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# Management of Offshore R&D in China: Cross Country Differences in Motivation and Performance\*

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**Abstract:** In this paper, multinationals' motivations for R&D in China are compared across firms' home countries. It is found that five types of companies (Europe, Japan, the other Asia, US and Taiwan, Hong Kong or Macau owned) can be grouped into two. Europe, Japan and the other Asia for production/market driven R&D, but the degree of market orientation is stronger for European firms, followed by Japanese and the other Asia. Another group is US and THKM firms for technology/cost driven R&D. It should be noted that THKM firms are inclined toward production oriented R&D as well. We have also investigated the relationship between types of R&D activities and firms' performances. In general, US firms are more profitable than Japanese ones, but this difference in profitability disappears once it is controlled for R&D type variables. In terms of an association of R&D type variables with profitability, heterogeneous results are obtained by host countries. The degree of linkage with universities and PRIs is significant for US firms, while the degree of R&D linkage with home country is important for European firms. It is also found that firm age is strongly correlated with profitability, while whether a firm is a joint venture with a local company or a wholly owned subsidiary does not make any difference.

**Keywords:** China, multinational corporation, offshore R&D, profitability

**JEL classifications:** F23, O31, O32

## 1. Introduction

During his visit to the south of China in 1992, Deng Xiaoping called for accelerated economic reforms and growth to generate dramatic growth in foreign direct investments (FDIs). Based on an open-door policy for foreign direct

investments, China has developed to be a factory of the world by attracting multinationals' investments in manufacturing industries. Recently, the Chinese government announced a new policy for FDIs, i.e. regulating the quality of FDIs by restricting simple manufacturing investments and encouraging FDIs to facilitate technological development of the Chinese economy. Multinationals' R&D activities in China are most welcomed in this regard. Corresponding to this policy direction, China is the most attractive location for international R&D according to the United Nations Conference on Trade and Development (UNCTAD) Survey (UNCTAD, 2005). Most Fortune 500 high tech companies such as Microsoft, IBM, Motorola, Intel, Nokia, Panasonic and Samsung have already set up an R&D centre in China.

Foreign R & D by multinationals can be regarded as a natural extension of international production and marketing. Multinationals might invest R&D funds to support production activities in China or, for localization of diverse home market products. Since China is a large developing nation with consumer needs and tastes differing significantly from developed economies, considerable product localization R&D is needed for market penetration. Levels of scientific research at Chinese universities have improved, due to a government focus on promoting S&T and high-tech developments. In certain scientific areas, multinationals have an understandable interest in working with Chinese universities as technology sources. A related motivation for R&D efforts by multinationals in China might include access to a pool of highly-qualified S&T human resources. The number of engineering and science students in China now exceeds those in Japan and so is second only to the US. This S&T labour supply allows multinationals to hire qualified Chinese graduates at relatively modest wages.

This paper provides a statistical analysis of the structure of and the motivation for multinational R&D in China, drawing on a large-scale dataset from the Science and Technology Survey conducted by the National Bureau of Statistics of the PRC. This dataset provides detailed variables on S&T for both foreign-owned and domestic companies and allows comparisons of multinationals' motivations for R&D in China compared to their home countries. Multinationals of the triad Europe, Japan and the United States are major players in China, and companies from other Asian countries such as Korea and Singapore are also actively engaged in innovative activities in China. Of course Taiwanese, Hong Kong and Macau firms invest in mainland China due to its regional and cultural proximity.

As an extension to Motohashi (2010), this paper compares the motivation and performance of multinationals' off-shore R&D in China with those in their home countries. A first research question of this paper then, is how a multinational's R&D in China is different compared to that in its home

country. We compare the type of R&D conducted by using the taxonomy of Gammeltoft (2006), based on empirical literature (Kuemmerle, 1999; Cantwell and Mudambi, 2005). This paper addresses also the relationship between management style and profitability. Ghoshal and Bartlett (1990) described how overseas operations by Japanese multinationals are generally managed under strong guidance from their headquarters, while those of European and US firms are given more autonomy (Ghoshal and Bartlett, 1990). We will investigate how these kinds of differences in management style lead to profitability of firms.

This paper is organized as follows. The subsequent section discusses the dataset used for this study and provides descriptive statistics on differences in R&D activities across home countries. The next section attempts a quantitative analysis of the R&D motivations for multinationals in China. Here, an intensive discussion on multinationals' R&D is provided and home countries' motivations for R&D are compared by using statistical models. The paper concludes with a summary of findings and questions that merit further investigation.

## 2. Data and Recent Trends in International R&D

The dataset used in this paper is based on the Survey of Science and Technology Activities, an annual survey of all large- and medium-scale enterprises (LMEs)<sup>1</sup> in the manufacturing sector undertaken by the National Bureau of Statistics (NBS) from 1998 to 2005. Approximately 22,000 samples are available for each year from 1998 to 2003, and around 28,000 for 2004 and 2005. In 2000, a census survey of S&T activities also included small firms (non-LMEs). In that survey, the share of S&T spending by LMEs in 2000 was approximately 67.3 per cent of total spending by all companies. Since the multinationals established in China are relatively large and more likely to be categorized as LMEs, the dataset used for this paper covers a significant share of the S&T activity by manufacturing multinationals in China.

