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R&D, Integration, and Foreign Ownership

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R&D, Integration, and Foreign Ownership[1]

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Abstract

This study empirically investigates the effect of foreign ownership on research and development (R&D) investment based on firm-level panel dataset for the period 2000-2008 taken from the *Basic Survey of Japanese Business Structure and Activities*. The results reveal the following. First, the "integration effect" on R&D is negative for domestic or foreign majority ownership. Second, although the "foreign ownership effect" controlling for integration effect is insignificant, it becomes positive only when the parent firm is located in a non-G7 country. Third, the negative integration effect is stronger for vertical integration than it is for horizontal integration. These findings have an important implication in that the globalization and integration of firms not only may affect the pattern of production process and the global supply chain, but also have important influence on the level of domestic R&D activities.

Keywords: R&D, Integration, Foreign ownership, Knowledge spillover, Globalization, Foreign direct investment

JEL code: O30, F21

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1. Introduction

Capital market opening and deregulation on cross-border capital investment has induced dramatic increases in capital flows across countries. These cross-border capital flows are very much heterogeneous in nature and their impact on the global and domestic economy should be understood on the basis of its specific nature. One distinct feature of the recent capital flows is the increases in relative proportion of foreign direct investment (FDI) flows in the total cross-border capital flows. This fact may reflect the recent growing efforts made by the countries trying to attract foreign capital through provision of foreign business friendly environments on one side, and the strategic decisions of the firms in taking advantage of multinational production network system on the other.

Increase in FDI is known to benefit the host country by enhancing production capacity and creating jobs. Furthermore, the FDI inflows from advanced economy may create technological spillovers and raise efficiency of the firms in the FDI host country. These benefits will depend on the degree of superiority in productivity and in innovative capacity of the foreign-owned firms located in the host country. Therefore, how much foreign-owned firms differ in innovative aspect may provide helpful answers to this issue. In this respect, this study focuses specifically on R&D activities of the foreign-owned firms. The key question is to see whether foreign-owned firms are behaving differently in R&D activity from domestic-owned firms. This question is complicated by the fact that most foreign-owned firms are usually local subsidiaries of parent firms located outside of the country. This integrated system of firms may naturally influence the R&D decisions of the parent and the subsidiary, respectively. Therefore, the different R&D behavior of the foreign-owned firms may come from two distinct sources: foreign ownership and integration effect. This study attempts to properly separate out these two effects and goes further to see whether the integration effect depends on whether the integration is vertical or horizontal.

In this study, we are making a distinction between the R&D activity and innovative activity in the sense that innovative activities are adoptions of the new technology or systems which are produced from R&D activity. It is therefore possible that a subsidiary may adopt the new technology of the parent firm and become highly active in innovative activities

without being active in R&D activities. This distinction may be important since the location of R&D activity may be a significant factor in determining the potential spillovers.

The economic impact of the FDI on the domestic economy has been a focus of recent studies in international economics. Recent studies have attempted to measure the different aspect of foreign-owned firms in terms of productivity (Doms and Jenson, 1998, Globerman et al., 1994), Benfratello and Sembenelli, 2006) and innovative activity (Un and Cuervo-Cazurra, 2008, Guadalupe et al., 2012). Other studies have tested the presence of technological spillovers from FDI (Aitkens and Harrison, 1999, Javorcik, 2004, Haskel et al., 2002, Keller and Yeaple, 2009). However, so far no studies have provided estimated effect of foreign ownership on the R&D activity controlling for the integration effects.

Given that firms are integrated, intangibles of the whole business organization can be shared within the business group (Hortacsu and Syverson, 2009). This implies that R&D decision could be made from the point of view of the whole group by the parent firm. Going further, the R&D could be performed by the parent firm and the resulting new technologies and innovation can be shared with the subsidiaries. Thus, R&D activity of a subsidiary may be less than that of an independent firm. On the other hand, more R&D activity may also be possible for a subsidiary with a foreign parent firm due to better financing opportunity provided by the parent firm which may have access to global financing.

