Are Foreign and Domestic R&D Activities Complements? Evidence from Swiss Manufacturing firms

July 2009

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, wherein evidence is still very scarce. It hypothesizes that (a) MNCs' R&D activities conducted abroad do positively impact their R&D activities at home and (b) this effect depend upon the type of motives for foreign R&D investment. Using detailed firm data from Swiss manufacturing, we find that foreign R&D activity of Swiss MNCs is a valuable source of knowledge which positively complements their domestic R&D activity at home when firms invest in knowledge-seeking R&D and negatively affect their domestic activity when firms invest in knowledge-exploiting R&D.

Keywords: FDI in R&D; The reverse knowledge transfer; The motives for foreign R&D; The Swiss case.

1. Introduction

MNCs are widely considered the main source for knowledge throughout the world. It is generally assumed to possess the advanced technology (production technology, marketing and management technique, etc.) they tend to exploit in many host countries and, consequently, other firms, particularly the host country's, expect to learn from this technology so as to get the necessary strength to face the foreign competition.

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

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). Existing studies so far have largely analyzed the traditional knowledge transfer from parent company to foreign affiliates whereas a very little attention has been given to reverse knowledge transfer from the affiliates to the parent company in the home country. This scarce evidence could be to some extent explained by the fact that the effect of the reverse knowledge transfer is much more difficult to assess since it is not occur automatically but depends on a number of factors, mainly, the MNC's type of motives for performing foreign R&D activities. We argued that reverse knowledge transfer should be differentiated by knowledge/asset-exploiting activity and knowledge/asset-augmenting activity and that the effect is more likely to occur when MNCs invest abroad to augment their existing knowledge/assets (Ben Hamida and Piscitello, 2008).

MNC focusing on investing in R&D in foreign industry with leading technologies are highly likely to result in transferring the valuable foreign technology to home country.[1] Thus, by investing in knowledge/asset-seeking FDI, the MNC explicit motive is to gain access to new technologies from the host country (Dunning and Narula 1995), raising its innovative capacity, its productivity, and consequently its competitive advantage, mainly, by means of reverse knowledge transfer when host country's technology is transferred from foreign affiliates back to the parent company or to the other sister units (Piscitello and Rabbiosi 2005). Foreign R&D investments from knowledge-seeking motivation tend then to complement (and thereby strengthen) the R&D activities conducted by the MNC at home (Kotabe, 1990 and Piscitello and Santangelo, 2008).

Within this context, the present paper aims at shedding some light on the empirical relationship between foreign and domestic R&D activities in terms of reverse knowledge transfer. It tends hence to propose some components for a research agenda on the effect of the reverse knowledge transfer from foreign affiliates to parent company which deserve more attention. In order to do that, we rely on firm-level data stemming from the Swiss Innovation Survey (2008), which is conducted at the Swiss Institute for Business Cycle Research "KOF". Switzerland is particularly an interesting case study since Swiss MNCs are increasingly investing in R&D abroad (Holenstein, 2008). Knowledge/asset-augmenting R&D activities of Swiss MNCs have the strongest tendency to increase than the Knowledge/asset-exploiting activities (Michel, 2008). In turn, we expect that at least some of the potential benefits of such investment would be to parent company, raising it innovative capacity at home.

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

Specifically, our econometric results 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 only when firms invest in knowledge/asset-seeking R&D.

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. Section 5 presents the estimation results, and section 6 concludes the paper.