Some limitations should be noted with regard to our dataset. First, it covers only firms with manufacturing activities, effectively excluding non-manufacturing firms such as software companies. Second, the surveys exclude any other companies (e.g. independent research laboratories) that do not engage in industrial activity.

The survey scope is broad. In addition to the variables commonly found in regular R&D surveys, such as R&D spending and staffing, it also covers innovation output variables such as new product sales and numbers of patent applications. Some survey items are based on the S&T concept, a broader heading than R&D as defined in the *Frascati Manual* (OECD, 2002). For example, S&T activities include the implementation of R&D results at actual production facilities, which the R&D definition excludes. This paper also discusses R&D expenses as defined in the *Frascati Manual*, but certain key

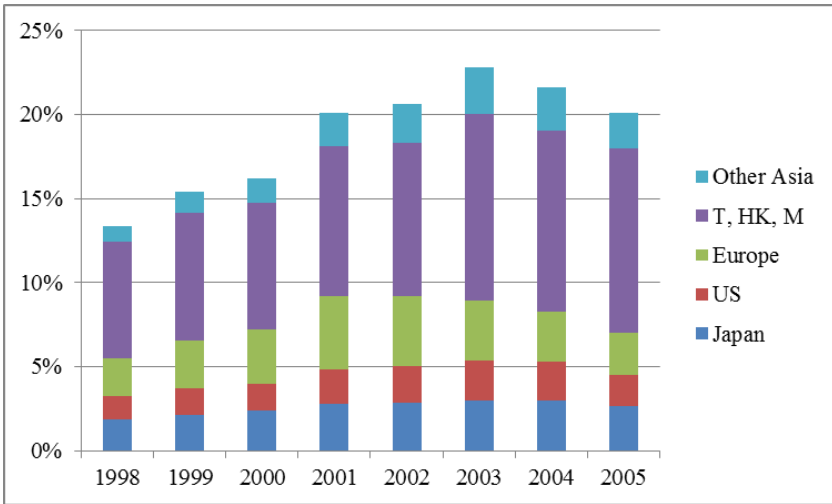
variables in our analysis, including university collaborations, are assessed on an S&T basis. Therefore, our study references both S&T and R&D data.<sup>2</sup>

Information on firm ownership can be used to compare patterns of R&D as well as S&T activities between foreign-owned and domestic companies. In this dataset, a company can be classified into one of the following categories: (1) domestic ownership; (2) Taiwan, Hong Kong or Macau (THKM) ownership; (3) foreign ownership. In this paper, we use only THKM and foreign owned companies. Since home country information for non THKM foreign companies is not available in this dataset, we have asked the national statistical bureau (NBS) to identify the home information by matching with the database of foreign owned companies, publicly available from the Ministry of Commerce. This database provides the list of each company name and its home country as well as other information such as address and contact person, and an NBS staff matched this with their S&T survey data by company name. Through this process, the host country information is added (without company name) to the dataset.

Figures 1 and 2 illustrate the proportions corresponding to total output by year and by industry, respectively, for foreign owned companies. These proportions have grown over time, and the total share of these firms' outputs compared to all manufacturing firms in China is around 20 per cent recently. It is found that the share of THKM (Taiwan, Hong Kong and Macau) firms is the largest, followed by Europe, Japan, US and other Asia almost equally. This share varies significantly across industries, as shown in Figure 2, which breaks down industrial output by industry in 2005. THKM firms play a dominant role in traditional sectors such as textile, leather, paper and wood. In mining, petrochemical and utilities industries, FDIs are strictly regulated, so that THKM firms gain a large share. On the other hand, Japanese companies are strong in general machinery, transportation machinery, electronics and electrical equipment industries. The US share is relatively large for drug, chemical and some machinery sectors, while Europe is strong in drug, chemical and transportation machinery industries.