Thorough investigation of this issue has several benefits and may generate important implications. First, our story is consistent with FDI spillover hypothesis. It will confirm that intangibles are shared across integrated units and thus support the FDI spillovers. Secondly, it will provide a clearer picture of integration patterns, their motives for integration, and the changes in pattern of R&D activities across countries resulting from the growing global production network. Thirdly, it has an implication that FDI spillover is not purely an additional benefit to the host country, but displacing its original innovative activity.

This study empirically investigates how the foreign ownership influences R&D activity of the local subsidiary firm based on the firm-level panel dataset from *Basic Survey of Japanese Business Structure and Activities* spanning the period of 2000 to 2008. The main results are as follows. First, “integration effect” on R&D is negative for the domestic or foreign majority ownership. Second, “foreign ownership effect” controlling for integration effect is insignificant but becomes positive only when the parent firm is located in a non-G7 country.

Third, the negative integration effect is stronger for vertical integration than for horizontal integration. These findings have an important implication that the globalization and integration of firms may not only affect the pattern of production process pattern and the global supply chain, but also have important influence on the level of domestic R&D activities. Although FDI may enhance the total factor productivity (TFP) of the acquired domestic firm through adoption of its parent firm technology, FDI reduces the domestic R&D and, therefore, possibly the positive externality arising from R&D activity.

The structure of this study is as follows. Section 2 reviews the existing studies on the relationships amongst foreign ownership, R&D, innovative activities, and productivity. Section 3 provides empirical model and methodology. Section 4 describes the data and section 5 presents the empirical findings. Section 6 concludes.

2. Related literature

Until recently, the effect of foreign ownership on the firm productivity has been discussed on the basis of internalization theory of multinational firms. Based on US firm-level data, Doms and Jenson (1998) find that domestic subsidiary of a foreign parent company shows a significantly higher TFP than a domestic firm even after controlling for various firm characteristics. However, Globerman et al. (1994) uses cross-section firm data in Canada to show that the higher productivity of multinational firms compared to the domestic firms disappears when capital intensity, firm size, labor compositions are controlled for. Benfratello and Sembenelli (2006) uses GMM estimations on the Italian firm panel data to show that productivity of foreign-owned firms are not significantly different from those of the domestic firms. Aitkens and Harrison (1999) find that the FDI increased the productivity of the target domestic firm, but hurt the productivity of the competing domestic firms in the same industry.

Many studies have been focusing on the productivity spillovers from FDI and their results are mixed. Studies on inward FDI to developing economies such as Haddad and Harrison (1993) on Morocco, Aitken and Harrison (1999) on Venezuela, Djankov and Hoekman (2000) on the Czech Republic, and Konings (2001) on Bulgaria, Romania, and Poland find insignificant or negative FDI productivity spillover effect on the domestic firms in the same sector. Aitkens and Harrison (1999) find that the FDI increased the productivity of the target domestic firm, but hurt the productivity of the competing domestic firms in the

same industry. On the other hand, Javorcik (2004) finds that spillovers from FDI exist through backward linkages. Furthermore, studies on FDI to advanced countries such as Haskel et al. (2002) on U.K. and Keller and Yeaple (2009) on U.S. find evidence of positive FDI spillovers. However, it is not clear how this increase in productivity is brought about.

Very recent study by Guadalupe et al. (2012) investigates the causal effect of foreign-ownership on "innovative activity". They use fixed effects panel regressions and propensity score reweighting estimations on Spanish firm-level data to find that foreign-acquisition of domestic firm leads to greater adoption of innovative activity and to higher labor productivity in the respective domestic firm. The innovative activities include product innovation, process innovation, assimilation of foreign technologies, adoption of new machines, and new method of organizing production. This research is very relevant to our research issue, but their focus is on "innovative activity" which is more comprehensive term and which could very well include adoption of technology without "R&D activity"

There are only few studies examining the effect of foreign ownership on R&D investments. David et al. (2006) analyzed this issue based on Japanese listed manufacturing firm panel data set for the period of 1991-1997. Their empirical findings suggest that foreign ownership leads the firms to engage in optimal level of R&D and capital investments. Park (2011) uses a comprehensive panel data set of Korean firms to find that the foreign ownership leads to lower R&D intensity. However, it is difficult to state that these studies provide conclusive answers to the relationship between foreign ownership and R&D due the limitations on the data set, empirical methodology, and available variables. Since David et al. (2006) uses only listed firm data set in Japan which does not represent the whole business population, the results may be biased. Park (2011) uses a comprehensive firm panel data set, however the time dimension is only 3 years. This makes it difficult to fully apply panel regression methodology. Furthermore, the data set does include a majority ownership variable.