2. Conceptual Framework and Hypotheses

MNCs do not pop up randomly in foreign countries. They constantly attempt to increase their profits over time and choose to undertake foreign R&D investment in locations where their long-term profitability is expected to be improved. Diverse factors mediate the choice of a foreign location and motivate an MNC to invest: The resource-seeking and market-seeking investment approaches, which were the first motives for foreign investment, and the efficiency-seeking and strategic asset or capability-seeking investment, which came out in 1960 (Behrman, 1972 and Dunning, 1992).[2]

As noted in Narula (2003), the first three kinds of investment can represent motives which are primarily asset exploiting in nature, while the strategic asset-seeking investment represents an asset augmenting activity whereby firms choose to acquire additional assets over their existing created ones to protect their long-term competitive

[2] A detailed analysis of the four motives of foreign investment is presented in Ben Hamida (2007).

power. It is largely argued that MNC's foreign activities, as a mean of exploiting its existing knowledge abroad, actively contribute to the transfer of new technologies to the host country, while MNC's activities as a mean of acquiring a host country's knowledge contribute to the reverse technology transfer from foreign units to domestic activity and between subsidiaries (Frost, 1998; Zhou, 2002; Monteiro et al., 2008; and Ben Hamida and Piscitello, 2008) .

Recent literature suggest that the MNC's foreign expansion can be regarded not only as a way to internally exploit its existing ownership advantage on a host market (Hymer 1960, and Casson and Buckley 1976), but also as a way to absorb local knowledge and then build new firm-specific advantage (Kuemmerle, 1999). Thus, by investing in knowledge/asset-seeking R&D, the MNC's explicit motive is to gain access to new technologies (e.g. innovative capacities, managerial and organizational knowledge, intangible resources, a better comprehension of the local customers) from the host country (Dunning and Narula 1995), raising its innovation performance in the home country. It emerges then that MNCs in the home country may gain benefit from reverse technology transfer which would complement their domestic R&D activities (Piscitello and Santangelo, 2008 and Ben Hamida and Piscitello, 2008).

Despite these strong arguments supporting that MNCs' R&D operations at foreign locations may positively influence their domestic R&D activity at home, evidence on the effect of this reverse knowledge transfer from the affiliates to the parent company is still very scarce. This could be to some extent explained by the fact that the effect of the reverse knowledge transfer is difficult to assess since it depends on a number of factors, mainly, the MNC's motives for performing foreign R&D. It is argued that reverse

knowledge transfer should be differentiated by knowledge/asset-exploiting activity and knowledge/asset-augmenting activity and that the effect is more likely to occur when MNCs invest abroad to augment their existing knowledge/assets (Ben Hamida and Piscitello, 2008).

The current literature on the effect of MNCs' R&D activity conducted abroad on their innovation performance at home 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 & Ghoshal, 1989; Kuemmerle, 1999; and 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 & Piscitello, 2000 and Tallman & 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 & Pearce, 1997 and Kuemmerle, 1999).

Theory and evidence on MNCs (Cantwell, 1995; Almeida, 1996; Dunning, 1998; and 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 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, and Piscitello and Rabbiosi 2006).

The above discussion raises the following research questions:

H1: Do MNCs' R&D activities conducted abroad positively impact their R&D activities at home?

H2: Does the distinction of firms according to the type of R&D motives yields differences in results?

H3: Do firms investing in knowledge/asset-seeking R&D gain larger benefit from their foreign activities than firms investing in knowledge/asset-exploiting R&D?

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.

In this context, Hollenstein (2008) stated that, during the last three decades, the level of the internationalization of Swiss firms' innovative activity (R&D here) strongly increased. This seems to be confirmed by Michel's study (2007) that, based on an analysis of patents of 71 Swiss MNCs issued between 1978 and 2006, she 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 into 2006-2008, by sector and type of R&D motives.[3] While, table 2 reports the sectoral share of Swiss firms' R&D abroad, part of their whole R&D investment, in 2004 and 2007 (percent). The data for these tables are derived from innovation activity survey (2005 and 2008) of manufacturing firms, with at least 5 employees providing a full coverage of large firms, 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 1262 manufacturing firms – 166 performing R&D abroad – within the period 2003-2005 and 1069 firms – 146 performing R&D abroad – within the period 2006-2008. All of 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.

[3] Following Narula (2003), the motives considered in this paper are classified into knowledge-seeking R&D and knowledge-exploiting R&D.
[4] Questionnaires can be downloaded from www.kof.ethz.ch, but the firm-level data are unpublished and highly confidential.

