

Foreign subsidiaries as a channel of international technology diffusion Some direct firm level evidence from Belgium*

by

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Abstract

The use of foreign direct investment as a channel of international spillovers is by now fairly established in the empirical literature on innovation and growth. It is often argued that subsidiaries of foreign multinational enterprises are a mechanism through which technological know-how flows across borders. For foreign subsidiaries to be channels of international spillovers, these subsidiaries need to source know-how internationally and transfer their know-how to the local economy. Using direct firm level evidence from Belgian Community Innovation Survey on the occurrence of technology transfers, we find that foreign subsidiaries are indeed more likely to acquire technology internationally. But after controlling for the superior access to the international technology market that foreign subsidiaries enjoy, we find that these firms are not more likely to transfer technology to the local economy as compared to local firms.

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1. Introduction

Ever since innovation was identified as an important driver of economic growth, policy makers have had a keen interest in understanding how the process of developing and integrating new knowledge in the innovation process leads to successful innovation. The models of endogenous innovation-driven growth (a.o. Grossman & Helpman (1991)) have emphasized the importance of knowledge spillovers for economic growth. Knowledge spillovers need not be confined to domestic borders. Therefore, the current empirical literature identifies the international transfer of technology as an important source for growth (e.g. Helpman (1997))¹. Different channels can be considered through which international technology transfers occur. The majority of empirical studies follow Coe and Helpman (1995) in analyzing the diffusion of technological know-how embodied in trade flows. Domestic firms can learn from the foreign goods they import by reverse engineering the technological innovations embodied in these goods. But there are other means through which technological knowledge can flow across national boundaries. An obvious alternative is foreign direct investment (FDI). Although the entry of foreign affiliates increases the competition for local producers, the production and/or research activities undertaken by multinational affiliates can confer “spillover” benefits to the local economy. Knowledge may flow from the affiliate to local producers through formal and informal contacts, or trained affiliate personnel switching jobs to the local economy. Despite all these potential benefits, the available empirical studies on spillover benefits from FDI have nevertheless generally failed to find robust evidence of positive effects from multinational investment on local productivity (see Mohnen (2001) for a review).

Despite the body of empirical research on the topic, and given the widespread belief among policy makers that FDI is good for growth, it is surprising that the link between technology transfers from FDI and growth is still a black box. Whether subsidiaries of foreign firms indeed are channels of international spillovers and hence are interesting sources of technology transfers to the local economy requires two conditions to be fulfilled. First, foreign subsidiaries should source technology internationally, and second, this technology should be transferred, willingly or unwillingly, to the local market. However, not much is known about the conditions and mechanisms through which

multinational firms do indeed acquire and transfer technology. Without a clearer understanding of these mechanisms it is difficult to evaluate what sorts of FDI are consistent with growth and to distinguish positive from negative effects of FDI.

Our research aims to contribute to the understanding of the relationship between FDI and host market growth by focusing on an empirical analysis of the existence of technology acquisitions and transfers by foreign subsidiaries. The eclectic theory on MNEs (e.g. Dunning (1988), Caves (1996)), provides some theoretical insights on both issues. The first issue is whether firms that form part of a foreign based multinational group are more able to acquire internationally available technology, compared to local firms. Since MNEs are characterized by their superior 'knowledge base', which is an ownership specific advantage that can be exploited in other markets through FDI, there will be know-how transfers from the parent to the subsidiary. In addition, subsidiaries may have easier access to externally available international technology by using their group's network of establishments worldwide for technology sourcing.²

While the affiliate might have access to an international base of know-how, this does not automatically imply the affiliate will transfer its know-how to the local market. This raises the second issue on whether foreign subsidiaries will transfer technology locally. Obvious motives for transferring technology are the monetary returns in case of licensing out or R&D contracting with local firms. But there is also a vast amount of know-how transferred without counter-payments. Know-how leaks out involuntarily through informal contacts, personnel mobility etc. Although these involuntary spillovers are mostly considered to be exogenous to the firm, reflecting the imperfect appropriability of know-how, firms may nevertheless engage in strategies to prevent know-how from leaking out. For instance, beyond building in secrecy, complexity or lead time, they can minimize the mobility of personnel through paying higher wages or select an entry mode that minimizes spillovers. As the eclectic theory indicates, the MNE has typically chosen to internalize