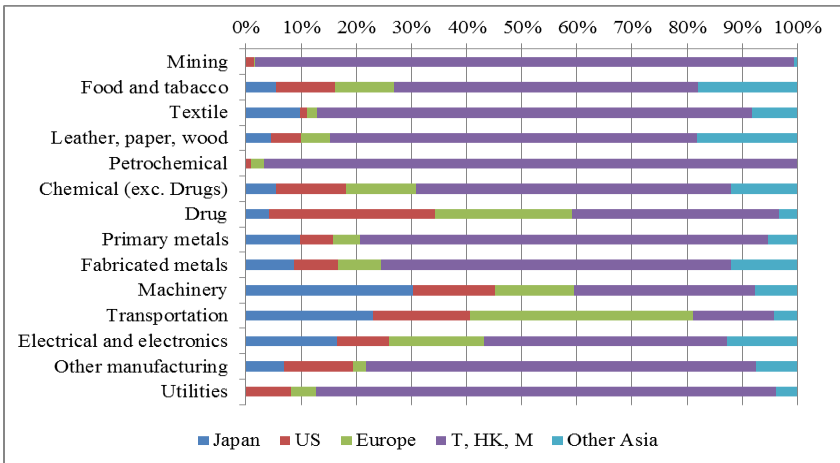
Figure 3 shows the ratio of R&D to total sales by type of firm's home country. In general, this R&D intensity index does not show an increasing trend over time, and is stable at around 0.5 per cent. In terms of host country difference, European and US firms seem to show higher R&D intensity than Asian companies. It is found that the R&D intensity for foreign owned companies is lower than that of Chinese domestic companies, since multinationals' innovation activities in China are based on larger technological capacity in home countries (Jefferson et al., 2003; Motohashi, 2010). Therefore, the difference in R&D intensity across host countries may reflect some differences in the breakdown of global R&D spending between home and host countries.

Figure 1: Output Shares of Multinationals by Home Country of All Manufacturing Firms



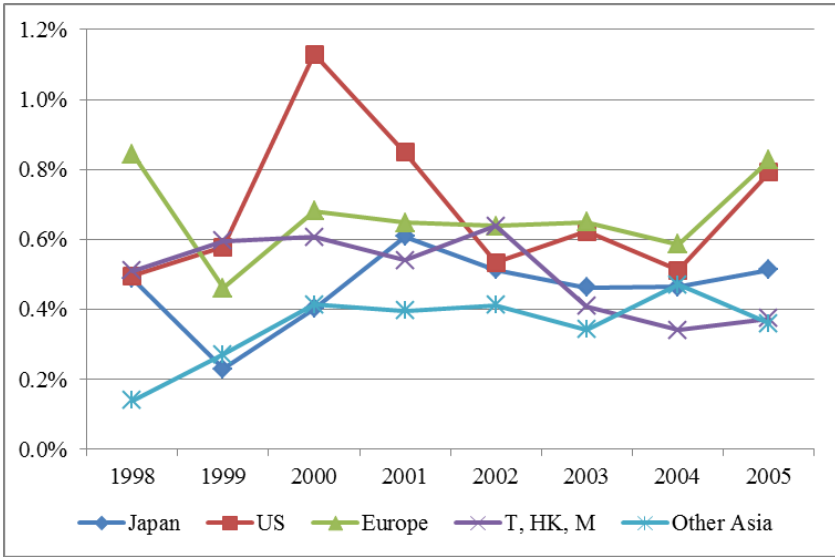
Source: Author's calculation.

Figure 2: Output Share by Industry



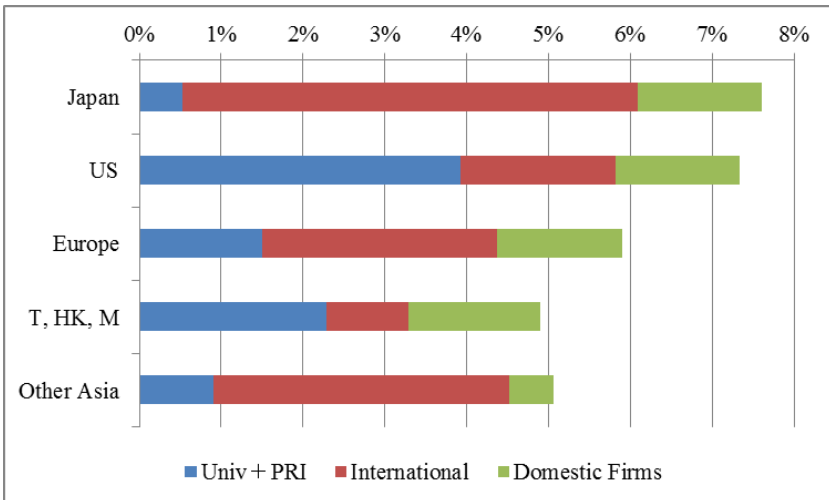
Source: Author's calculation.

Figure 3: R&D/Sales by Home Country



Source: Author's calculation.