In general, the share of Swiss manufacturing MNCs performing R&D abroad is about 15% indicating that at the aggregate level Swiss firms do not seem to largely invest in foreign R&D activity. This share seems to be equally distributed between R&D knowledge-seekers and R&D knowledge-exploiters. However, across sectors this result changes considerably; that is, in some sectors the share of Swiss MNCs investing in foreign R&D becomes large as in pharmaceuticals, plastics, and communication equipments. While in others it remains small, particularly in metalworking, wood products, textiles, and food. In addition, firms in sectors such as textiles, plastics, metal production, and electrical machinery appear to invest more in knowledge-exploiting R&D while firms in, mainly, chemicals, pharmaceutical, and non-metal mineral products invest more in knowledge-seeking R&D. And there are also sectors (e.g. tobacco, food, and watches) wherein the share of firms investing in knowledge-seeking R&D remains as much as that of firms performing knowledge-exploiting R&D.

Regarding the share of Swiss firms' R&D at foreign locations relative to that at home, table 2 reports that this share is equal to 26 percent in 2004 and hides significant differences across sectors, that is it recognizes a substantial increase up to 63 percent in paper, followed by chemicals, watches and transport equipments, while in other sectors it falls by as much as 7 percent in non-metal mineral products and 9 percent in metalworking. In 2007, the share of foreign R&D investment within Swiss MNCs slightly decreased to 20 percent. This decrease results from the fact that firms in most manufacturing sectors (12 of sectors) recognized a sharp decrease in the share of their foreign R&D investment. These sectors are mainly paper, transport equipments, and chemicals. Nonetheless, it is also noteworthy that firms in other sectors such as

pharmaceuticals and watches increased their R&D investment level in foreign locations, marking that R&D activity in these sectors is no longer centralized at the home.

In this context, testing whether foreign R&D investment may increase the innovative capacity of the home country is the focal point of our empirical analysis discussed in following sections. In particular, we test econometrically whether foreign and domestic R&D of Swiss MNCs are complement or substitute and whether this relationship is influenced by the type of motives for foreign R&D investment.

4. Econometric models and variables

We test for the effects of the foreign R&D activity of Swiss MNCs on their domestic R&D activity in the home country, in which the domestic R&D investment of firm i between 2006 and 2008 is a function of its foreign investment in R&D in 2007 as follows.[5]

$$R\&D\exp_{ij,06-08} = a_0 + a_1 Overseas\ R\&D_{ij,07} + a_2 Size_{ij,07} + a_3 Investment_{ij,06-08} + a_4 Pdty\ GAP_{ij,07} + a_5 Skilled\ Lab_{ij,07} + a_6 Competition_{ij,07} + a_7 FP_{j,07} + a_8 R\&D\exp_{j,06-08} + a_9 FOR_{ij,07} + a_{10} Incentives_{ij,06-08} + u_i \quad (1)$$

Where the subscripts i and j denote firm and industry, respectively.

- $R\&D\exp_{ij}$ is our proxy for the domestic innovative effort of the firm i in industry j and measures its own expenditure on domestic R&D within the period 2006-2008.

[5] Table 3 details the variables and their measurements, table 4 reports their descriptive statistics, and table 5 shows their Pearson correlations.

- $Overseas\ R\&D_{ij}$ is the measure of the firm's foreign activity in R&D in industry j and is calculated as its percentage share of foreign R&D, part of its whole R&D investment in 2007. This measure allows for the assessment of the effects of knowledge transfer from FDI in R&D on the innovation performance of investing MNCs and thus if foreign and domestic R&D of the firm are complements or substitutes.
- FOR_{ij} is a dummy variable used to control if the firm i in the industry j is foreign-owned or domestic.

