The Relationship between Overseas and Domestic R&D Activities: Evidence for Switzerland

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Abstract

This paper examines whether foreign direct investment (FDI) in R&D works as a channel of knowledge transfer to home country heightening its innovative capacity. In particular, it tests for the effect of the knowledge transfer from FDI in R&D on the domestic R&D performance of investing multinational corporations (MNCs), "the own-firm effect", as well as the potential spillover effects that other domestic firms may enjoy from this investment. Many have studied the spillover effects from MNCs to the host country's firms, but there is still scant evidence on the effects of outward FDI on the MNCs' home country, especially, in terms of domestic R&D performance. Using detailed firm data from Swiss manufacturing, we find evidence that (a) foreign R&D activity of Swiss MNCs is a valuable source of knowledge which seems to be complementary to their domestic R&D activity, and (b) other domestic firms at the home country enjoy significant R&D spillovers from Swiss outward FDI in R&D.

Keywords: internationalisation of R&D; outward FDI, spillovers.

1. Introduction

Available statistics confirm an increasing degree of R&D internationalization by multinational firms, although there is no strong evidence of a rapid rise in the share of foreign R&D (Belderbos and Sleuwagen, 2007 and UNCTAD, 2005).

Existing studies show that the internationalization of the innovation process through FDI improves the economic performance of MNCs, for example in terms of their productivity and export competitiveness. However, the recent trend in the outsourcing of intellectual labor has given rise to the fear in European countries, and developed market economies in general, that they stand to lose their comparative advantage in knowledge intensive products as new countries emerge with the basic capabilities needed to provide some technology-based services. This phenomenon has been amplified by the shift from traditional competence exploiting (home base exploiting) foreign R&D activities (i.e. associated with adaptation and modification of existing technological assets to local demand conditions) to the competence creating (home base augmenting) ones, where MNCs 'tap into' local technical and scientific infrastructures (Kuemmerle, 1999; Pearce, 1999; and Cantwell and Mudambi, 2005).

MNCs investing in R&D in foreign industry with leading technologies are highly likely to result in transferring the valuable foreign technology to their home country.[1] Thus, by investing in knowledge/asset-seeking FDI, the MNC gains access to new technologies available in the host country (Dunning and Narula 1995). This in turns raises the MNC's productivity, mainly by means of reverse knowledge transfer when host

[1] Cantwell (1989) has already shown that MNCs tend to locate production or R&D in "centers of excellence" abroad.

country's technology is transferred from foreign affiliates back to the parent company or to the other sister units (Piscitello and Rabbiosi 2005).[2] Consequently, other MNCs and/or domestic firms in the home country may also gain benefits as the foreign technology could later spill over to them, raising their innovative capacity. Many have studied the spillovers from MNCs to the host country's firms, but there is still scant evidence on the effects of outward FDI on the home country of the MNCs (Veugelers et al. 2005).[3]

Recent literature on MNCs debates on whether the foreign R&D investments really complement (and thereby strengthen) the R&D activities conducted by the MNC at home, or instead they substitute the MNC's parent competences (Kotabe, 1990 and Piscitello and Santangelo, 2008). And whether other domestic firms at the home country may enjoy spillover benefits from these investments. The existing evidence on spillovers for the home country mostly focuses on domestic productivity development rather than R&D performance. Our paper tries to bridge this gap by testing the spillover effects of foreign R&D investment on the domestic R&D performance of the home country of MNCs.

Specifically, the present paper aims at shedding some light on the empirical relationship between foreign and domestic R&D activities. In order to do that, we rely on firm-level data stemming from two waves of the Swiss Innovation Survey (2002, 2005), which is conducted at the Swiss Institute for Business Cycle Research KOF. Switzerland constitutes a particularly interesting case study since Swiss MNCs are increasingly investing in R&D abroad (Hollenstein, 2008). In addition, "asset exploiting" and

[2] The resultant increase in cross border knowledge flows, both intra-MNC and between different innovation systems, involves both technology transfer from headquarters to foreign subsidiaries and 'reverse' technology transfer from foreign R&D units to domestic operations and between subsidiaries (Håkanson and Nobel, 2001 and Criscuolo et al., 2005).

[3] this could be to some extent explained by the fact that the theoretical prediction about this kind of effects are not so clear cut as in the case of inward FDI (Vahter and Masso, 2006).