Figure 4: S&T Outsourcing/Total S&T by Type of Firm Ownership in 2003

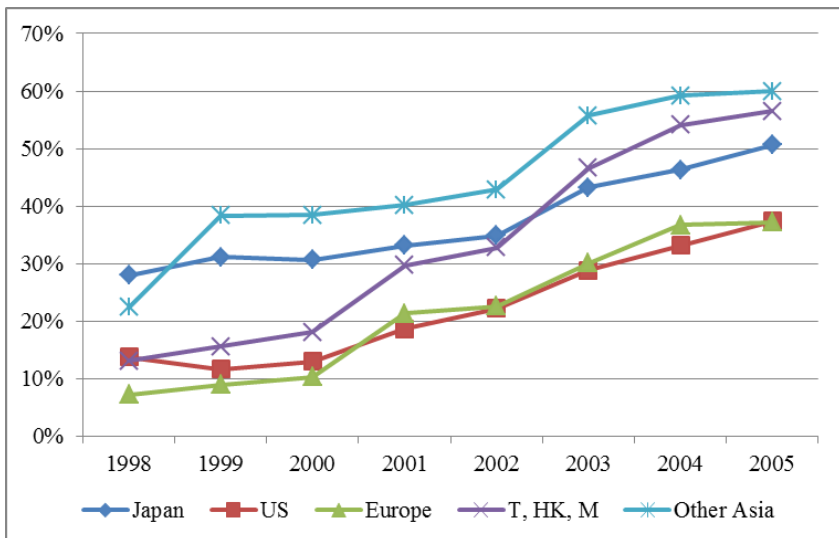


Source: Author's calculation.

Figure 4 compares the ratio of S&T outsourcing to total S&T (S&T outsourcing intensity) in 2005 across host countries. The S&T Survey by NBS provides data on the volume of S&T activities outsourced to external organizations. This data is sorted by type of counterpart – i.e., (1) domestic universities and public research institutions (PRIs), (2) domestic firms and (3) international counterparts (including firms, universities, and PRIs).<sup>3</sup> Figure 4 shows the calculated share of S&T outsourcing to total S&T expenses by counterpart type. The total outsourcing intensity indicator is higher for Japanese and US firms. Japanese firms heavily rely on international S&T sourcing, presumably from their headquarter companies at home. On the other hand, US firms use local universities and PRIs as S&T outsourcing partners. This is the case for THKM firms. Other Asian firms show a similar pattern to Japan’s in a sense of strong connection with their home country.

Figure 5 shows the share of wholly owned company by the number of firms. Thanks to Chinese government liberalization of FDIs, the share of wholly owned companies is increasing for all countries. Japan’s is the highest, and the share of joint ventures with local companies is relatively larger for Europe and the US. A wholly owned company can be managed solely by its headquarters at home, and managerial freedom in a host country is a merit. On the other hand, by forming a joint venture with a local firm, it becomes easier to enter the Chinese

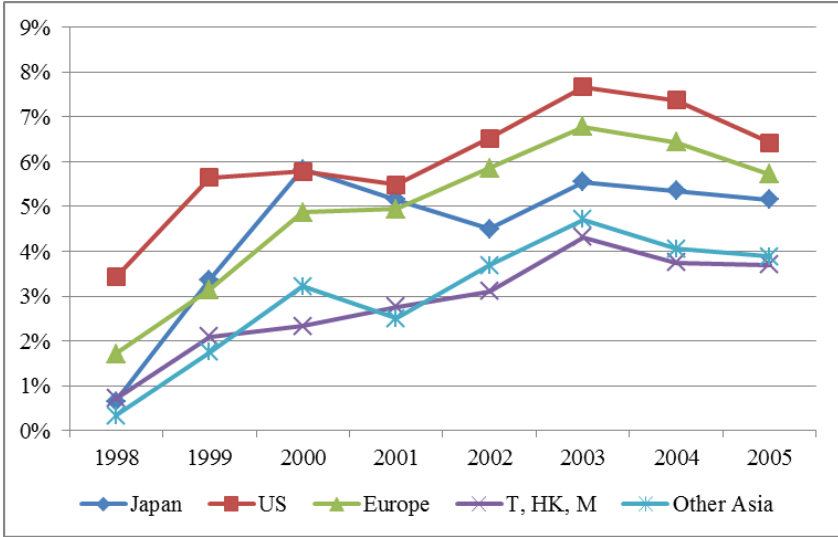
Figure 5: Share of Wholly Owned Company by Number of Firms across Home Countries



Source: Author’s calculation.



Figure 6: Profit/sales Ratio by Home Countries



Source: Author’s calculation.

market, by capitalizing on the local partner’s existing marketing information and channels. For a firm in Japan and other Asian countries, regional and cultural proximity makes it easier to operate its Chinese site from its headquarters. On the other hand, European or US firms’ headquarters are far from China, so that existence of a local partner may be more beneficial for such firms.

Finally, profitability is compared with home countries. Figure 6 shows the trend of profit to sales ratio. Multinationals’ profitability increased until 2003, but went down a bit thereafter. Here, US and European firms show higher profitability, followed by Japanese ones. In firms of THKM and other Asia, profitability is quite low compared to those in developed countries. It may be the case that the firms in these countries are facing head-to-head competition from local Chinese firms, so that their profitability is lower.

### 3. Motivations for International R&D

While numerous papers address R&D globalization, most analyze developed, not developing nations. Studies show R&D FDIs tend to concentrate in a small number of advanced industrialized nations (Florida, 1997). China is a major exception, and growing attention has focused on this large and rapidly-developing nation. In recent years, numerous multinationals have set up R&D facilities in China, and researchers have examined their activities through

interviews and mailed surveys (Xue and Wang, 2001; Walsh, 2003). Wu and Callahan (2005) used data on international R&D alliances in China to analyze the relationship between motivation, form, and function. Chen and Reger (2006) used a database from the Delegation of German Industry and Commerce in Shanghai to show that R&D for German firms focused on the domestic market and industrial buyers.