The literature suggests as well the use of other firm's characteristics such as the size, the absorptive capacity, and the percentage of the qualified labors, since they influence the innovative capacity of the firm. Larger firms may be more efficient and hence they should take more advantage of innovations (Dimelis and Louri 2002, Meyer and Sinani 2004). In addition, firms that have achieved competitive technological levels at home and possess a sufficient level of absorptive capacity in terms of learning and investment efforts are more able to make productive use of foreign knowledge. (Cohen and Levinthal, 1990; Cantwell, 1989; and Ben Hamida and Gugler, 2008). Yang et al. (2008) state that firms with more available relevant knowledge would like to invest more in foreign R&D to absorb external knowledge. And large shares of qualified labors are also likely to raise the firms' innovative capacity.

- $Size_{ij}$ is the measure of the firm's size in industry j, defined as the number of its employees.

- $Pdty\ GAP_{ij}$ is the measure of the technological capacity of the firm i. It is measured by the difference between the firm's own labor productivity and the average labor productivity in its industry j in 2007.
- $Investment_{ij}$ is the level of investment expenditures in new equipment and training activities for product/process innovation, within the period 2006-2008.
- $Skilled\ Lab_{ij}$ is a measure of the percentage share of the firm's skilled labors in 2007.

And as there are often many firms operate in the same industry, it is argued that the intensity of competition on the market might influence the innovative performance of the firm. Hollenstein and Arvanitis (2006) assume that a firm‘s decision to perform foreign R&D is not independent of the market environment in which it operates. A very competitive market environment, for example, forces firms to move nearer to the customer, what may induce market-seeking (sales-supporting) R&D activities.

- $Competition_{ij}$ is the measure of the intensity of competition of the firm i in its industry j in 2007, in terms of prices and other aspects of competition (such as product differentiation, flexibility to meet the needs of customer services, etc.). It is calculated based on a five-point Likert scale.

In addition, 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.

- FP_j is the measure of foreign presence, calculated for each industry as the ratio of the foreign firms' sales to total sales in 2007.

We control for the industry-specific knowledge differences using the variable R&D intensity in the industry – $R\&D\exp_j$ – measured by the sum of the firms' expenditures on domestic R&D in the industry j, except for the firm i. This variable corrects for the omission of unobservable variables that might undermine the relationship between the foreign R&D activity of the firm and their Domestic R&D. It is calculated as

$R\&D\exp_j = \sum_{k \neq i} R\&D\exp_{kj}$; where k are the firms belonging to sector j within the period 2006-2008.

And finally, we control whether the firm investing abroad benefits from national and/or international public financial incentives. Doing so, we might examine the role of the national and international institutions in increasing the innovative capacity of the firm. It is by far argued that host countries use more and more substantial financial incentives to attract MNCs (UNCTAD, 2003).

- $Incentives_{ij}$ is a dummy variable indicating whether the firm i benefits or not from public financial incentives within the period 2006-2008. We test, alternatively, the effect of national and international incentives.

To test our hypotheses 3 and 4 in which the size and the extent of the effect of the foreign R&D activity of Swiss MNCs on their domestic R&D activity in the home country may vary according to the diverse types of motives for foreign R&D investment, we proceed to make various tests using equation (1). We divide our full sample of firms investing abroad into two sub-samples characterized by the type of R&D motives and estimate equation (1) separately for firms investing in knowledge-seeking R&D and knowledge-exploiting R&D.

We test equation (1) using KOF data derived from the surveys of 2008. Because of missing data for some variables, the regression analyses make use of a sample of only 87 manufacturing firms performing foreign R&D activity, 26 firms investing in Knowledge-seeking R&D, and 29 firms investing in knowledge-exploiting R&D.

We test for the equality of coefficients across sub-samples using Chow-tests. All regression results are robust and refer to OLS estimations of equation (1).