¹ See Rodriguez & Rodrik (1999) for a more skeptical view on previous empirical literature

² Especially the recent emphasis in the literature on the more active role of subsidiaries in global technology sourcing for the multinational innovation strategy, implies that subsidiaries are more innovation active and are more likely to interact with their external affiliated and non-affiliated environment both nationally and internationally (see

the transfer of technology through FDI rather than licensing in order to maintain control on technology flows.³ From this perspective, MNEs, may be less likely to transfer technology locally, as compared to indigenous firms.

Rather than inhibit informal flows of know-how, firms are often found to actively nurture these flows, as the growing emphasis on the importance of networking suggests. The motivation for the sender lies in the reciprocal access to know-how (a.o. von Hippel (1988), Schrader (1991)). Firms transfer know-how to be able to acquire technology in return.⁴ Alliances can be a particularly effective mechanism for linking external technology sources. Technological alliances allow firms to actively and voluntarily manage transfers of know-how between partners. Therefore, cooperative agreements between local firms and subsidiaries can include an important technology transfer component, at least if the technologies available in exchange are valuable to the partners.

While the existing empirical literature typically relies on indirect evidence for international spillovers through assessing the effects of FDI on local productivity, in contrast, we explore direct measures of technology transfers obtained from survey data on Belgian manufacturing firms from the EUROSTAT Community Innovation Survey. We test whether foreign subsidiaries are more or less likely to transfer their technology locally, as compared to local firms, controlling for whether foreign subsidiaries can more easily source technology internationally. Various embodied and disembodied technology transfer and acquisition mechanisms are considered including internal transfers between headquarters and affiliates and transfers to and from external partners. Therefore, we are able to disentangle the two conditions for having foreign subsidiaries as mechanisms for international technology spillovers: sourcing international know-how and transferring know-how to the local economy.

a.o. the Research Policy Special Issue on the Internationalization of Industrial R&D, 1999, for some evidence on this).

³ See Fosfuri (2000) for a theoretical model of firms deciding between licensing, which induces dissipation of know-how, versus FDI, which involves higher set-up costs but can prevent know-how from dissipating. He finds that if imitation costs are low, firms will prefer FDI. Ethier & Markusen (1996) however indicate that locating production factors abroad in case of FDI will still lead to dissipation of know-how. Only exports can prevent spillovers.

⁴ Siotis (1999) for instance discusses the choice between exports and FDI, considering reciprocal spillovers. Although FDI will lead to dissipation of know-how, it simultaneously allows for the possibility to source local know-how. He finds that if imitation is easy, the technologically backward firm may prefer FDI over exports for

The main result of the paper is that companies that source technology internationally are more active in generating local know-how transfers. This implies that technology transfers to the local economy are more likely to originate from firms that have acquired technology internationally. We find that being part of a multinational group makes international sourcing more likely and, hence, makes technology transfers to the local economy more probable. But this indirect effect is not sufficient to compensate for the direct negative effect which being affiliated to an international group has on the likelihood of the occurrence of local technology transfers. Having controlled for access to the international technology market, foreign subsidiaries are less likely to transfer technology locally and be locally networked. As a result indigenous firms that have access to international technology could be interesting alternative targets for know-how diffusion to the local economy.

Unfortunately, our data do not allow us to measure the effect of technology transfers on (growth in) productivity of firms and industries of the local economy. However, given that the wider body of existing empirical work on the effects of international technology transfers on growth leaves inconclusive evidence (see Mohnen (2001)), we feel that distinguishing between the issue of existence of technology transfers and the issue of their effects on growth is an important first step for getting a clear view on this important but ambiguous relationship.

The outline of the paper is as follows. In the next section we briefly review the existing empirical literature. Section 3 discusses the sample. In Section 4 we specify the model and present the main results of our analysis on the determinants of local technology transfers from manufacturing firms located in Belgium. Section 5 presents some extensions to the empirical model, while Section 6 concludes.