"asset augmenting" are found to be the most important motives of Swiss MNCs for performing R&D investment abroad, although the former is most prevalent (Arvanitis and Hollenstein 2006 and Le Bas and Sierra 2002). In turn, we expect that at least some of the potential benefits of such investment would spill over to the home country. Through an econometric model, we show that foreign R&D activity of Swiss MNCs is increasingly a valuable source of knowledge which is complementary to their domestic R&D activity as well as to the domestic R&D activity of the whole sector (at home).

The structure of the paper is as follows. Following this introduction, section 2 analyzes the theoretical framework underlying our hypotheses, together with a review of the relevant empirical studies. Section 3 discusses the Swiss data and gives some insights about the extent of the R&D activity of Swiss MNCs at foreign locations. Section 4 presents the econometric model, while Section 5 reports the estimation results. Section 6 concludes the paper.

2. Conceptual Framework and Hypotheses

The current literature is not that far from what Kotabe (1990) defined a "*state of flux as to whether or not firms' offshore sourcing stifles their innovative ability*". In particular, the appearance of emerging countries on the international scene as important recipients also for foreign innovative activities, has led developed market economies to fear that they stand to lose their comparative advantage in knowledge intensive products. This phenomenon has been amplified by the growing awareness among scholars that MNCs also use their multinational network to augment their competitive advantages and/or to create new advantages (Bartlett and Ghoshal, 1989; Kuemmerle, 1999; Pearce, 1999). Specifically, the increased role of geographically dispersed sourcing of technology

through the international networks of globally integrated MNCs has led to a growing interest in the asset-acquiring motive for FDI (Cantwell and Piscitello, 2000; Tallman and Yip, 2001). It is becoming recognized that the observed decentralization in the management of international R&D can be related to the capture of 'home base augmenting' benefits (Papanastassiou and Pearce, 1997; Kuemmerle, 1999).

Theory and evidence on MNCs (Cantwell, 1995; Almeida, 1996; Dunning, 1998; UNCTAD, 2001; 2005) has traditionally acknowledged that FDI are more and more selectively tapping knowledge in specific host markets when designing their global knowledge sourcing strategies. According to this "technology-seeking" or "knowledge-seeking" argument, firms may expand abroad in search of capabilities complementary to those available in their home markets (Cantwell 1989). This suggests that firms use knowledge-seeking investments also to source technical diversity, and knowledge developed abroad can be transferred back to the parent company (Mudambi et al., 2008) or other sister units, raising their innovation performance, their productivity, and consequently their competitive advantage (Cantwell and Piscitello 1999, Griffith et al. 2004; Piscitello and Rabbiosi 2006). In line with the knowledge-seeking argument, we then contend that

H1: MNCs' R&D activities conducted abroad do positively impact their R&D activities at home.

This increase in cross border knowledge flows involves both the traditional technology transfer from headquarters to foreign subsidiaries, but also 'reverse' technology transfer from foreign R&D units to domestic operations and between subsidiaries (Frost, 1998;

Håkanson and Nobel, 2000; 2001; Zhou, 2002; Monteiro et al., 2008; Yang et al., 2008). However, we claim that these knowledge flows may spill over and also benefit other domestic companies operating in the same industry of the MNCs conducting R&D activities abroad (intra-industry spillovers). This is in line with previous evidence on the impact of technology sourcing, as proxied by outward FDI, on the diffusion of technology (Lichtemberg and van Pottelsberghe de la Potterie, 1996; Globerman et al., 2000). In particular, Lichtenberg and van Pottelsberghe de la Potterie (1996) studying the R&D spillovers through both outward and inward FDI in OECD countries find support for the hypothesis that R&D spillovers are transmitted through outward FDI across OECD countries, but no evidence for R&D spillovers from inward FDI. Alike, Braconier et al. (2001) test for the R&D spillover effects form inward and outward FDI for Swedish manufacturing, using both industry-level and firm-level data. They find no evidence of FDI-related R&D spillovers – neither at the firm-level nor at the industry-level. The only variable that consistently affects total factor productivity in Sweden is own investment in R&D. In contrast, using data from patent citations, Globerman et al. (2000) note that outward FDI seems to create spillovers of knowledge back to the home country. They find that Swedish firms, both MNCs as well as SMEs, are more likely to cite patents from countries hosting higher amount of Swedish FDI. The reason why SMEs gain benefits from outward FDI is the exchange of knowledge through business associations, personal contacts, labor mobility, and other similar channels. Similarly, measuring knowledge flows through patent citations, Popovici (2005) supports the hypothesis that a U.S. subsidiary conducting R&D overseas facilitates the flow of knowledge between its host and home countries.