5. Empirical findings

Regression 6.1 and 6.2 in table 6 shows the results of the effect of MNCs' foreign R&D investment on their domestic R&D investment in the home country using the full sample of manufacturing firms. The estimated coefficient of the variable $Overseas\ R\&D_i$ is negative and not significant, showing that the firm's innovative capacity at home in terms of R&D investment in 2006-2008 does not increase with its own foreign R&D investment in 2007.[6] This result does not support our hypothesis 1; that is the assumption that the reverse knowledge transfer is homogeneous across the full sample of firms, without any distinction by the type of R&D motives is rejected. The absence of evidence for reverse knowledge effect in Swiss manufacturing firms, when taking all the firms together, appears to indicate that this effect might be determined by the firms' heterogeneity in terms of the type of R&D motives as was arguably suggested by among others (Cantwell and Piscitello, 1999; Griffith et al. 2004, Piscitello and Rabbiosi 2006; Mudambi et al., 2008; and Ben Hamida and Piscitello, 2008).

[6] Table 7 summarizes our hypotheses and their corresponding estimated results.

Firms' characteristics do not seem to have any significant effect on domestic R&D performance of all firms, except the size in which larger firms see to take more advantage of innovations. The presence of foreign firms in the industry does not seem to have significant positive spillover effects. And international institutions appear to have significant role in increasing the innovation performance of MNCs, that is international public incentives have a positive significant effect on the domestic R&D investment of Swiss MNCs (regression 6.2).

In regressions 6.3-6.6, we have divided our full sample of manufacturing firms into sub-samples of firms characterized by the type of R&D motives and we have made various tests of the effect of reverse knowledge transfer using equation (1). Our results change considerably wherein significant effects occur for firms in some sub-samples of data. This seems to confirm our hypothesis 2 in which the distinction of firms according to different R&D motives yields differences in results. The chow tests soundly support our divisions of manufacturing sample.

In regressions 6.3 and 6.4 we have proceeded to divide the entire sample of manufacturing firms into two sub-samples characterized by the type of R&D motives (knowledge-seeking R&D and knowledge-exploiting R&D). The results suggest that the estimated coefficient for $Overseas\ R\&D_i$ is only positive and highly significant in the sub-sample of Swiss firms with knowledge-seeking R&D (regression 6.3). This result could be interpreted as reflecting that, as expected, firms performing knowledge-seeking R&D manage to fully exploit the technological opportunities arising from their

investment in foreign locations by increasing their innovation performance.[7] This finding corroborates our hypothesis 3, in which the sub-sample of firms with knowledge-seeking R&D seems to benefit the most from the effect of reverse knowledge transfer. We could thus state that domestic investment in R&D of such kind of firms is effectively complemented with their foreign R&D activities.[8] In addition, the size, the technological capacity, and the intensity of competition on the market seem to positively affect the innovation performance of firms with knowledge-seeking R&D. These firms seem to also gain benefits from the presence of foreign affiliates in their industry. And as far as national public incentives are concerned in regressions 6.3 and 6.4, we find that they have any significant effect.

Similar to regressions 6.3 and 6.4, in regressions 6.5 and 6.6, we have made the same tests for the effect of reverse knowledge transfer according to type of R&D motives but with a control for the role of international public incentives. Doing so, for the sub-sample of firms performing knowledge-seeking R&D (regression 6.5), the estimated coefficient of $Overseas\ R\&D_i$ remains positive but no longer significant, while the estimated coefficient for public incentives, $Int-Incentives_{ij}$, become significant once considering the international incentives. The insignificance of $Overseas\ R\&D_i$ could be due to the positive correlation effect we found between the two regression variables (about 0.46), that is firms benefiting from international incentives seem to invest more in knowledge-seeking R&D. This (high) correlation might undermine the significant effect of $Overseas\ R\&D_i$.

[7] This finding is in line with, among others, Kotabe (1990), Cantwell & Piscitello (2000), and Tallman and Yip (2001).

[8] Hollenstein and Arvanitis (2006) and Hollenstein (2008) also found that domestic and foreign R&D of Swiss MNCs are complements, based on a descriptive analysis of FDI motives in R&D.

Regarding other regression variables, the results are quite similar to regression 6.3.