2. Technology transfers to the local economy

Rather than measuring international R&D spillovers via trade, more recent empirical models in *International Trade* have started to focus on the effects of FDI on output growth (see a.o.

Lichtenberg and van Pottelsberghe (1998), Barell & Pain (1999), Baldwin *et al.* (1999), Braconier *et*

technology sourcing motives, while the technological leader will prefer exports to prevent know-how from spilling over. See also Fosfuri & Motta (1999) for similar results.

al. (1999). FDI flows are used as weights when summing the stock of foreign R&D, based on the notion that FDI increases the proximity between the home and host country and hence leads to higher spillovers⁵. The magnitude of spillovers is asserted from the return on foreign R&D, i.e. by how much foreign R&D increases domestic output. Lichtenberg and van Pottelsberghe de la Potterie (1998), combining Coe and Helpman's trade data with data on inward and outward FDI across OECD countries, find positive output elasticities for import-weighted foreign R&D and outward FDI weighted foreign R&D while inward FDI does not seem to matter.

Industrial Organization studies at the industry and firm level infer the presence of international knowledge spillovers from changes in the productivity of domestic firms associated with the "entry" of foreign subsidiaries. Without a direct measure of technology transfers, these effects include not only technology transfers, but also the effect of increased competition from the presence of affiliates. In one of the early industry studies, Caves (1974) attempts to distinguish between the competitive effect and the technology diffusion effect. He finds that average profit rates are lower in industries with a higher percentage of foreign subsidiaries. This result supports the hypothesis of increased allocative efficiency. At the same time, he finds that in industries that have a higher percentage of output produced by foreign owned firms, domestic owned firms have higher value added per worker. This is consistent with domestic firms increasing their technical efficiency and taking advantage of technology transfers by the multinational firms. More recent studies use firm level evidence, correlating domestic firms' productivity to the presence of foreign affiliates in the industry. Most of the studies are for developing countries and have failed to find robust evidence of positive knowledge spillovers from multinational investment, accounted for by the lack of absorptive capacity in the host country (a.o. Aitken & Harrison (1999), Blömström & Sjöholm (1999), and Blömström & Kokko (1998) for a review). Turning to evidence for developed countries,

⁵ Next to trade and FDI flows, international knowledge transfers may also be traced through foreign technology payments, i.e. licensing fees, royalties on copyrights, payments for consulting services, the financing of R&D outsourced abroad, the acquisition of international targets in technology sourcing M&As. And there are also spillovers without counter-payments such as through international migration of people, informal international contacts, international conferences or trade fairs, international research collaborations. There is little research focusing on these international channels.

Haskel *et al.* (2002), using firm level data from the UK, do find a significant positive correlation, although this correlation is smaller for lagging domestic plants.

Rather than assessing technology transfers through FDI, by inferring them from their effect on local productivity, scholars in search of further improvements of the empirical literature have recently turned to alternative, more direct, measures of technology transfers. Patent citations are used to trace knowledge spillovers to assess technology transfers.⁶ Branstetter (2000) uses patent citations to foreign subsidiaries by local firms to measure international inter-firm knowledge spillovers through FDI. Using US Patent Office data on the impact of changes in Japanese firm-level FDI on USPTO patent citation counts, he finds that Japanese FDI in the US is a significant channel of knowledge spillovers, i.e. increasing the likelihood of patent citations both by the investing Japanese firm to indigenous US firms and by the indigenous US firms to the investing Japanese firm. Similarly, Almeida (1996), using patent citations on foreign subsidiaries in the US semiconductor industry, finds that patents belonging to foreign firms located in the US are cited by local US firms more than expected, supporting positive technology transfers through FDI.

Patent citations are only a partial measure for technology transfers if only because not all innovations are patented. Survey level evidence provides more direct, be it subjective, evidence of technology transfers arising through affiliates of foreign firms. In a UK survey, Mansfield and Romeo (1980) found that two third of the sampled firms indicated that their technological capabilities were raised by technology transfers from US firms to their overseas UK subsidiaries. But only 20% felt that this effect was important.