Yet, the existing literature on spillovers stemming from outward FDI in R&D for the home country focuses mostly on domestic productivity development rather than R&D performance. Our paper instead tests the spillover effects of foreign R&D investment on the domestic R&D performance of the home country of MNCs. Namely, our second hypothesis is the following:

H2: MNCs' R&D activities conducted abroad do positively impact on R&D activities carried at home by other firms belonging to the same sector.

3. The Data

Before introducing our empirical model, it is worth giving some insights about the extent of the R&D activity of Swiss MNCs at foreign locations relative to that at home. During the last three decades, the level of the internationalization of Swiss firms' innovative activity (R&D here) strongly increased (Hollenstein, 2008). Likewise, relying on the analysis of patents of 71 Swiss MNCs issued between 1978 and 2006, Michel (2007) found that Swiss MNCs patents generated in foreign affiliates amounted to 43.6 percent of the total Swiss MNCs patents in the 1980s, grew up in the 1990s to reach 54 percent and 61.8 into 2000-2006. In contrast, the inventions of Swiss MNCs made at home have grown at a lower rate than their overall inventions. Also, Le Bas and Sierra (2002) found that in 1994-1996 about 60% of Swiss MNCs' patents of 13 firms are based on research activities undertaken abroad.

Table 1 presents the percentage share of Swiss manufacturing MNCs performing overseas R&D in the period 2003-2005, by sector and by foreign location. Table 2 reports the sectoral share of Swiss firms' R&D abroad, measured as a percentage share of their whole R&D investment, in 2001 and 2004. The data come from the innovation

activity survey of manufacturing firms with at least 5 employees, conducted at the Swiss institute for business cycle research "KOF".[4] The survey was based on a stratified sample of firms according to the industry affiliation and the industry-specific firm size classes. Individual information covers the technological behavior of 1490 firms – of which 209 performing R&D abroad – within the period 2003-2005 and 1352 firms – of which 130 performing R&D abroad – within the period 2000-2002.[5] Our calculations are based on weighted data sets so as to give a representative picture of the Swiss economy – the weights are used to correct for the selection bias resulting from "unit" non-response and for the deviations of the sample structure from that of the underlying population.

The share of Swiss manufacturing MNCs performing R&D abroad is about 10% indicating that at the aggregate level Swiss firms do not seem to largely invest in foreign R&D activity. European Union attracts the most part of Swiss foreign R&D followed by United States and Canada – according to Hatzichronoglou (2008), Switzerland is the second-largest source of R&D investment in Austria in 2004 and in Finland in 2005; the third in Sweden and the fourth in Germany, in 2005.[6] However, this result changes considerably across sectors (see Table 1). Swiss MNCs invest in foreign R&D especially in beverage (68.7%), computer and office equipments (48%), communication equipment (30%), apparel, leather and footwer (22.9%) and chemicals (20.2%). In most of the manufacturing sectors, European Union remains the most attractive foreign

[4] Questionnaires administered to the firms can be downloaded from www.kof.ethz.ch.
[5] The latest data available come from the survey 2005. The survey response rates were 38.7% and 39.6% for2002 and 2005, respectively. To correct for distortions that may arise from the "unit" non-response, KOF conducted a non-response analysis by interviewing a number of non-respondents taken at random (Schönenberger, 2008).
[6] Considering only patents related to inventions developed abroad, Michel (2008) reported that Germany accounted for 40.7 percent
of all patents, the United States 23.2 percent, France 8.3, United Kingdom 7.1, Sweden 5.9, Japan 3.4, and Italy 3.

location for Swiss MNCs to perform R&D activity.[7] However, Japan, China and India attract the most part of Swiss foreign R&D in the watches sector, while in computer and office equipments, United States and Canada catch the attention of Swiss foreign R&D as much as European Union.

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Table 1 approximately here

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Table 2 reports that the share of Swiss firms' R&D at foreign locations relative to that at home has slightly increased from 2 percent in 2001 to 2.5 percent in 2004. However, considering sectors individually allows to detect again quite a high heterogeneity. The most internationalised sector in 2001 is pharmaceuticals (10% of the MNCs' R&D investment was conducted abroad), while in 2004 is computer and office equipment (14.3%). Some sectors, like computer and office equipments (from 6.5% in 2001 to 14.3% in 2004), chemicals (from 2.1% to 8.1%), watches (from 0.4% to 3.6%), increased dramatically their propensity to foreign R&D investment; while other sectors, like pharmaceuticals (from 10% to 2.1%), metalworking (from 2.4% to 0.1%), printing and publishing (from 2.8% to 0.6%), increased their domestic R&D investment. Within this context, the focal point of our empirical analysis (discussed in the following sections) is testing whether foreign R&D investment may increase the innovative capacity of the MNCs' home country. In particular, we test econometrically whether foreign and domestic R&D of Swiss MNCs are complement or substitute and whether the foreign knowledge is later on transmitted to the home country, thus benefiting other domestic firms.