In addition, for the sub-sample of firms investing knowledge-exploiting R&D, the estimated coefficient of $Overseas\ R\&D_i$ remains negative and becomes significant showing that foreign R&D activity of firms benefiting from international incentives seems to substitutes their domestic R&D activity.

6. Conclusions

This paper addresses the effects of FDI in R&D on the innovative capacity of the home country of the MNC. It hypothesizes that the foreign R&D activity of MNCs would positively affect their domestic R&D activity in the home country in terms of reverse knowledge transfer, and that this effect depends largely on the type of R&D motives. Many have studied the traditional knowledge transfer from the parent company to foreign affiliate, but there is still scarce evidence on the effect reverse knowledge transfer from the foreign affiliates to the parent company at home.

Based on a sample of Swiss manufacturing firms, we show that it is important to take account of the type of R&D motives when evaluating the effect of reverse knowledge transfer generated from FDI in R&D. That is, taking all the firms together the results do not reveal significant evidence for reverse knowledge benefit in Switzerland, so foreign R&D investment of MNCs does no seem to complement their domestic R&D investment at home. However, looking separately at the sub-samples of Swiss firms characterized by the type of R&D motives yields differences in results. In fact, we find that foreign R&D activity of Swiss MNCs is increasingly a valuable source of knowledge which is complementary to their domestic R&D activity only for the sub-

sample of firms performing knowledge-seeking R&D. This evidence is stronger when firms benefit from national public incentives than international incentives. However, in the sub-sample of firms investing in knowledge-exploiting R&D, domestic R&D investment decreases in response with the share of the foreign R&D investment. These findings underline the importance of controlling for the firms' characteristics regarding R&D motives when assessing the effect of the reverse knowledge transfer.

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 when they invest in knowledge-seeking R&D. Actions should then promote foreign affiliates' ability to engage in knowledge-seeking R&D and then transferring local knowledge to parent company in the home country.

A future research aiming to analyze other determinants of the reverse knowledge transfer is promising such as the characteristics of knowledge, the location of foreign R&D, etc. For example, Yan et al. (2008) suggest that knowledge relevance could help parent firms pay attention to the new knowledge of affiliates and recognize the potential benefits. The more their knowledge overlaps, the more likely the parent takes interest in the affiliate's knowledge and understands its benefits.

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Table 1: Share of Swiss manufacturing MNCs performing overseas R&D during the period 2006-2008: Sectoral share by type of R&D motive (percent)

Sector	OutR&D	OutR&D Knowledge-seeking R&D[a]	OutR&D Knowledge-exploiting R&D[b]
Manufacturing	15.3	4.9	5.3
Food	9.8	0.9	0.8
Tobacco	47.4	47.4	47.4
Textiles	8.4	2.1	4.2
Wood products	8.5	8.5	8.5
Chemicals	25.5	12.1	8.4
Pharmaceuticals	42.0	19.6	8.4
Plastics	34.8	0.0	9.5
Non-metal mineral products	23.2	18.4	0.0
Metal production	20.2	0.0	7.9
Metalworking	8.8	3.3	3.0
Machinery	21.2	4.8	6.4
Electrical machinery	26.4	2.8	9.5
Communication equipments	26.6	12.9	13.7
Medical instrument	21.5	4.7	6.2
Watches	6.2	6.2	6.2

OutR&D denote foreign R&D

a: share of Swiss MNCs assessing knowledge-seeking R&D as an important motive (value 4 or 5 on five-point Likert scale)

b: share of Swiss MNCs assessing a knowledge-exploiting R&D as an important motive (value 4 or 5 on five-point Likert scale)

Source: Author's calculations of data derived from KOF innovation surveys (2008).