3. Sample

The Belgian subsample of EUROSTAT's Community Innovation Survey in 1992⁷ provides direct survey evidence on the occurrence of international technology acquisition and local technology

⁶ The use of patent citations for knowledge spillovers has been pioneered by Jaffe, Trajtenberg and Henderson (1993). They use patent data to show that proximity matters and that being close to an external information source increases the impact of spillovers from that source on own know-how.

⁷ The survey intended to develop insights into the problems of technological innovation in the manufacturing industry and was the first of its kind organized in many of the participating countries. A representative sample of

transfers at the firm level. Firms were asked about their use of different mechanisms to acquire technology nationally and internationally, as well as the use of different mechanisms to transfer technology nationally and internationally. The mechanisms identified were: licensing, R&D contracting, consulting advice, acquiring & selling (parts of) companies, personnel mobility and other informal forms of technological acquisition.⁸ The advantage of this data set is that it provides direct and firm-specific information on technology transfers and allows to link national transfers of technology to international technology acquisition. A limitation is that it does not provide evidence on the importance of these flows. Furthermore, it only records local transfers as perceived by the sender.

Of the total Belgian sample firms, which includes innovating and non-innovating firms, 28% (N=204) are subsidiaries of a foreign based international group (*FSUB*). Only 4% (N=25) of the sample companies are Belgian Headquarters. This distribution is very typical for a small and open economy such as the Belgian economy, with little own multinationals but a pervasive representation of foreign affiliate firms. Foreign subsidiaries are on average more than double the size of local firms. With respect to the distribution of firm types across industries, foreign subsidiaries are over-represented in chemicals & pharmaceuticals, electronics, and cars.

Belonging to an international group is strongly associated with innovation. The dummy variable *INNOV* takes the value of 1 for firms that claimed to have been actively involved in introducing new or improved products or processes in the observed period 1990-1992 and reported a positive budget for innovation. 55% of sampled Belgian firms claim to be innovation active. For foreign subsidiaries, the percentage of firms claiming to be innovation active is 82%. These innovations are not simply imported but are associated with own R&D activities, since 70% of foreign subsidiaries in the sample are active in R&D. The dummy variable *MAKE* takes the value of

1335 Belgian manufacturing firms was selected. The response rate was higher than 50% (748). The researchers in charge of collecting the data also performed a limited non-response analysis and concluded that no systematic biases could be detected (Debackere and Fleurent (1995)).

⁸ Included in the sample was also the purchase/sale of equipment. We ignored the “embodied” purchase of equipment, mainly because too many firms responded positively on this item. Probably not all of them interpreted the question as buying equipment with the explicit purpose of obtaining new technologies as an alternative to developing the technology internally. Including purchase did not alter the reported results, but slightly reduced the significance.

1 for firms that report being permanently engaged in R&D activities. In the remainder of the analysis, we will have to restrict the sample to the innovating companies, since the survey only provides information on knowledge flows for this subsample (N=445). This might introduce a sample selection bias that is dealt with in the econometric analysis of Section 4.

Our measure of transfer of technological know-how to the local economy as dependent variable, *TRANSFERnat*, is a dummy variable with value 1 for innovative firms that report having transferred technology to a firm located in Belgium. Table 1 shows that only 80, or 18%, of the innovative firms in the sample report having transferred technology locally. Although the percentage is somewhat lower for foreign subsidiaries than for local firms, the difference is small. The most frequent mechanism reported as being used to transfer technology locally is “other forms, e.g. informal contacts” (43) followed by consulting advice (38) and personnel mobility (35).⁹ Transfers through licensing (20), R&D contracting (25) and company sell-offs (10) are less frequent.

Insert Table 1 here

Another mechanism through which technology can be transferred is cooperation in R&D. The survey allows us to check whether firms have cooperative agreements with local partners. *COOPnat* is a dummy variable with value 1 for innovative firms that have cooperation in R&D with a Belgian non-affiliated partner.¹⁰ The affiliates of foreign firms have a higher incidence of local cooperative agreements as compared to local firms (41.5% relative to 29.2%). Note that we can only measure the incidence of occurrence of local cooperation, not whether there are transfers of technology occurring to the local partner through cooperation.¹¹

⁹ Although it is always difficult to interpret an “other forms” category, in this case the framing of the questionnaire was clearly directed to informal contacts. The results of the analysis are not sensitive to including or not this category.