[7] For example, according to Hatzichronoglou (2008), Swiss firms' R&D in Germany is concentrated in chemicals excluding pharmaceuticals (46%), non-electrical machinery (18%), and scientific instruments (10%).

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Table 2 approximately here

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4. Econometric model and variables

We study the effects of FDI in R&D on the home country innovative capacity, through a model in which the domestic R&D investment of firm i depends also on its foreign investment in R&D, other than the knowledge intensity of its industry (see Mol, 2005 for a discussion on the relationship between R&D intensity and outsourcing). As the literature on MNCs has acknowledged the importance of spillovers stemming from the presence of foreign actors in a geographical area (for a recent survey, see Castellani and Zanfei, 2006), we also control for the presence of foreign affiliates at home (i.e. in Switzerland). Other firm's characteristics, such as size and age, have also been included as larger and more experienced firms may be more efficient and better able to take advantage from innovations (Bladwin 1996, Dimelis and Louri 2002, Meyer and Sinani 2004, Hollenstein et al. 2005).

Therefore, our variables are the followings (see table 3 for further details):

- $R\,\&\,D\_\exp_{ij}$ is our proxy for the domestic innovative effort of firm i in industry j. It is measured by the firms' own expenditure on domestic R&D (in 10'000000 CHF).
- $Overseas\ \ R\,\&\,D_{ij}$ measures the foreign R&D activity of firm i in industry j. It is calculated as the percentage share of foreign R&D (over the firm's whole R&D investment). This measure is a proxy for "the own-firm effect", thus allowing to detect whether foreign and domestic R&D of the firm are complements or substitutes.

- $Size_{ij}$ is the defined as the number of employees of firm *i* in industry j.
- Age_{ij} is the age of the firm i in industry j, defined as the number of years the firm is present on the market.
- FP_j is the measure of foreign presence, calculated for each industry as the ratio of the foreign firms' sales to total sales.
- $Domestic\ R\&D_j$ is the sum of the firms' expenditures on domestic R&D in the industry j, except for the firm i. It is a proxy for the R&D intensity in the given industry j, and it is used to control for the industry-specific knowledge differences. It is calculated as:

  $$Domestic\ R\&D_j = \sum_{k \neq i} Domestic\ R\&D_{kj}$$

  where k are firms belonging to sector j.
- $Overseas\ R\&D_j$ is a proxy for R&D spillovers stemming from foreign R&D in industry j. It is calculated as:

  $$Overseas\ R\&D_j = \sum_{k \neq i} Overseas\ R\&D_{kj}$$

  where k are firms belonging to sector j.
- FOR_{ij} is a dummy variable used to control for the firm's ownership. It takes value 1 if the firm i in the industry j is foreign-owned, and zero otherwise.

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Table 3 approximately here

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Table 4, 5, and 6 report descriptive statistics and correlations for the variables that have been calculated using the survey data of 2002, 2005, and both levels for growth, respectively. At the first glance, we could see a significant positive correlation between

the firm's domestic and foreign R&D in 2002 (the coefficient 0.16 is significant at p<.01, see Table 4), and in 2005 (the coefficient increases to 0.23 remaining significant at p<.01, see Table 5). However, the correlation coefficient remains positive for the growth between 2002 and 2005, although not significant (see Table 6), thus revealing that an increase in the share of the firm's foreign R&D investment does not lessen its domestic investment. Based on an analysis of the motives for doing R&D abroad, Hollenstein and Arvanitis (2006) and Schönenberger (2008), found that foreign and domestic R&D of Swiss MNCs are complement rather than substitutes, that is assets exploiting is more prevalent as a strategy of foreign R&D than assets augmenting.

The firm's domestic R&D and the sectoral foreign R&D are significantly positive correlated only for growth (the coefficient 0.17 is significant at p<.01, see Table 6), while both in 2002 and 2005 the correlation coefficient is positive but not significant (see Table 4 and 5, respectively). In other words, an increase in sectoral foreign R&D appears to positively affect the growth of the firm's domestic R&D, thus providing a first evidence of the existence of spillover effects at the growth level.