Un and Cuervo-Cazurra (2008) focuses on integration effect on R&D. They use tobit estimation based on cross-section data of 1215 Spanish firms from 1991 to 1994 and find that subsidiaries of foreign MNEs invest less in total R&D than domestic firms. The reason is that they invest less in external R&D than domestic firms; however, they have similar internal R&D investments compared to domestic firms. This may imply that the transfer of

technology and knowledge from other parts of the MNE acts as a substitute for the purchase of external R&D while internal R&D acts as a complement to the technology and knowledge transferred from other parts of the MNE. However, they find that integration involving domestic parent firm has no influence. Their results are very relevant to our study. However, their models did not properly separate out the integration effect from the foreign ownership effect. Furthermore, the identification of causal relationship between foreign ownership and R&D seems incomplete given the fact that they used cross-section data.

Some studies looks into causal effect of foreign acquisitions. Bertrand(2009) investigates the causal effect of foreign acquisitions on the research and development (R&D) activities of domestic target firms over the period 1994–2004 for the French innovative manufacturing firms. Using difference-in-difference estimation techniques associated with a matching propensity score procedure the study finds that the acquisitions of French firms by foreign companies boost R&D spending. There is a simultaneous rise in the external and in-house R&D expenditures of French acquired firms. Foreign takeovers may not hamper the R&D development of target firms and may not be detrimental to the national innovation system of the host country. The study, however, did not appropriately separate out the integration effect.

Our study uses a comprehensive Japanese firm-level panel data set for the period of 2000 – 2008. This data set has a very unique and critical variable that is not available in most of the data set in the existing studies. One critical data problem in most of the earlier studies is that the share of foreign ownership is used as the main variable of interest. However, this variable is a sum of all foreign shares, which may include foreign direct investment as well as simple portfolio investments. On the other hand, our data set can identify the majority ownership of each firm and the nationality of the respective ownership. Therefore, we can distinguish whether operation of a firm is in full control by a single foreign identity (i.e. over 50 percent ownership) or not.

3. Empirical model and econometric methodology

This study empirically investigates the following two questions on R&D activity: First, we examine whether foreign-owned firms are behaving differently in R&D activity from domestic-owned firms. Different R&D behavior of the foreign-owned firms may come from two distinct sources: foreign ownership and integration effect. This study attempts to properly

separate out these two effects. We test the integration effect on R&D activity, then test the effect of foreign ownership on R&D activity controlling for integration effect. Second, we question if there are any differential effect due to differences in nature of integration. This study goes further to see whether the integration effect depends on whether the integration is vertical or horizontal. As described in section4, our database is unique in that the data set includes variables identifying whether a firm is owned in majority share (50% or more) by another company, whether the parent company is domestic or foreign, and which country the parent firm is located.

The first empirical question posed in this study is to see to what extent, controlling for integration effect, foreign ownership influences R&D investments. As discussed in the previous section, foreign ownership may lead to an increase or reduction in R&D investment. In order to address this issue, we consider a latent variable tobit and random effects tobit models to control for the estimation bias due to the fact that the dependent variable is left censored at 0. The model is as follows.

$$RD^*_{i,t} = \beta_1 + \beta_{21} majown_{i,t-1} \quad + \beta_{22} majown_{i,t-1} * forown_{i,t-1} + \sum \beta_k X_{i,t-1} + D_i + \epsilon_{i,t}$$

$$RD_{i,t} = \begin{cases} RD^*_{i,t}, & RD^*_{i,t} \geq 0 \\ 0, & RD^*_{i,t} < 0 \end{cases} \qquad (1)$$