Several studies have examined the activities of Taiwanese firms in mainland China and linkages between Taiwan and mainland China (Chen, 2004). All of these studies are based on information restricted to the activities of multinationals in China collected by ad-hoc surveys, except for Motohashi (2010) which analyzed the characteristics of multinationals' R&D in China, compared with R&D activities of domestic companies, based on official statistics by the National Bureau of Statistics in China.

Multinationals set up foreign subsidiaries for various purposes, including exploiting the markets and technologies provided by host countries. The fundamental approach underlying the quantitative analysis in this section is to compare the activities and goals of R&D by foreign-owned companies with that in their home countries. Such comparisons will allow us to characterize different (or similar) motivations for R&D efforts by multinationals in China across home countries.<sup>4</sup>

Gammeltoft (2006) provides an extensive survey of the literature on R&D internationalization, positing six types of factors motivating R&D internationalization: (1) market-driven; (2) production-driven; (3) technology-driven; (4) innovation-driven; (5) cost-driven; and (6) policy-driven. On the one hand, with motives falling into the first two categories, a multinational uses its home country technology capabilities as a base and reinforces non-R&D activities such as marketing and production in the host country. On the other hand, the goal of both technology-driven and innovation-driven R&D is to identify new technologies, new ideas, new products, and process innovations in the overseas R&D country to reinforce the technology and innovation capabilities of the home base.

Kuemmerle (1999) divides R&D FDI into Home Base Exploitation (HBE) and Home Base Augmentation (HBA) categories. While HBE exploits home base technological capabilities, HBA R&D augments home base technological capabilities. Correspondingly, while activities in the former category at host country R&D sites are primarily driven by the host market, activities in the latter category target the absorption of the host country's technologies. In the same vein, Cantwell and Mudambi (2005) provide a distinction between "competence creating R&D", driven by supply side factors such as local technological capabilities and "competency exploiting R&D", driven by the demand factor of the local market.

The remaining two motive categories – cost-driven and policy-driven – also pertain to our analysis of conditions in China. With growing attention to emerging markets, cost becomes an important factor to consider in the globalization of business. Ghemawat (2007) proposes an AAA framework, standing for “Aggregation”, “Adaptation” and “Arbitrage” for understanding global strategies of multinationals. “Aggregation” and “Adaptation” correspond to a traditional dimension of global business, i.e., a global scale of standard product/service or market adaptation in individual host countries. Ghemawat (2007) argues that the growing importance of emerging markets such as BRICs leads to a third pillar of globalization strategy – “Arbitrage”, which stands for making profit by taking advantage of the difference in economic conditions between home and host countries. In this sense, China is an attractive site for global R&D, where large numbers of qualified but not very expensive S&T human resources are available.

Policy-driven motives are also important in a context of R&D in China. It is relatively difficult to obtain policy information there. Locating its R&D centre in China particularly in Beijing is important to keep continuous communication with the Chinese government. For example, one important motivation for telecommunication companies to operate a Beijing R&D centre is to be involved in mobile telecommunications standard setting activities by the government.

In this study, differences between home countries’ R&D motivations are addressed by statistical analysis using the NBS’s Science and Technology Survey data. We have chosen four motives from the foregoing discussion, i.e., (1) production driven, (2) market driven, (3) technology driven and (4) cost driven. Policy driven R&D, relevant only to limited industries and locations, is difficult to be addressed by a comprehensive dataset covering all of China, so that we present some descriptive observations in a later section. With respect to major distinctions among these four motives, we examined three sets of indicators: (1) intensity of R&D activities, (2) R&D focus, (3) type of technology sourcing, and (4) exporting products. We compiled the following indicators based on the S&T Survey data:

- (1) Intensity of R&D activities
  - STR: Ratio of S&T expenses to sales
- (2) S&T focus
  - RDST: Proportion of R&D spending to S&T spending
- (3) Type of technology sourcing
  - U\_PRI: Proportions of S&T outsourcing to universities and public research institutes (PRIs) in China
  - INTER: Proportions of S&T outsourcing to international counterparts

## (4) Exporting products

- EXR: Proportion of exporting amount to total output of new products

Each of these indicators is compared across multinationals' home countries in order to identify a major motivation for R&D in China. We have used the identification strategy, shown in Table 1, an extended version of that used in Motohashi (2010).

Table 1: Expected Signs of Innovation Indicator Coefficients

	Production	Market	Technology	Cost
(Intensity of S&T)				
STR	-	-	+	+
(Focus of S&T)				
RDST	-	0	+	0
(Type of S&T outsourcing)				
U_PRI	-	0	+	0
INTER	0	-	-	+
(Exporting products)				
EXR	+	-	0	+

Source: Author's calculation.