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Tables 4-6 approximately here

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As far as our econometric model is concerned, the equation is the following:

$$Domestic\ R\&D_{ij} = a_0 + a_1 Overseas\ R\&D_{ij} + a_2 Overseas\ R\&D_j + a_3 Size_{ij} + a_4 Age_{ij} + a_5 FP_j + a_6 Domestic\ R\&D_j + a_7 FOR_{ij} + \mu_i \quad (1)$$

Where a_0, a_1, a_2, a_3, a_4, a_5, a_6, and a_7 are the parameters to be estimated.

We test equation (1) using KOF data derived from the surveys of 2002 and 2005. Specificially, the model has been estimated both at the 2002 level data, the 2005 level data, and the two-levels for growth. Because of missing data for some variables, the regression analyses make use of a sample of 761 manufacturing firms from the 2002 survey data, 724 firms from the 2005 survey data, and 268 firms when matching the two data sets.[8] All regression results are robust and refer to OLS estimations.[9]

5. Empirical findings

Empirical findings from the regression estimates are reported in Table 7. Specifically, column (A) shows the results for the survey data of 2002, column (B) for the survey data of 2005, and column (C) for the growth calculated as difference between 2005 and 2002 data. As far as the first column is concerned, the estimated coefficient for the variable $Overseas\ R\ \&\ D_j$ (the so called "own effect) is positive but not significantly different from zero, while $Overseas\ R\ \&\ D_i$ (so called spillover effect) is positive and significant (at p<.01). In other words, the firm's innovative capacity at home in terms of R&D investment in 2000-2002 did not increase with its own foreign R&D investment in 2001, but only with the foreign R&D of other firms in its industry; so there is evidence only for R&D spillovers to the home country.[10]

Regarding other regression variables, it appears that domestic R&D of firms in Switzerland increases with their size (significant at p<.01) and decreases with their age (significant at p<.01). FP_j does not come out significantly different from zero, showing

[8] For robustness test, the own-firm effect has also been tested using samples that include only MNCs performing overseas R&D. The results are the same.

[9] As our dependent variable is truncated to the left of zero, we estimated equation (1) also using the QLIM (qualitative and limited dependent variable Model) procedure (Amemiya, 1973). However, as the results are better with OLS procedure, we report only the latter.

[10] Michel (2007) found that inventions of Swiss MNCs undertaken in Switzerland have cited foreign locations and therefore foreign R&D activities maybe a valuable source of foreign technologies available to firms in the home country.

that foreign presence does not have any effect on the firms' domestic innovative capacity in Switzerland. This result provides a further confirmation that the foreign presence, traditionally used to measure the benefit of inward FDI in Switzerland, does not capture the whole information on the ways this effect occurs (Ben Hamida and Gugler, 2007, Ben Hamida, 2008), and that the assessment of this benefit requires a detailed analysis of the effect regarding the technological characteristics of local firms, such as their absorptive capacity.

Finally, being a foreign affiliate slightly significantly (at $p<.10$) decreases the domestic R&D activity of the firm.

Column (B) reports results obtained using the 2005 survey data. In this case, as expected from the correlation results, the coefficient of the variable $Overseas\ R\ \&\ D_i$ is significantly positive (at $p<.01$) thus suggesting that an increased share of foreign R&D in the firm could be a valuable source of knowledge, which is complementary to its domestic R&D investment capability[11]. The evidence for positive and significant industrial spillover effects of outward FDI in R&D remains also in 2005, although the size and the significance of this effect is about half smaller than in column (A). The estimation results for other regression variables seem to be very similar to those obtained for 2002 (and reported in column A).

Finally, column (C) in table 7 refers to the estimation results for growth when matching the 2002 and 2005 level data. The results still support the evidence for spillovers from outward FDI in R&D (the coefficient for the variable $\Delta Overseas\ R\ \&\ D_j$ is positive and significant at $p<.05$) while, alike the results using the 2002 survey level data, the change

[11] This result is in line with Hollenstein and Arvanitis (2006) and Hollenstein (2008). Specifically, using the same data, and relying on a descriptive analysis of FDI motives in R&D, they find that domestic and foreign R&D of Swiss MNCs are complements.

in the firm's foreign R&D does not seem to significantly increase its domestic R&D (the coefficient for the variable $\Delta Overseas\ R\&D_i$ is positive but not significantly different from zero). However, such a result may well depend from the dominance level of the 2002-survey firms, when matching the two data sets. The coefficient for the change in FP, as well as the coefficients for Age and FOR do not come out significantly different from zero.