$RD_{i,t}$ represents R&D intensity of a firm and is measured by the log of one plus the ratio of R&D to sales (i.e. ln(1+R&D/Sales)). $majown_{i,t-1}$ is the majority ownership variable which is measured by the dummy variable where it takes a value of one if there exists a parent firm and its share is greater than or equal to 50%. This variable represents integration effect. $forown_{i,t-1}$ is the foreign ownership dummy which is one if the parent firm is a foreign entity.[1] Therefore, the interaction term, $majown_{i,t-1} * forown_{i,t-1}$ captures the additional effect from foreign ownership controlling for the integration effect. $X_{i,t-1}$ represents a vector that includes other control variables such as firm size, firm's age, etc. which may additionally explain the firm's R&D behavior. Foreign ownership effect could depend on whether the parent firm country has a technological capacity commensurate to that of Japan. We use a non-G7 country dummy variable in the regression. Table 3-1 summarizes the variables and

[1] In our sample, since we find that all firms under foreign majority ownership have parent firms without exception, we do not include $forown_{i,t-1}$ as a separate independent variable.

measures used in this paper.

(Insert Table 3-1)

Since R&D, integration, foreign ownership, and other firm characteristic variables can all be considered to be determined endogenously, a bias may exist due to potential endogeneity problem. Since appropriate instruments are difficult to find within this dataset, we choose to take lags of all the independent variables. We further consider firm-specific random effects tobit regressions to account for unobserved firm characteristics. In all regressions, we include industry dummies and year dummies to control for the unobserved industry characteristics which is significant across industries and year-specific shocks

Second question posed in this study is to see whether there are any differential effects due to differences in nature of integration. This study examines whether the integration effect depends on whether the integration is vertical or horizontal. If we apply the knowledge sharing hypothesis, it is natural to predict that the integration effect would be stronger for vertical integration case.

4. Data Description

The data are from the *Basic Survey of Japanese Business Structure and Activities*, which is conducted annually by the Ministry of Economy, Trade and Industry (METI). The dataset covers all firms with at least 50 employees or 30 million yen of paid-in capital in the Japanese manufacturing, mining, electricity and gas, commerce, and service industries. The purpose of the survey is to provide comprehensive information of Japanese firm activities and to this end the survey includes basic financial information, information on the composition of firms' business activities, R&D activities, IT, exports, foreign direct investment, and more. As firms included in the survey are assigned a permanent firm ID code, firm-level longitudinal data set is available.

We use a comprehensive Japanese manufacturing firm-level panel dataset from *Basic Survey of Japanese Business Structure and Activities* spanning the period of 2000 to 2008 (68,258 annual observation of 12,097 firms). Firms with less than 3 years of observation are excluded from the sample. R&D intensity is measured as the ratio of R&D expenditure over a firm's total sales, and the firms with more than 100% in R&D intensity are excluded. 'Textiles' industry and 'pulp, paper and paper products' industry are excluded since the observations

with foreign ownership is too small (10 observations each). 'Manufacturing not elsewhere classified' industry is also excluded since the firms within this category are very much heterogeneous and industry dummy will not be enough to correct for the unobserved industry-level characteristics.

Table 1 shows the distribution of the observations and share of integrated subsidiaries and foreign-owned firms across ten industries that are included in our sample. We find that the share of integrated subsidiaries and foreign-owned firms are large in 'Chemicals', 'Electrical machinery, equipment and supplies' and 'Transport equipment'. There are 22979 observations for the integrated subsidiaries, which comprises about 33.7% of total observations. Our data includes 757 foreign-owned firm observations, and the share of foreign-owned firm observation of the total integrated subsidiary observations is about 3.29%.

(Insert Table 4-1)

Figure 1 shows the differences in average R&D intensity (the ratio of R&D to sales) across different types of ownership structures. In comparison, foreign firms have higher average R&D intensity than either of the independent or integrated domestic firms. In particular, we find that the R&D intensity of foreign firms which belongs to non- G7 countries is predominantly high.

(Insert Figure 1)

Table 4-3 presents the summary statistics and correlation matrix.