For production and market-driven R&D, since the primary activities at international R&D sites are product localization and process engineering, R&D intensity should be lower. As shown by von Zedtwitz and Gassmann (2002), the choice between the two strategies by multinationals is determined by the relative scarcity of research (R) to development (D) inputs, in the sense that the development portion of R&D should be greater for production/market-driven motives. Therefore, the share of R&D to S&T is relatively smaller for these categories.

However, it becomes lower for production motives, since non R&D S&T activities are mostly production related such as scaling up production facilities for mass production. The differences between these two motives come also from S&T outsourcing and exporting products. Production driven R&D is supposed to import the home country's production technology, which leads to lower levels of collaboration with local universities and PRIs (U\_PRI). In contrast, market driven R&D targets local markets, and R&D activities tend to be localized so that the level of linkage with home country R&D (INTER) becomes lower. In addition, the output of such R&D, such as new products, is supposed to be offered in local markets, instead of exporting to the other countries (lower EXR).

In terms of technology driven R&D, the proportions accounted for by universities and PRIs should be higher for technology/innovation motives, since advanced technologies in the science sector are more readily found at such institutes (Kuemmerle, 1999). It is also presumed that research intensity is relatively higher for R&D centres based on this motive. In addition, the focus of R&D is upstream research, corresponding to local universities and PRIs, instead of developing actual products. Moreover, technology sourcing from home countries should be lower, because knowledge flow in a reverse direction is expected here.

Finally, cost driven R&D can be identified by higher R&D intensity, but downstream development focus, because activities at such sites are not high end R&D, but arbitraging reasonably priced S&T human capital in China. Labour intensive engineering works such as software development for electronics products are a typical activity at such sites. Also, technology sourcing from home countries is higher since the original technology comes from there, and an output from such offshore development is distributed globally.

Table 2 shows a correlation matrix of five types of S&T indicators. While U\_PRI and INTER are moderately correlated (correlation coefficient is 0.14), the correlation coefficients are small in general. Therefore, we can treat them as independent variables for further statistical investigations.

Table 2: Correlation Matrix of S&T Variables

	STR	STRD	U_PRI	INTER	EXR
STR	1.000	-	-	-	-
STRD	-0.021	1.000	-	-	-
U_PRI	0.049	-0.020	1.000	-	-
INTER	0.023	-0.034	0.144	1.000	-
EXR	-0.033	0.018	-0.034	0.009	1.000

Source: Author's calculation.

Table 3 presents regression analysis results.<sup>5</sup> Here, dummy variables for the US, Europe, THKM and other Asia as home countries, are established by setting Japan as a base category. Therefore, the coefficients to these dummies represent the relative position of a firm in each country as compared to that of Japan. In addition to these dummy variables, the following controlling variables are included to control for other factors related to R&D motivations.

- FOREIGN: dummy for wholly-owned
- LAGE: log of company age
- LEMP: log of number of employees

- Industry dummies for 4-digit industrial classification (561 categories)
- Year dummies

Table 3: Regression Results of Innovation Indicators

	STR	STRD	U_PRI	INTER	EXR
US	0.000 (0.07)	-0.026 (1.41)	0.009 (3.12)**	-0.011 (1.36)	0.035 (2.19)*
EUROPE	0.006 (1.23)	-0.002 (0.09)	-0.002 (0.38)	-0.021 (1.84)+	0.011 (0.44)
T, HK, M	-0.022 (2.74)**	0.017 (0.44)	0.011 (1.71)+	0.024 (1.30)	0.169 (4.89)**
Other Asia	0.002 (0.38)	-0.049 (1.73)+	0.007 (1.53)	-0.019 (1.52)	0.015 (0.58)
Foreign	-0.004 (1.06)	0.019 (0.96)	-0.008 (2.42)*	0.003 (0.41)	0.171 (8.61)**
Log(Age)	-0.006 (2.11)*	0.032 (2.19)*	0.001 (0.32)	-0.001 (0.14)	0.046 (3.73)**
Log(Emp)	-0.006 (3.80)**	0.017 (2.21)*	0.003 (2.30)*	0.005 (1.50)	0.026 (3.74)**
Constant	0.103 (9.28)**	0.207 (3.72)**	0.002 (0.21)	0.007 (0.29)	-0.096 (2.01)*
Ind Dummy	yes	yes	yes	yes	yes
Year Dummy	yes	yes	yes	yes	yes
Observations	4679	4679	4677	2832	3006
R-squared	0.12	0.13	0.16	0.17	0.48
Absolute value of t statistics in parentheses + significant at 10%, * significant at 5%; ** significant at 1%					

Source: Author's calculation.

First, positive and statistically significant coefficients to the US dummy can be found for U\_PRI and EXR. Therefore, multinationals from the United States are engaged in technology sourcing from local universities and PRIs, and export propensity of their new products is higher than that of Japanese multinationals. According to Table 1, this pattern suggests that R&D by US multinationals is characterized as a combination of “technology driven” and “cost driven”. An active collaboration with a university may be related to recruiting a well qualified student as an employee. Therefore, US multinationals

are focusing on linkage with China's national innovation system to secure technological as well as human resources over there.