Table 2: Sectoral share of Swiss firms' R&D abroad, part of their whole R&D investment, in 2004 and 2007 (percent)

Sector	2004	2007
Manufacturing	25.9	19.2
Food	11.1	13.1
Textiles	18.2	13.5
Wood products	35.9	40
Paper	63.1	9
Chemicals	46.7	21.8
Pharmaceuticals	14.1	49.5
Plastics	14.7	3.1
Non-metal mineral products	7.5	22
Metal production	11.7	9.8
Metalworking	9.4	27.1
Machinery	27.3	16.4
Electrical machinery	14.8	13
Computer and office equipments	29.8	25
Communication equipments	16.5	14.4
Medical instrument	19.9	15.3
Watches	42.5	70
Transport equipments	40	16.4
Other manufacturing	33.5	2.4

Source: Author's calculations of data derived from KOF innovation surveys (2005 and 2008).

Table 3: Variable definitions

Variables	Definitions
$R\&D\exp_{ij}$	The firm's expenditure on domestic R&D in the industry j (in 10'000000 CHF) within the period 2006-2008.
$Overseas\ R\&D_{ij}$	The firm's percentage share of foreign R&D, part of its whole R&D investment in 2007.
FOR_{ij}	A dummy variable used to control if the firm i in the industry j is foreign-owned or domestic in 2007.
$Size_{ij}$	The number of the firm's employees.
$Competition_{ij}$	Intensity of Competition based on a five-point Likert scale: value 1 for very low degree of competition and value 5 for very high degree of competition, calculated for 2007.
$Pdty\ GAP_{ij}$	The difference between the firm's own labor productivity and the average labor productivity in its industry j (in 10'000 CHF), calculated for 2007.
$Investment_{ij}$	The level of investment expenditures in new equipment and training activities for product/process innovation, within the period 2006-2008.
$skilled\ Lab_{ij}$	The percentage share of the skilled labor in the firm in 2007.
FP_j	The ratio of the foreign firms' sales to total sales in 2007.
$R\&D\exp_j$	The sum of the firms' expenditures on domestic R&D in the industry j, except for the firm i (in 100'000000 CHF), within the period 2006-2008.
$Nat-Incentives_{ij}$	A dummy variable indicating whether or not the firm benefits from national public incentives within the period 2006-2008.
$Int-Incentives_{ij}$	A dummy variable indicating whether or not the firm benefits from international public incentives within the period 2006-2008.

Table 4: Descriptive statistics of variables by type of R&D motives

Sample		Full sample of firms		Firms investing in knowledge-seeking R&D		Firms investing in knowledge-exploiting R&D	
Variables	Unit	Mean	S.D.	Mean	S.D.	Mean	S.D.
$R\&D\exp_{ij}$	10'000000 CHF	3.5	15.7	2.07	8.7	8.04	26.7
$Overseas\ R\&D_{ij}$	%	17.4	18.1	16.2	13.4	20.6	20.4
FOR_{ij}		0.28	0.45	0.26	0.45	0.37	0.49
$Size_{ij}$		476.0	980.2	371.9	1098	35.5	28.8
$Competition_{ij}$		7.21	1.3	7.1	1.59	7.17	1.16
$Pdty\ GAP_{ij}$	10'000 CHF	5.53	20.32	-0.29	8.18	11.7	32.3
$Investment_{ij}$		2.75	0.71	2.79	0.84	2.8	0.64
$skilled\ Lab_{ij}$	%	71.7	20.0	69.7	18.4	75.4	18.6
FP_j	%	33.1	27.2	26.4	18.0	35.5	28.8
$R\&D\exp_j$	100'000000 CHF	13.65	35.8	17.2	39.9	11.4	31.6
$Nat-Incentives_{ij}$		0.2	0.4	0.23	0.42	0.24	0.43
$Int-Incentives_{ij}$		0.12	0.33	0.15	0.36	0.24	0.43

