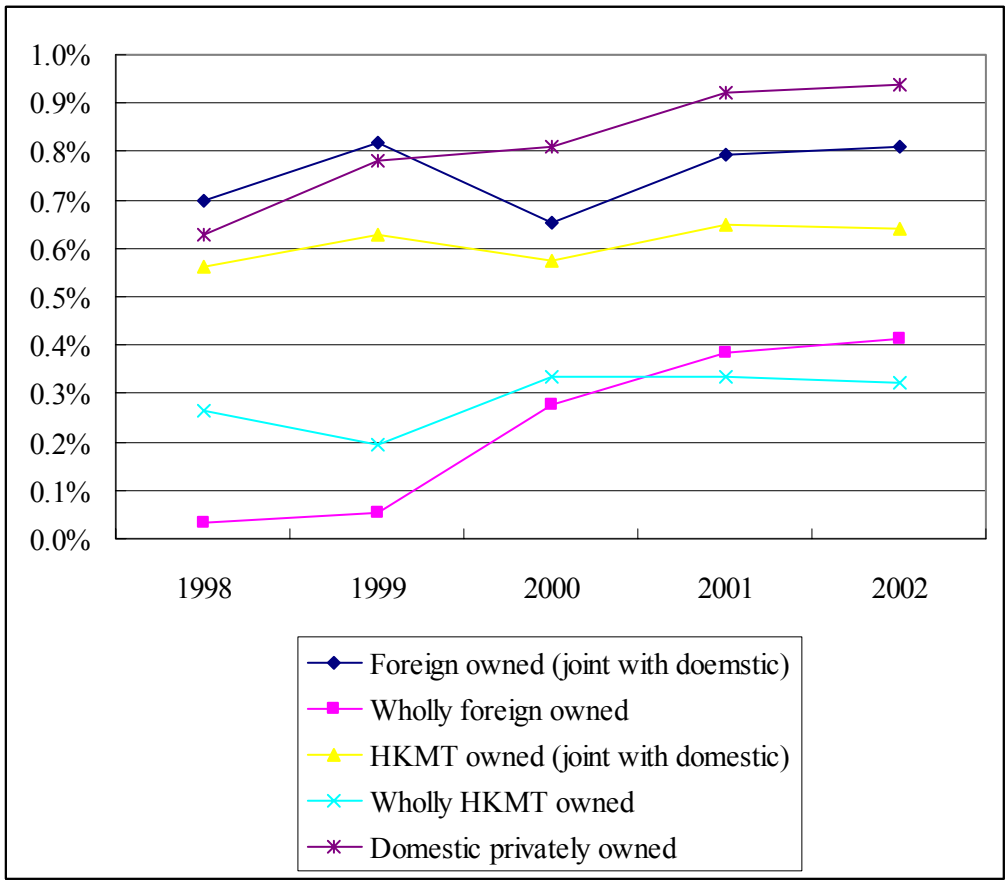

Figure 4: S&T Outsourcing/Total S&T by type of firm ownership in 2002

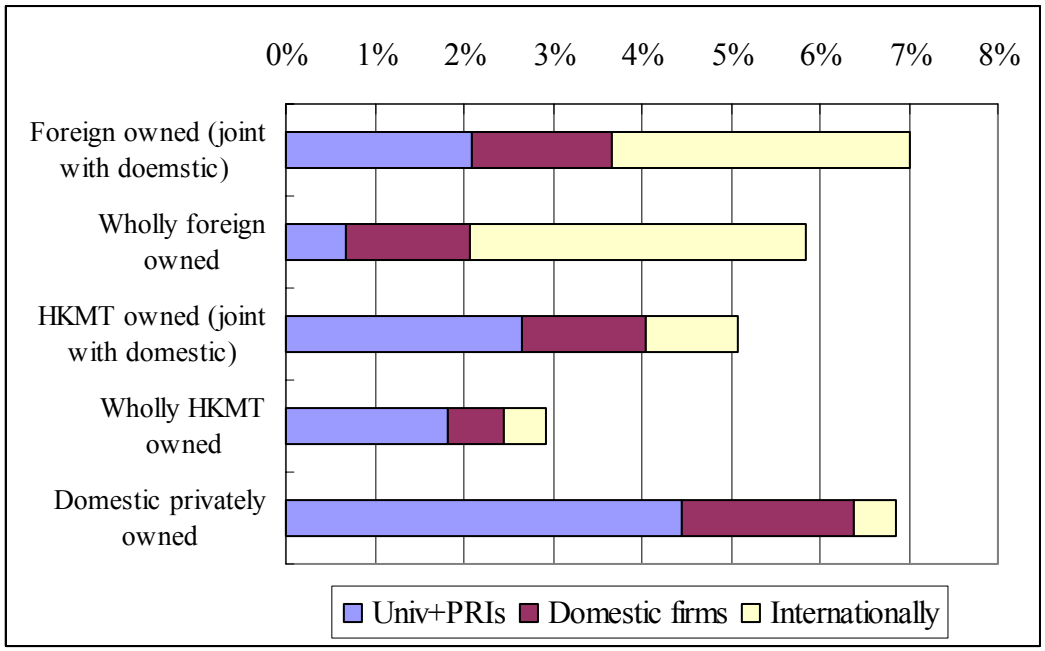

Table 2: Regression results (all samples)