As for European multinationals, a negative statistically significant coefficient is found for INTER. In general, the S&T activities of European multinationals are quite similar to those of Japanese companies. However, compared to US firms, both European and Japanese firms are motivated by production or market in China. European firms have a weaker linkage with home country R&D (negative INTER), so that these firms are likely to be driven by the market, while Japanese ones tend to be production driven.

THKM multinationals show a similar pattern to US ones. Positive coefficients are found for U\_PRI and EXR, suggesting technology/cost driven R&D is dominant in mainland China. One difference from US firms is lower S&T intensity (STR). It should be noted that THKM firms are very close to Chinese firms, in a sense of sharing common language and culture. Formally, Hong Kong and Macau now belong to China's territory and Taiwan is also one of China's regions according to an official statement of the Peoples Republic of China. Therefore, it is easier for them to collaborate with Chinese universities and PRIs.

In addition, closer linkage with China's local knowledge may lead to active upstream research activities at their mainland R&D sites. At the same time, it is well known that Taiwanese firms actively locate their production facilities on the mainland. Therefore, their motivation for R&D in China is inclined to be production driven as well.

Finally, multinationals in other Asia such as Korea and Singapore are very similar to Japanese companies in their motivation for R&D in China. One difference is a smaller share of R&D to S&T, suggesting that these firms are inclined toward production driven R&D.

#### **4. Profitability Comparison and its Determinants**

In this section, profitability is compared across home countries and its determinants are identified. Here, profitability is defined as the ratio of profit to total sales. This variable is regressed by the country dummies variables and innovation activity variables in the previous section. Since we include detailed industry dummies (for 561 categories) as well as time dummies, the regression results reveal firm level difference in profitability within the same industry and the same year. Therefore, after controlling for industry specific factors such as the degree of market completion and macro economic shocks by business cycle, the results reflect firm level business capability in China. The results are presented in Table 4. It should be noted that regression results here present just correlation between S&T indicators and profitability, instead of presenting causality of S&T indicator to profitability.

Table 4: Regression Results of Profitability

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
US	0.009 (1.96)+	0.007 (0.92)	0.006 (0.99)	0.010 (1.66)+	0.006 (1.28)	0.006 (1.03)	0.007 (1.08)	0.011 (2.37)*	-0.002 (0.13)
EUROPE	-0.003 (0.47)	-0.003 (0.24)	-0.004 (0.65)	-0.002 (0.25)	-0.003 (0.55)	-0.007 (0.90)	-0.004 (0.34)	0.001 (0.16)	-0.044 (1.79)+
T, HK, M	-0.004 (0.42)	0.001 (0.08)	-0.013 (1.17)	-0.007 (0.52)	-0.004 (0.41)	-0.018 (1.29)	0.001 (0.04)	0.003 (0.34)	-0.002 (0.07)
Other Asia	-0.002 (0.34)	-0.010 (0.87)	-0.001 (0.15)	-0.019 (2.09)*	-0.001 (0.14)	-0.012 (1.35)	0.006 (0.57)	-0.009 (1.22)	-0.007 (0.26)
FOREIGN	0.000 (0.07)	0.011 (1.21)	0.000 0.00	0.000 (0.10)	0.000 (0.06)	0.011 (1.80)+	-0.001 (0.21)	0.003 (0.59)	0.001 (0.12)
AGE	0.017 (4.93)**	0.016 (2.79)**	0.017 (4.91)**	0.017 (4.81)**	0.017 (4.85)**	0.016 (3.46)**	0.016 (3.70)**	0.017 (4.95)**	0.014 (3.27)**
STR		-0.010 (0.33)	-0.027 (1.06)						
RDST		-0.009 (1.36)		-0.003 (0.74)					
UNIV_PRI		-0.005 (0.12)			-0.021 (0.70)				
INTER		0.024 (1.31)				0.020 (1.23)			
EXR		-0.017 (1.93)+					-0.009 (1.15)		
			STR	RDST	U_PRI	INTER	EXR	FOREIGN	AGE
US Cross			0.081 (0.92)	-0.003 (0.34)	0.102 (2.05)*	0.000 0.00	0.005 (0.36)	-0.022 (1.59)	0.005 (0.65)
Europe Cross			0.038 (0.91)	-0.001 (0.10)	0.044 (0.51)	0.131 (2.14)*	-0.008 (0.37)	-0.014 (1.06)	0.019 (1.72)+
THKM Cross			0.324 (1.57)	0.005 (0.27)	0.011 (0.08)	0.037 (0.64)	0.003 (0.10)	-0.035 (1.60)	-0.001 (0.04)
O Asia Cross			-0.034 (0.24)	0.041 (2.72)**	-0.041 (0.50)	-0.002 (0.02)	-0.024 (0.91)	0.030 (1.94)+	0.002 (0.17)
Constant	-0.008 (0.60)	0.034 (1.48)	-0.006 (0.44)	-0.007 (0.50)	-0.007 (0.54)	0.017 (1.02)	0.016 (0.97)	-0.009 (0.64)	-0.003 (0.21)
Ind Dummy	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year Dummy	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	4353	1648	4353	4353	4351	2632	2822	4353	4353
R-squared	0.23	0.32	0.23	0.23	0.23	0.24	0.27	0.23	0.23
Absolute value of t statistics in parentheses + significant at 10%, * significant at 5%; ** significant at 1%									

Source: Author’s calculation.