Table 5: Pearson correlations of variables using the full sample of firms

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) $R\&D\exp_{ij}$	1.00											
(2) $Overseas\ R\&D_{ij}$	0.02	1.00										
(3) FOR_{ij}	0.16	0.03	1.00									
(4) $Size_{ij}$	0.76***	0.08	0.06	1.00								
(5) $Competition_{ij}$	0.08	-0.28***	-0.06	0.14	1.00							
(6) $Pdty\ GAP_{ij}$	0.03	0.28***	0.26**	0.001	0.03	1.00						
(7) $Investment_{ij}$	0.06	-0.12	-0.09	0.16	0.2	-0.1	1.00					
(8) $skilled\ Lab_{ij}$	0.13	0.14	0.35***	0.1	-0.09	0.23**	-0.01	1.00				
(9) FP_j	0.11	-0.12	0.23	0.11	0.03	0.17*	0.07	0.17*	1.00			
(10) $R\&D\exp_j$	-0.03	0.17	0.06	-0.06	-0.08	-0.08	-0.03	-0.03	-0.29***	1.00		
(11) $Nat-Incentives_{ij}$	0.29***	0.11	0.05	0.39***	-0.12	-0.1	0.04	0.05	0.07	0.04	1.00	
(12) $Int-Incentives_{ij}$	0.36***	0.07	-0.08	0.34***	-0.06	-0.08	0.11	0.02	-0.1	0.01	0.31***	1.00

*, **, and *** denote the significance level of the correlation coefficients at the 10%, 5%, and 1% levels, respectively.

Table 6: Estimation results for manufacturing: the role of R&D motives

Variables	6.1	6.2	6.3	6.4	6.5	6.6
Overseas R & D$_i$	-0.073	-0.077	0.03*	-0.31	0.014	-0.36*
	(0.073)	(0.071)	(0.01)	(0.19)	(0.01)	(0.18)
Size$_i$	0.012***	0.011***	0.007***	0.015***	0.007***	0.014***
	(0.001)	(0.001)	(0.0002)	(0.002)	(0.0002)	(0.002)
Investment$_i$	-1.37	-1.54	-0.78***	-1.11	-1.15***	-1.65
	(1.66)	(1.62)	(0.29)	(5.54)	(0.3)	(5.13)
Pdty GAP$_i$	0.02	0.03	0.10***	0.06	0.14***	0.08
	(0.06)	(0.06)	(0.04)	(0.12)	(0.03)	(0.11)
Skilled Lab$_i$	0.02	0.019	0.006	0.13	0.01	0.16
	(0.06)	(0.06)	(0.009)	(0.21)	(0.008)	(0.2)
Competition$_i$	-0.53	-0.31	0.3**	-1.42	0.3***	-0.88
	(0.96)	(0.93)	(0.1)	(3.07)	(0.1)	(2.81)
FP_j	0.0017	0.012	0.05***	0.03	0.07***	0.06
	(0.04)	(0.04)	(0.02)	(0.12)	(0.02)	(0.11)
Nat – Incentives$_i$	-0.65		-0.03	0.59		
	(3.16)		(0.43)	(9.18)		
Int – Incentives$_i$		6.71*			1.15*	11.57
		(3.67)			(0.57)	(8.36)
$R \& D \exp_j$	0.01	0.01	0.004	-0.02	0.008*	-0.04
	(0.03)	(0.03)	(0.005)	(0.1)	(0.004)	(0.1)
FOR_i	3.04	3. 4	-1.12	7.67	-1.17**	7.6
	(2.87)	(2.82)	(0.76)	(8.05)	(0.71)	(7.51)
$\overline{R}^2$	0.54	0.56	0.9	0.62	0.9	0.62
F-Chow			5.84		6.66	
N	87	87	26	29	26	29

Regressions 6.1 and 6.2 refers to the results using the full sample of firms investing in R&D abroad, 6.3 and 6.5 refers to the estimation using the sub-sample of firms investing in knowledge-seeking R&D, and 6.4 and 6.6 refers to the estimation using the sub-sample of firms investing in knowledge-exploiting R&D. All these estimations use the 2008 survey-level data.

All standard errors, in parentheses, are corrected for heteroskedasticiy.

*, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 7: Hypotheses and estimated results

Hypotheses	Regressions	Support (S)/not support (N)
H1	6.1 and 6.2	N
H2	6.3-6.6	S
H3	6.3	S
	6.5	N