(Insert Table 4-2)

5. Empirical results

Table 5-1 provides estimation results on whether the integration of firms has any significant influence on the firm's R&D investments based on tobit and random effects tobit regression models presented in equation (1). The variable *majown* which is a dummy variable for having a majority ownership parent firm is the main variable of interest. In all three

models in Table 5-1, we find that the *majown* has a significant negative influence on R&D. This finding suggests that when a firm has a parent firm with a majority ownership, the R&D intensity of the respective firm is less than the independent firms.[2] This confirms the hypothesis that the integration between firms may influence the R&D activities of the involved firms. The negative integration effect may be due to the fact that the innovation from R&D performed by the parent firm is shared with the subsidiary firm, and thus less R&D is needed in the subsidiary firm.

(Insert Table 5-1)

Table 5-2 provides estimation results on whether the foreign majority ownership has any significant influence on the firm's R&D investments based on tobit and random effects tobit regression model. In addition to the variable *majown*, the foreign ownership variable *majown*forown* is included in models (1) and (3). Both models still show significant and negative integration effects. In tobit model (1), the foreign ownership effect is positive, but is not significant in random effects tobit model (3). This implies that when a domestic subsidiary has a foreign parent firm, the R&D intensity will be less than otherwise. The reason for the lower R&D intensity is not because it has a foreign parent firm, but because it has a parent firm. In other words, the negativity is due to the integration effect, and not due to the foreign ownership effect.

The models (2) and (4) allow for differentiated effects of foreign ownership according to the source country where parent firm resides. The variable *majown*forown*dum_ng7* is added to the model to see whether a foreign ownership effect is different if the respective parent firm is not from a G7 country. In both cases, the *majown* is still negative and *majown*forown* is still insignificant. The added variable *majown*forown*dum_ng7* is found to be positive and significant. This indicates that the foreign ownership effect is insignificant if the parent firm is from a G7 country, but is positive and significant if the parent firm is from a non-G7 country. This result may be capturing the fact that since the non-G7 country parent firm's innovative capacity may be inferior to that of the local subsidiary in Japan, the

[2] Here, we are defining the independent firms as "firms without a majority ownership parent firm". Therefore, some firms with a parent firm with less than 50 percent share may be included in this group. Since it is uncertain how much these firms are under the managerial influence of limited ownership parent firms, we are treating these firms just as other purely independent firms.

parent firm may decide to transfer the R&D activity from the innovation-inferior parent to the innovation-advanced local subsidiary. Thus, the integration effect is negative, but the foreign ownership effect is positive in this case. Furthermore, if we compare the estimates, the foreign ownership effect dominates the integration effect. Thus, the net effect is positive for the local subsidiary with a non-G7 parent firm. As for the local subsidiary with a G7 parent firm, the net effect is negative since the integration effect is negative and the foreign ownership effect is insignificant.

(Insert Table 5-2)

Table 5-3 introduces an additional variable *majown*VI* into the base model. Since most of the vertical integration happens when firms integrate within similar or related industry, the vertical integration dummy VI is designed so that it takes a value of one when a firm has a majority ownership parent firm and if the firm operates in the same 3-digit level industry of the parent firm. Otherwise, the dummy is zero and it is considered to be horizontal integration. This additional variable will capture additional effect of integration when the integration is vertical in nature. Thus, the coefficient estimate of *majown* represents integration effect when the firms are horizontally integrated, and the sum of the coefficient estimates for *majown* and *majown*VI* represents the integration effect when the firms are vertically integrated. In both tobit and random effects tobit regressions, coefficient estimates for *majown*VI* is negative and significant. This implies that the R&D reducing effect is stronger under vertical integration than under horizontal integration. Vertical integration or not, the “pure integration effect” exists due the knowledge and intangible sharing. Therefore, the effect on R&D will be negative. Furthermore, vertical integration in general is expected to lower R&D in greater magnitude (compared to the horizontal integration) since more intangible can be shared under vertical integration. This additional negative “vertical integration effect” on R&D is observed from the results.

(Insert Table 5-3)

6. Conclusion

Our study provides empirical analyses on the effect of foreign ownership on the local subsidiary firm's R&D activity based on a Japanese firm-level panel data set. Unlike most of the studies in the literature, this study appropriately separates out the foreign ownership effect from the integration effect. The results show that R&D activity level of an integrated firm (i.e. a firm with a parent firm) is less than that of an independent firm, regardless of the nationality of the parent firm. When a foreign parent firm from G7 country is involved the pure foreign ownership effect is insignificant. For this case, the effect on R&D is negative solely due to integration effect, but not due to foreign ownership effect. However, when a non-G7 country parent firm is involved, the net effect on R&D is positive, since the positive foreign ownership effect dominates the negative integration effect. Regarding the nature of the integration, the negative integration effect is stronger for vertical integration than for horizontal integration.