The model (1) shows the result with only country dummies, showing the profitability of US multinationals is higher than Japanese ones. In contrast, THKM firms are less profitable than Japanese ones. There is no statistically significant difference in profitability as compared to European or other Asian multinationals. However, once we control for innovation variables such as



STR, DEVRD and so on, statistically significant coefficients to US and THKM dummies disappear (Model (2)). Hence, cross country differences in profitability in Model (1) come from the difference in R&D management in China. It should be noted that firm age is always strongly correlated with profitability. It takes some time for multinationals to adjust to local environments. However, it makes little difference whether a firm is a joint venture or a wholly owned subsidiary.

From Model (3) to Model (9), the results from including cross terms of country dummies and innovation indicators are presented. For example, in Model (3), cross terms of countries dummies (US, Europe, THKM and other Asia) and STR are included as well as independent variables in Model (1). These cross terms represent the relative importance of each innovation indicator for particular countries compared to those of Japan. For the US, positive and statistically significant coefficients are found in U\_PRI, which reflects that an active university/PRI collaboration is associated with higher profitability for US multinationals, benchmarked by Japanese multinationals (model (5)).

For European firms, cross terms with both INTER and AGE have positive and statistically significant coefficients (model (6)). Higher linkage with home country R&D and older firms tends to be more profitable, benchmarked by Japanese firms again. Another statistically significant sign is found in the cross term of other Asia and RDST and Foreign, implying higher R&D share in S&T and wholly owned subsidiary tend to be positively associated with their profitability (model (4)). In contrast, we cannot find cross country difference in the relationship between STR and EXR (models (3) and (7)).

## **5. Conclusion**

In this paper, multinationals' motivations for R&D in China and the impact of R&D types on firm's profitability are compared across firms' home countries (Europe, Japan, the other Asia, US and THKM owned), and a significant cross country differences are found. In terms of the motivations for R&D, The R&D of European, Japanese and the other Asian firms are driven by production activities and market adaptation in China, and the degree of market orientation is stronger for European firms. In contrast, the R&D of US and THKM firms are driven by technology and HR cost in China. It is also found that US firms are more profitable than Japanese ones in general. However, this difference in profitability disappears once it is controlled for R&D type variables, so that the differences in profitability come from the difference in R&D orientation across countries. Another important finding is that firm age is strongly correlated with profitability, so that experience in local R&D activities does matter with firm's performance.

Based on a large scale database, this paper provides quantitative evidence on the diversity in R&D motivations in China across multinationals. However, many questions remain to be answered. In the datasets examined, for example, multinationals' strategies in terms of international R&D may be changing over time. Chen (2007) presents interesting examples of Motorola and Microsoft in China, describing how R&D centres of both companies have gradually strengthened linkages with local partners and repositioned the role of Chinese sites in the world wide R&D networks. This type of dynamic analysis of learning process is important for providing some managerial implications for existing firms.

In addition, multinationals' R&D differs considerably across industry and regions. We use an industry dummy for controlling this factor throughout this paper, but a study focusing on specific industries would give some insightful results. In addition, regional breakdown might also be important. We have not touched upon policy driven R&D – as in Gammeltoft's (2006) taxonomy – in this paper, but this kind of R&D is presumed to be concentrated in Beijing. For example, most of the major telecommunication companies in the world have their R&D centres there, in order to access government information on mobile standard setting activities. Further detailed analysis of the location of R&D centres will continue to shed new light on global R&D management by multinationals.

## Notes

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- <sup>1</sup> 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 – for example, 'tons' for chemicals and 'sheets' for textiles. Details of this definition can be found in Hu et al. (2005).
- <sup>2</sup> In 2002, the ratio of total R&D to total S&T for all samples was approximately 48%. The ratio for multinationals was somewhat higher, at 54%.
- <sup>3</sup> A detailed analysis of the S&T outsourcing data from the S&T Survey is provided in Motohashi and Xiao (2007).
- <sup>4</sup> Another approach involves using a dataset for the activities of the parent company and its foreign subsidiaries. Examples include Iwasa and Odagiri (2004) and Belderbos (2001).

- <sup>5</sup> The size of observations for INTER is smaller than those of STR, STRD and U\_PRI, since the variable of international S&T outsourcing is available only for 2000-2003 surveys, instead of 1998-2005 for other variables. The size of observations for EXR is also smaller, since this indicator can be created only for firms with positive new product sales value.

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