¹⁰ Cooperation with local partners includes competitors, vertically linked firms and research institutes. We exclude affiliated partners, since we want to focus on external transfers to the local economy. The reported results are not sensitive to this exclusion.

¹¹ In principle any transfer that occurs through such cooperative agreements should be recorded in our direct measure *TRANSFERnat*. There is no explicit category for cooperative agreements in *TRANSFERnat*, but “other, e.g. informal contacts” should be picking up this mechanism. However, of the 150 firms who report *COOPnat*,

Our measure for access to international technology is *BUYinat*, a dummy variable that takes the value of 1 if the firm has reported having acquired technology from abroad. This holds for 259, or 58%, of all innovative firms in our sample. The most frequently reported mechanism for international technology acquisition is again “other forms” (143) followed by licensing (133) and R&D contracting (101). Different from *TRANSFERnat*, personnel mobility (65) is a relatively less important mechanism for international acquisition of technology. Table 1 further shows that foreign subsidiaries have a higher frequency of acquiring technology internationally, with 76% of all innovation active foreign subsidiaries acquiring technology internationally. We would expect that a large part of these international technology acquisitions originate from their parent companies. Of the foreign affiliates located in Belgium who reported having acquired technology from abroad, 66% indicated they had received international transfers within the group, from sister or, typically, parent companies.¹²

A next step in the analysis is to examine if there exists a link between the international acquisition of technology and local technology transfer behavior. Table 1 shows that companies that acquire technology internationally have a higher frequency of transferring technology nationally. This holds especially for local Belgian firms when they acquire technology internationally: 29% of the local firms that buy technology internationally transfer technology locally, compared to an average of 18%. For foreign subsidiaries the frequency of local technology transfer is only marginally higher in the subgroup of subsidiaries that are acquiring technology internationally. Also, the incidence of local cooperation is higher for firms that acquire technology internationally, both for Belgian firms and foreign subsidiaries.

These first descriptive results already hint at the importance of access to the international technology market, rather than being part of a multinational concern, for explaining technology

only 47 reported positively on *TRANSFERnat*, from which only 29 also report “other, e.g. informal contacts” included in *TRANSFERnat*. In any case, cooperation, providing mutual access to partner’s know-how, implies simultaneously to transfer, acquisition of technology. While 30% of foreign subsidiaries which are cooperating with local partners report having transferred technology locally, 64% report having acquired technology locally, indicating that acquiring technology is a major motive for subsidiaries engaged in local cooperative agreements.

¹² Both for selling and buying technology it was not possible to distinguish between technology transfers and acquisitions within the boundaries of the multinational and external transfers and acquisitions.

transfers to the host country. We explore this result in more depth in the following econometric analysis of Section 4.

4. Econometric evidence on firm characteristics conducive to local technology transfers

We further explore the importance of the firms' multinational profile for local technology transfers in a probit regression analysis. The central dependent variable in the analysis will be the explicit transfer variable *TRANSFERnat*, as this is our direct measure for local technology transfers (Section 4.2). Since cooperative agreements with local firms occur more frequently and may be picking up technology transfers beyond those recorded in *TRANSFERnat*, we will also discuss the results for *COOPnat* in Section 5 as an extension.

4.1 Econometric Model

The focus of the analysis is on whether Foreign Subsidiaries (*FSUB*) are more or less likely to transfer technology to the local economy (*TRANSFERnat*), correcting for other determining variables such as firm size, technological origin and innovative profile. When estimating *TRANSFERnat* there is a possible sample selection bias, since we only have information on *TRANSFERnat* for innovative firms and since foreign subsidiaries are more likely to be innovative (see Table 1). We use a Heckman procedure specific for probit analysis to correct for this possible bias.