This finding has an important implication that the globalization and integration of firms may not only affect the pattern of production process pattern and the global supply chain, but also have important influence on the level of domestic R&D activities. Integration of firms involving a foreign parent may influence R&D of the respective subsidiary firm positively or negatively depending on the technological competitiveness of the parent firm. The results in this study imply that an FDI from a technologically advanced country will reduce the local R&D activities. This study reveals that this is not due to foreign ownership, but due to integration effect. The foreign ownership effect is present and may lead to higher local R&D only when FDI is from a technologically less competitive country.

At an individual firm level, this story is consistent with FDI spillover hypothesis. It confirms that intangibles are shared across integrated units (FDI spillovers) and therefore the need for local R&D is less. It also provides a clearer picture of integration pattern, the motives for integration, and the changes in pattern of innovative activities across countries resulting from the growing global production network.

At the aggregate economy level, first, it has an implication that FDI spillover is not purely an additional benefit to the host country, but may displace its original R&D activity. Second, this may lead to a weaker link between domestic R&D activity and productivity growth.

Third, although the host country may benefit from FDI spillover in the short-run through adoption of parent firm technology, it may lose the long-run engine of growth since important R&D may not be performed by the local firms in the host country. As a result, potential regional R&D spillovers may also be absent.

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Table 3-1 Definition of Variables

Variables	Variable Definition	Variable Description
Dependent Variable		
ln(RDS+1)	R&D intensity	ln((R&D expendtiures/sales)+1)
Independent Variables		
Majown	Integrated subsidiaries	A dummy variable where it is one when a parent firm owns at least 50 percent of the firm
*Majown*forown*	Foreign subsidiary firm	A dummy variable where it is one when a foreign firm owns at least 50 percent of the firm
*Majown*forown*dum_ng7*	G7 foreign subsidiary firm	A dummy variable where it is one when the foreign parent firm which belongs to non-G7 countries
VI	Vertical integration	A dummy variable where it is one when a subsidiary operates in the same 3-digit level industry of the parent firm Majown×vertical integration
LOGL	Log of Employees	log(Employees)
EXS	Export intensity	Exports/sales
ADS	Advertising intensity	Advertising expenditure/sales
AGE	Log of Age	log(Number of years since the foundation of the firm)

Table4-1. Industry Distribution of Observations

Industry	Number of Observations	Share of total observation in %	Observations of integrated subsidiaries (majority ownership)	Share of integrated subsidiaries in total(%)	Observations of firms with foreign majority ownership	Share of foreign-majority ownership firms in
Food poducts and beverages	10828	15.9	3256	30.1	40	1.23
Chemicals	7050	10.3	2419	34.3	216	8.93
Petroleum and coal products	328	0.5	118	36.0	5	4.24
Non-metallic mineral products	3450	5.1	1125	32.6	22	1.96
Basic metals	3128	4.6	1106	35.4	17	1.54
Fabricated metal products	8392	12.3	2245	26.8	31	1.38
General machinery	11008	16.1	3038	27.6	94	3.09
Electrical machinery, equipment and supplies	13713	20.1	6149	44.8	180	2.93
Transport equipment	7846	11.5	2700	34.4	101	3.74
Precision instruments	2515	3.7	823	32.7	51	6.20
Total	68258	100	22979	33.7	757	3.29