	STR	RDE	DEVRD	U_PRI	INTER	STER	HSTER	STW
FOREIGN	-0.013	-0.006	0.017	-0.017	0.028	-0.051	-0.008	0.576
	(5.84)**	(3.64)**	(2.53)*	(8.09)**	(14.50)**	(4.12)**	(4.80)**	(28.52)**
NKMT	-0.005	-0.002	0.027	-0.010	0.006	-0.037	-0.006	0.335
	(2.16)*	(1.39)	(3.91)**	(4.50)**	(2.76)**	(2.90)**	(3.61)**	(16.10)**
WHOLLY	-0.003	-0.001	0.008	-0.003	0.000	-0.035	-0.013	0.050
	(0.78)	(0.40)	(0.74)	(0.89)	(0.13)	(1.59)	(4.37)**	(1.40)
LAGE	-0.002	-0.001	0.003	0.001	0.000	0.012	0.000	-0.035
	(2.94)**	(0.93)	(1.27)	(0.93)	(0.48)	(2.74)**	(0.69)	(4.98)**
LEMP	-0.033	-0.016	0.043	0.015	0.000	-1.023	-0.168	-0.301
	(5.44)**	(3.74)**	(2.59)**	(2.63)**	(0.05)	(30.96)**	(36.34)**	(5.62)**
LEMP2	0.002	0.001	-0.003	-0.001	0.000	0.073	0.012	0.027
	(4.18)**	(2.95)**	(2.65)**	(2.07)*	(0.69)	(29.38)**	(33.64)**	(6.66)**
constant	0.181	0.081	0.774	-0.017	-0.004	3.623	0.623	2.517
	(8.98)**	(5.79)**	(13.64)**	(0.91)	(0.23)	(32.75)**	(40.38)**	(14.05)**
Ind Dummy	yes	yes	yes	yes	yes	yes	yes	yes
Year Dummy	yes	yes	yes	yes	yes	yes	yes	yes
Observations	20050	20050	9203	20075	14103	20088	20088	19829
R-squared	0.06	0.05	0.09	0.14	0.08	0.06	0.13	0.3

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

Figure 5: Share of number of firms across regions by type of ownership

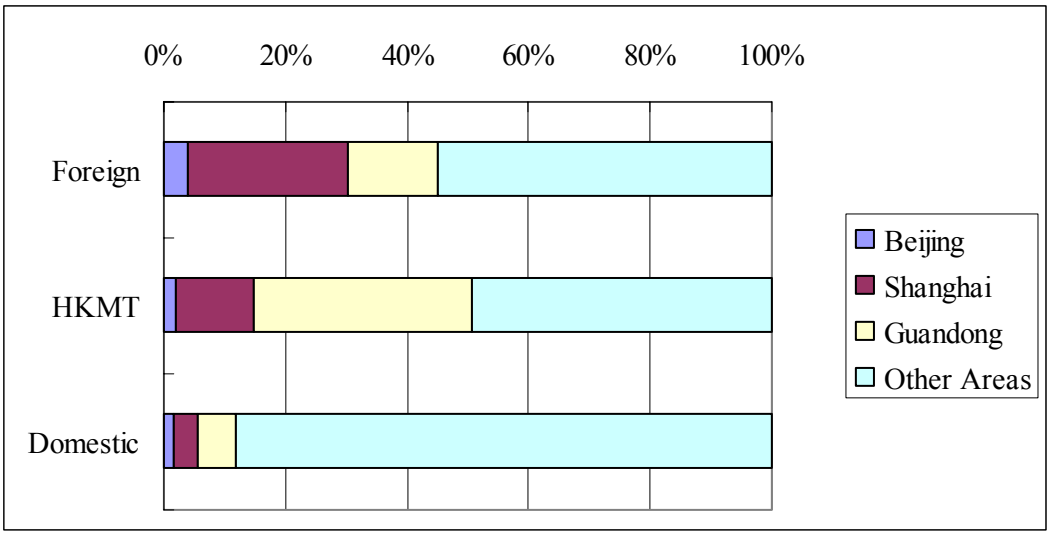

Table 3: Regression results by region (foreign owned enterprise)

	All region	Beijing	Shanghai	Guandong
(Intensity of R&D)				
STR, RDR	-	-	0	-
(Focus of R&D)				
DEVRD	+	0	0	+
(Type of S&T outsourcing)				
U_PRI	-	+	0	-
INTER	+	0	+	+
(HRST)				
STER, HSTER	-	-	-	-
STW	+	+	+	+

(note) +: positive and statistically significant at 5%

0: not statistically significant

-: negative and statistically significant at 5%

Table 4: Regression results by region (HKMT owned enterprise)

	All region	Beijing	Shanghai	Guandong
(Intensity of R&D)				
STR, RDR	-	-	0	-
(Focus of R&D)				
DEVRD	+	0	0	0
(Type of S&T outsourcing)				
U_PRI	-	0	0	-
INTER	+	0	0	0
(HRST)				
STER, HSTER	-	0	0	-
STW	+	0	+	+

(note) +: positive and statistically significant at 5%

0: not statistically significant

-: negative and statistically significant at 5%