In addition to establishing whether foreign subsidiaries will be more or less likely to transfer technology locally compared to indigenous firms, we want to examine what makes foreign subsidiaries different. In particular, we want to analyse the role of international technology acquisitions in explaining the probability that a firm will transfer technology locally. This will allow to check whether any *FSUB* effect in *TRANSFERnat* is due to differences in access to international technology for foreign subsidiaries. We explore which firm characteristics determine international technology acquisition (*BUYinat*) and, then, enter *BUYinat* as explanatory variable in *TRANSFERnat*.¹³ One firm characteristic beyond *FSUB* that we expect to be important in explaining

¹³ When including *BUYinat* in *TRANSFERnat* we have to correct for a possible error-in-variables bias, if only because of common measurement errors or other unmeasured common determinants of *BUYinat* and *TRANSFERnat*. Such correlation could cause a biased estimate of the coefficient for *BUYinat* in *TRANSFERnat*,

international technology acquisition is the internal R&D capability of the firm. First, internal R&D capabilities allow the firm to scan and screen the external technology markets. Second, the internal R&D abilities increase the absorptive capacity of the organization to integrate external technology with own innovative projects. Foreign subsidiaries, for instance, may need an internal R&D capability to adjust the centrally developed innovations to their local market. We use the dummy *MAKE* to proxy for the internal R&D capability.¹⁴

The proposed model allows not only to identify the total effect from foreign affiliates (*FSUB*) on local technology transfers (*TRANSFERnat*), but also to decompose this total effect into a direct component and an indirect component running through international technology sourcing (*BUYinat*) and the internal R&D capability of firms (*MAKE*), while correcting for a possible sample selection and error-in-variables bias. Box 1 presents the full specification of the econometric model.

Box 1 : The econometric model for TRANSFERnat

Sample selection	
$INNOV = a_i Z + b_i FSUB + c_i Z_{INNOV} + e_{innov}$	(0)
Structural Form	
$MAKE = a_m Z + b_m FSUB + c_{mm} Z_{MAKE} + e_{make}$	(1)
$BUYinat = a_b Z + b_b FSUB + c_{bb} Z_{BUYinat} + d_b MAKE + e_b Sc(MAKE) + e_{buyinat}$	(2)
$TRANSFERnat = a_{st} Z + b_{st} FSUB + c_{stt} Z_{TRANSFERnat} + f_t BUYinat + g_t Sc(BUYinat) + e_{stransnat}$	(3)
Reduced form	
$TRANSFERnat = a_{rt} Z + b_{rt} FSUB + c_{rtt} Z_{TRANSFERnat} + c_{bt} Z_{BUYinat} + c_{mt} Z_{MAKE} + e_{rtransnat}$	(4)
$Z = (SIZE, SIZEsq, SECTOR DUMMIES)$	
$Z_{INNOV} = (OBSTneed, OBSTcost, OBSTlack)$	
$Z_{MAKE} = (OBSTinfo, OBSTcost, OBSTlack)$	
$Z_{BUYinat} = (EXTINF)$	
$Z_{TRANSFERnat} = (PROT)$	
$Sc(MAKE) = \text{generalized residual from (1)}$	
$Sc(BUYinat) = \text{generalized residual from (2)}$	

Both the structural form (3) and the reduced form (4) estimation of *TRANSFERnat* are estimated with the probit Heckman correction for sample selection on innovative firms using

which is of central concern in the analysis. This correction is done by including the generalized residual obtained from regressing *BUYinat* on its determinants (Gouriéroux et al (1987)).

¹⁴ A dichotomous variable like *MAKE*, is very unlikely to pick up the full notion of internal R&D capabilities. Unfortunately, we have no reliable continuous variables available such as R&D expenditures or R&D personnel. When including *MAKE* in *BUYinat*, we again have to correct for the possible error-in-variables bias due to correlation in error terms between *MAKE* and *BUYinat*. This implies that again we analyze the characteristics driving *MAKE*, which includes examining whether foreign affiliates are more likely to have an own R&D capability.

equation (0). As explanatory variables for *INNOV* in equation (0), we can only include those variables that are available for the total sample. Besides *FSUB*, we include as firm characteristics *SIZE*, as measured by sales. Larger firms may have higher market power or they may enjoy economies of scale, raising the payoffs to innovation activities. We also include a quadratic size term to account for non-linearities in this relation (*SIZEsq*). In addition, the data allow to test whether obstacles to innovation are preventing firms from innovating, such as costs & risks (*OBSTcost*), a lack of innovation personnel (*OBSTlack*), and no interest from customers (*OBSTneed*).¹⁵ A number of industry dummies at the 2 and 3 digit level of sectoral aggregation are included to correct for any technological opportunities or competitive considerations that might give rise to more or less opportunities to innovate (see Table A.1 in appendix).