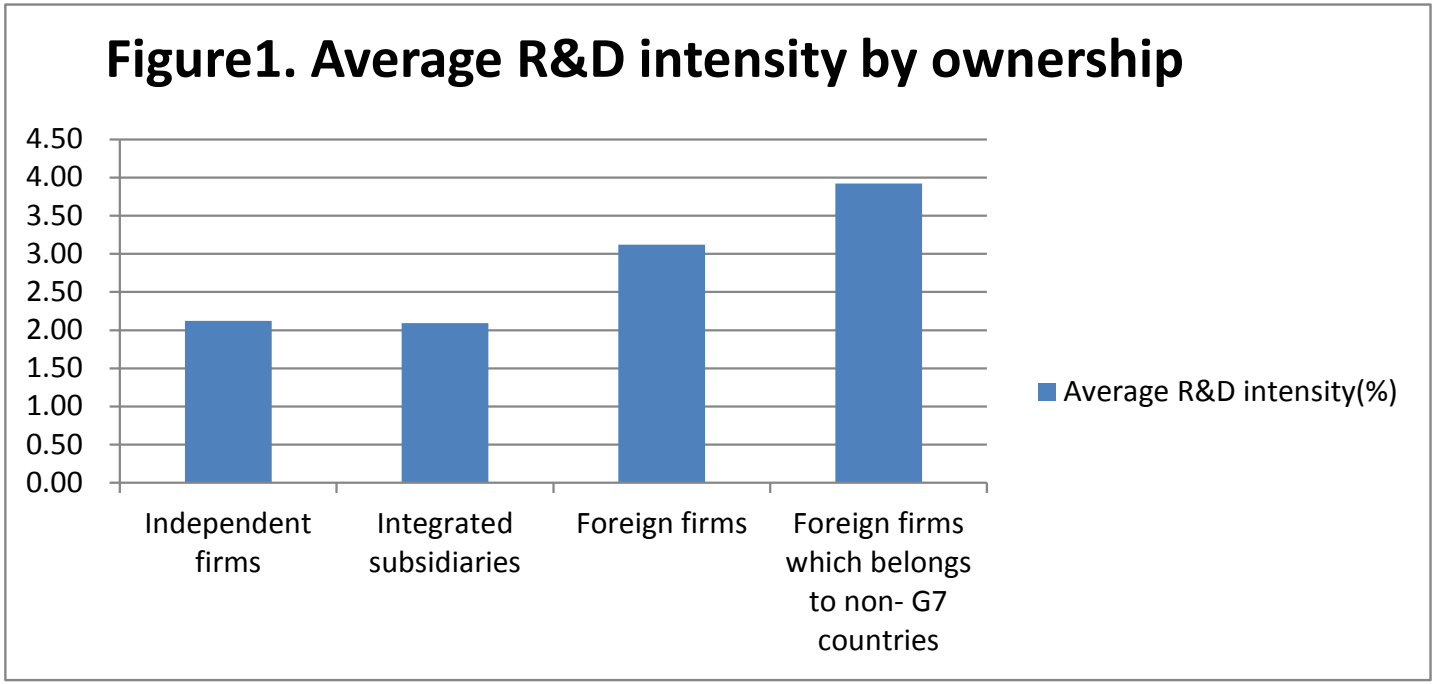
Figure1. Average R&D intensity by ownership
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Independent firms
Integrated subsidiaries
Foreign firms
Foreign firms which belongs to non- G7 countries
Average R&D intensity(%)

Table 4-2 Summary Statistics and Correlation Matrix, all firms

Variable	Obs	Mean	Std. Dev.	Min	Max
ln(RDS+1)	68258	0.014	0.026	0.000	0.965
Majown	68258	0.337	0.473	0.000	1.000
Majown*forown	68258	0.011	0.105	0.000	1.000
Majown*forown*dum_ng7	68258	0.003	0.058	0.000	1.000
VI	68258	0.124	0.330	0.000	1.000
LOGL	68258	5.285	1.039	3.912	11.300
EXS	51466	0.071	0.148	0.000	1.000
ADS	68258	0.004	0.017	0.000	1.500
AGE	56278	3.587	0.659	0.000	6.486

	ln(RDS+1)	Majown	Majown*f	Majown*f	VI	LOGL	EXS	ADS	AGE
ln(RDS+1)	1								
Majown	-0.0269*	1							
Majown*forown	0.0476*	0.1487*	1						
Majown*forown*dum_ng7	0.0394*	0.0823*	0.5538*	1					
VI	-0.0583*	0.5281*	0.1142*	0.0342*	1				
LOGL	0.2936*	0.0450*	0.0372*	0.0224*	0.0188*	1			
EXS	0.2733*	-0.0427*	0.0878*	0.0446*	-0.0636*	0.2465*	1		
ADS	0.0921*	-0.0823*	0.0236*	0.0202*	-0.0526*	0.0873*	-0.0151*	1	
AGE	0.0547*	-0.3664*	-0.0839*	-0.0348*	-0.2081*	0.1332*	0.0267*	0.0658*	1