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Table 7 approximately here

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6. Conclusions

This paper addresses the effects of FDI in R&D on the innovative capacity of the home country of the MNCs, in particular we test for the effect of the knowledge transfer from FDI in R&D on the innovation capacity of investing MNCs, the so-called "own-firm effect", as well as the potential spillover effects that other domestic firms may enjoy from this investment. Many have studied the spillover effects from MNCs to the host country's firms, but there is still scarce evidence on the effects of outward FDI on the home country of the MNCs, especially, in terms of domestic R&D performance.

Based on samples of Swiss manufacturing firms, our regression results reveal that foreign R&D activity of Swiss MNCs is increasingly a valuable source of knowledge which is complementary to their domestic R&D activity. There is evidence for the own-firm effect when using the survey data of 2005, that is the firm's domestic R&D significantly increase in response to the share of its foreign R&D investment. In

addition, we found significant R&D spillovers for the home country stemming from FDI in R&D.

On the policy front, these findings support the actions to motivate foreign R&D activity of Swiss MNCs; however, suggestions with respect to encouraging FDI in R&D following such findings must take into account that this foreign investment should complement the domestic R&D of Swiss MNCs. Actions should then promote foreign affiliates' ability to engage in knowledge transfer to parent company in the home country and discourage Swiss MNCs to simply relocate their R&D activity abroad. Moreover, since foreign R&D investment of Swiss MNCs is also beneficial for other domestic firms in the home country, actions to support learning in domestic firms seem to be a necessary ingredient in a policy package to maximize this spillover benefit.

A future research aiming to analyze the key determinants of the effect of FDI in R&D on the home country could be also promising. The literature suggests that the MNCs' behavior (particularly their motives for investing in R&D abroad) could affect the size and the extent of the own-firm and spillover effects. Moreover, how domestic firms benefit from spillovers may also depend largely on their technological characteristics such as the level of their absorptive capacity. In so doing, we could then examine further policy alternatives in order to maximize the benefit for the home country from FDI in R&D.

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Table 1: Share of Swiss manufacturing MNCs performing overseas R&D during the period 2003-2005: Sectoral share by foreign location (percent)

Sector	OutR&D All locations	OutR&D US_CAD	OutR&D EU	OutR&D CH_IND	OutR&D JPN	OutR&D Others
Manufacturing	10.3	2.3	9.2	1.8	0.5	1.9
Food	1.9	0.3	1.9	0.8	0.0	0.8
Beverage	68.7	6.8	68.7	0.0	0.0	6.8
Tobacco	5.7	0.0	0.0	0.0	0.0	0.0
Textiles	15.9	2.2	8.3	0.0	0.0	7.6
Apparel/leather/ footwear	22.9	0.0	22.9	0.0	0.0	0.0
Wood products	2.1	0.0	2.1	0.0	0.0	0.0
Paper	5.1	0.0	5.1	0.0	0.0	1.4
Printing/publishing	1.5	0.0	1.5	0.3	0.0	0.0
Chemicals	20.2	7.7	19.7	4.8	1.9	1.3
Pharmaceuticals	17.2	5.9	17.2	1.6	3.7	5.9
Plastics	17.5	1.9	17.5	1.9	1.0	1.4
Non-metal mineral products	5.2	0.0	5.2	0.0	0.0	0.0
Metal production	5.7	1.5	5.7	0.0	0.0	1.5
Metalworking	1.1	0.4	0.9	0.0	0.0	0.2
Machinery	19.0	5.3	16.8	3.4	0.5	2.3
Electrical machinery	9.0	1.9	7.5	2.4	1.0	0.9
Computer and office equipments	48.0	32.6	32.6	0.0	0.0	15.4
Communication equipments	30.0	9.8	30.0	4.5	2.2	16.1
Medical instrument	18.8	5.6	18.1	2.4	0.0	2.8
Watches	8.4	0.0	1.8	6.6	6.6	6.6
Transport equipments	12.1	0.0	12.1	0.0	0.0	0.0
Other manufacturing	16.7	1.3	15.4	7.7	0.0	1.3
Energy	1.5	0.0	1.5	0.0	0.0	0.0

OutR&D denote overseas R&D, US_CAD is Unites States and Canada, EU is European Union, CH_IND is China and India, and JPN is Japan.
Source: Author's calculations of data derived from KOF innovation surveys (2005).