Note: * p<0.05

Table5-1. Effect of Integration on Firm R&D: Tobit, Random Tobit

Dependent Variable=ln(RDS+1)	(1)	(2)	(3)
Majown(t-1)	-0.006***	-0.005***	-0.004***
	(-17.987)	(-12.321)	(-7.803)
LOGL(t-1)		0.011***	0.011***
		(69.045)	(36.056)
EXS(t-1)		0.043***	0.022***
		(38.353)	(14.789)
ADS(t-1)		0.103***	0.070***
		(11.389)	(6.237)
AGE(t-1)		0.001**	0.000
		(2.351)	(0.483)
Constant	-0.006***	-0.061***	-0.066***
	(-10.324)	(-44.324)	(-30.182)
Industry dummies	Yes	Yes	Yes
year dummies	Yes	Yes	Yes
firm effects	No	No	Random
Number of Observations	56,395	44,816	44,816

Note: t-statistics in parentheses, *** p<0.01, ** p<0.05

Table5-2.Effect of Integration and Ownership Structure on Firm R&D: Tobit, Random Tobit

Dependent Variable=ln(RDS+1)	(1)	(2)	(3)	(4)
Majown(t-1)	-0.005***	-0.005***	-0.004***	-0.004***
	(-12.462)	(-12.483)	(-7.846)	(-7.890)
Majown*forown(t-1)	0.003*	-0.000	0.001	-0.001
	(1.877)	(-0.072)	(0.854)	(-0.416)
Majown*forown*dum_ng7(t-1)		0.009***		0.006**
		(3.080)		(2.173)
LOGL(t-1)	0.011***	0.011***	0.011***	0.011***
	(69.044)	(69.053)	(36.053)	(36.064)
EXS(t-1)	0.043***	0.043***	0.022***	0.022***
	(38.056)	(38.082)	(14.752)	(14.773)
ADS(t-1)	0.102***	0.102***	0.070***	0.071***
	(11.323)	(11.266)	(6.229)	(6.261)
AGE(t-1)	0.001**	0.001**	0.000	0.000
	(2.439)	(2.387)	(0.484)	(0.470)
Constant	-0.061***	-0.061***	-0.066***	-0.066***
	(-44.354)	(-44.328)	(-30.171)	(-30.170)
Industry dummies	Yes	Yes	Yes	Yes
year dummies	Yes	Yes	Yes	Yes
firm effects	No	No	Random	Random
Number of Observations	44816	44816	44816	44816

Note: t-statistics in parentheses, *** p<0.01, ** p<0.05, *p<0.1

Table5-3.Effect of Vertical vs. Horizontal Integration and Ownership Structure on Firm R&D: Tobit, Random Tobit

Dependent Variable=ln(RDS+1)	(1)	(2)
Majown(t-1)	-0.003***	-0.004***
	(-6.250)	(-6.928)
Majown*forown(t-1)	0.001	-0.001
	(0.806)	(-0.321)
Majown*forown*dum_ng7(t-1)	0.008***	0.006**
	(2.631)	(2.163)
VI(t-1)	-0.006***	-0.001*
	(-10.212)	(-1.886)
LOGL(t-1)	0.011***	0.011***
	(69.112)	(36.079)
EXS(t-1)	0.042***	0.022***
	(37.652)	(14.745)
ADS(t-1)	0.101***	0.071***
	(11.172)	(6.269)
AGE(t-1)	0.001**	0.000
	(2.310)	(0.435)
Constant	-0.061***	-0.065***
	(-44.343)	(-30.149)
Industry dummies	Yes	Yes
year dummies	Yes	Yes
firm effects	No	Random
Number of Observations	44816	44816

Note: t-statistics in parentheses, *** p<0.01, ** p<0.05