Table 2: Sectoral share of Swiss firms' R&D abroad, part of their whole R&D investment, in 2001 and 2004 (percent)

Sector	2001	2004
Manufacturing	2.0	2.5
Food	0.8	0.2
Beverage	0.0	1.1
Textiles	7.1	2.9
Apparel/leather/footwear	3.7	6.9
Wood products	0.0	0.7
Paper	0.8	3.2
Printing/publishing	2.8	0.6
Chemicals	2.1	8.1
Pharmaceuticals	10.0	2.1
Plastics	3.3	2.6
Non-metal mineral products	2.2	0.3
Metal production	0.2	0.4
Metalworking	2.4	0.1
Machinery	2.7	4.7
Electrical machinery	0.5	1.3
Computer and office equipments	6.5	14.3
Communication equipments	1.5	3.9
Medical instrument	1.3	3.6
Watches	0.4	3.6
Transport equipments	1.5	4.9
Other manufacturing	0.0	5.6

Source: Author's calculations of data derived from KOF innovation surveys (2005).

Table 3: Variable definitions

Variables	Definitions
$R\&D\exp_{ji}$	The firm's expenditure on domestic R&D in the industry j (in 10'000000 CHF).
$Overseas\ R\&D_{ij}$	The firm's percentage share of foreign R&D, part of its whole R &D investment.
$Size_{ij}$	The number of the firm's employees.
Age_{ij}	The number of years the firm is present on the market.
FP_j	The ratio of the foreign firms' sales to total sales.
$Domestic\ R\&D_j$	The sum of the firms' expenditures on domestic R&D in the industry j, except for the firm i.
$Overseas\ R\&D_j$	The firms' expenditures on foreign R&D in the industry j, except for the firm i.
FOR_{ji}	A dummy variable used to control if the firm i in the industry j is foreign-owned or domestic.
$\sum_{t=2000}^{2005} R\&D\exp_{ij}$	The sum from 2000 up 2005 of the firm's expenditure on domestic R&D in the industry j.
$\Delta Overseas\ R\&D_{ij}$	The change between 2001 and 2004 in the firm's percentage share of foreign R&D "$Overseas\ R\&D_{ij}$".
ΔFP_j	The change between 2001 and 2004 in the foreign share "FP_j".
$\sum_{t=2000}^{2005} Domestic\ R\&D_j$	The sum from 2000 up 2005 of the the firms' expenditures on domestic R&D in the industry j, expect for the firm i.
$\Delta Overseas\ R\&D_j$	The change between 2001 and 2004 in the firms' expenditures on foreign R&D "$Overseas\ R\&D_j$".

All of the variables are measured in 2001 and 2004, except the domestic R&D which represent the investment in 2000-2002 and 2003-2005, using, respectively, the 2002 and 2005 survey data.

Δ represents changes in the variables between 2001 and 2004, used for growth regression.

Table 4: Descriptive statistics and Pearson correlations of regression variables at the 2002 survey level data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unit	10'000000 CHF	%		years	%	10'000000 CHF	%	
Mean	0.87	2.70	181.43	58.12	25.40	29.81	121.27	0.17
Std. Dev.	13.14	10.11	477.35	40.71	17.8	75.93	113.87	0.37
Min	0.00	0.00	1.00	0.00	1.98	0.00	-59.00	0.00
Max	360.00	80.0	8009	345.0	100.00	385.39	351.00	1.00
(1) $R\ \&\ D\exp_{ij}$	1.00							
(2) *Overseas* $R\ \&\ D_{ij}$	0.16***	1.00						
(3) $Size_{ij}$	0.65***	0.20***	1.00					
(4) Age_{ij}	0.05	0.04	0.22***	1.00				
(5) FP_j	-0.036	0.03	0.007	-0.03	1.00			
(6) *Domestic* $R\ \&\ D_j$	0.004	0.08**	-0.017	-0.06*	-0.2***	1.00		
(7) *Overseas* $R\ \&\ D_j$	0.02	0.001	-0.064*	-0.065*	-0.10***	0.26***	1.00	
(8) FOR_{ij}	-0.008	0.007	0.067*	-0.03	0.14***	0.11***	0.014	1.00

All of the variables are measured in 2001 except the domestic R&D which represent the investment in 2000-2002.
*, **, and *** denote the significance level of the correlation coefficients at p<.10, p<.05, and p<.01, respectively.

Table 5: Descriptive statistics and Pearson correlations of regression variables at the 2005 survey level data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Unit	10'000000 CHF	%		years	%	10'000000 CHF	%	
Mean	0.89	3.89	184.04	58.95	24.18	27.69	144.14	0.18
Std. Dev.	8.69	12.67	538.06	42.66	18.97	52.61	116.86	0.38
Min	0.00	0.00	1.00	0.00	1.76	0.00	0.00	0.00
Max	220.00	100.00	10900	348.00	95.70	257.38	413.00	1.00
(1) $R\&D\exp_{ij}$	1.00							
(2) *Overseas* $R\&D_{ij}$	0.23***	1.00						
(3) $Size_{ij}$	0.81***	0.22***	1.00					
(4) Age_{ij}	-0.04	0.05	0.04	1.00				
(5) FP_j	0.02	0.064*	0.042	-0.16***	1.00			
(6) *Domestic* $R\&D_j$	0.02	0.005	-0.002	-0.09***	0.067*	1.00		
(7) *Overseas* $R\&D_j$	0.037	-0.023	-0.017	-0.21***	0.14***	0.47***	1.00	
(8) FOR_{ij}	0.008	0.09**	0.056	-0.07**	0.167***	0.11***	0.12***	1.00

All of the variables are measured in 2004 except the domestic R&D which represent the investment in 2003-2005.
*, **, and *** denote the significance level of the correlation coefficients at p<.10, p<.05, and p<.01, respectively.

Table 6: Descriptive statistics and Pearson correlations of regression variables at the 2002 and 2005 survey levels for growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Unit	10'000000 CHF	%		years	%	10'000000 CHF	%		
Mean	0.94	-0.68	181.56	59.16	-1.82	67.54	24.38	0.17	26.18
Std. Dev.	3.04	13.30	424.24	40.35	16.22	140.05	145.14	0.38	18.33
Min	0.00	-80.00	2.00	1.00000	-56.74	0.44	-324.00	0.00	1.98
Max	30.00	95.00	4458	348.00	63.34	642.77	353.00	1.00	96.04
(1) $\sum_{t=2000}^{2005} R\&D\exp_{ij}$	1.00								
(2) $\Delta Overseas\ R\&D_{ij}$	0.037	1.00							
(3) $Size_{ij,t=2001}$	0.73***	-0.0004	1.00						
(4) Age_{ij}	0.082	0.082	0.16***	1.00					
(5) ΔFP_j	0.007	0.005	0.01	0.12**	1.00				
(6) $\sum_{t=2000}^{2005} Domestic\ R\&D_j$	0.02	-0.08	-0.03	-0.03	0.18***	1.00			
(7) $\Delta Overseas\ R\&D_j$	0.17***	0.01	0.087	-0.09	0.12**	0.16***	1.00		
(8) FOR_{ij}	0.01	0.13**	0.04	-0.08	0.005	0.10*	0.069	1.00	
(9) $FP_{j,t=2001}$	0.036	-0.001	0.067	-0.062	-0.44***	-0.19***	0.07	0.09	1.00

Δ represents changes in the variables between 2001 and 2004.
*, **, and *** denote the significance level of the correlation coefficients at p<.10, p<.05, and p<.01, respectively.

Table 7: Estimation results for manufacturing: own-MNC effects and spillovers to home country from FDI in R&D

Variables	**(A)**	**(B)**	**(C)**
$Overseas\ R\&D_i$	0.04	0.039***	
	(0.03)	(0.015)	
$\Delta Overseas\ R\&D_i$			0.01
			(0.009)
$Size_i$	0.018***	0.013***	0.005***
	(0.0007)	(0.0003)	(0.0003)
Age_i	-0.031***	-0.016***	-0.003
	(0.009)	(0.004)	(0.003)
FP_j	-0.024	-0.012	-0.005
	0.02)	(0.01)	(0.007)
ΔFP_j			-0.008
			(0.008)
$Domestic\ R\&D_j$	-0.0016	0.001	
	(0.005)	(0.003)	
$\sum_{t=2000}^{2005} Domestic\ R\&D_j$			0.0007
			(0.0009)
$Overseas\ R\&D_j$	0.0069**	0.003*	
	(0.003)	(0.001)	
$\Delta Overseas\ R\&D_j$			0.002**
			(0.0009)
FOR_i	-1.84*	-1.13**	-0.28
	(0.97)	(0.49)	(0.33)
$\overline{R}^2$	0.44	0.67	0.54
N	761	724	268

(A) refers to the estimation using the 2002 survey-level data, (B) refers to the estimation using the 2005 survey-level data, (A) refers to the estimation using the two-levels for growth.
All standard errors, in parentheses, are corrected for heteroskedasticiy.
*, **, and *** denote significance at p<.10, p<.05, and p<.01, respectively.