As explanatory variables for internal R&D capabilities (*MAKE*) in equation (1), we include *FSUB*, firm size, industry dummies and a number of variables on obstacles to innovation. We include, beyond costs and risks (*OBSTcost*), and lack of innovation personnel (*OBSTlack*), a lack of market and technology information (*OBSTinfo*). The latter variable is expected to drive firms away from external sourcing, encouraging them to resort to an R&D strategy that relies on internal R&D inputs only.¹⁶

When estimating international technology acquisition (*BUYinat*) in equation (2), we include, next to *FSUB*, firm size and sector variables, the internal R&D capability of the firm as proxied by the *MAKE* dummy.¹⁷ As additional explanatory variable for *BUYinat*, we include the firm's openness to generally available external know-how through publications, patent information, seminars,

¹⁵ The questions on obstacles were clearly phrased in terms of identifying factors external to the firm that may inhibit the firm to innovate, such as imperfections in the market for risk capital, the market for R&D personnel or the final product market. Nevertheless, the extent to which these imperfections effectively impede the firm to innovate may at least partly be influenced by the firm's strategy, suggesting endogeneity. Although we cannot claim that all control variables are truly exogenous, we only correct for those variables whose coefficients are central to the analysis, i.e. for *BUYinat* and *MAKE*. This to keep the analysis tractable.

¹⁶ The Belgian Headquarter firms cannot be considered as pure local firms neither as foreign subsidiaries. Including a separate dummy for headquarter firms is not possible given that all firms are innovation active and have own R&D activities. Hence the 25 headquarter firms had to be eliminated in the analysis. Both *INNOV* and *MAKE* are estimated using the full sample (N=748). Due to missing values on the independent variables and dropping the Belgian headquarter firms the sample size is reduced to 572 (*MAKE*) and 540 (*INNOV*). *TRANSFERnat* and *BUYinat* are only available for innovative firms (N=445), but due to missing values on the independent variables sample size reduces to 358 (*TRANSFERnat*) and 400 (*BUYinat*).

¹⁷ Since the error terms for *MAKE* and *BUYinat* are possibly correlated, we include in the *BUYinat* regression the generalized residual for *MAKE* from (1) (*sc(MAKE)*).

conferences and trade shows (*EXTINF*). Openness serves as a catalyst for external international sourcing, providing awareness on available external technological know-how.

We now turn to the explanatory variables for *TRANSFERnat* in the structural form estimation (3). Our central variable of interest is ofcourse whether the firm belongs to a foreign based multinational (*FSUB*). To test the importance of access to the international technology market, we also include whether the firm acquires technology internationally (*BUYinat*).¹⁸ Furthermore, firms that are larger in size may be more likely to generate local technology transfers (*SIZE*). A quadratic size term is included as well, to check for non-linearities (*SIZEsq*). Moreover, the survey data allow us to include the effectiveness of protecting know-how, both through legal mechanisms such as patents, and strategic mechanisms such as complexity, secrecy and lead time (*PROT*). When the firm can better appropriate the rents from its innovations, it is more likely to be actively trading on the technology market. A secure appropriation regime is an important precondition for technology transfers. Finally a number of industry dummies are included to correct for any technological opportunities or competitive considerations that might give rise to more or less technology transfer opportunities. The reduced form estimation of *TRANSFERnat* in equation (4) contains all the exogenous common and specific explanatory variables for *MAKE*, *BUYinat* and *TRANSFERnat*. As an extension, we also include directly *MAKE* in *TRANSFERnat*.

From combining the structural and reduced form results we can decompose the total effect of *FSUB* on *TRANSFERnat* into a direct and an indirect effect. The **total effect** of *FSUB* is obtained from the coefficient of *FSUB* (b_r) in the reduced form estimation for *TRANSFERnat* in equation (4). The **direct effect** is obtained from the coefficient for *FSUB* (b_{st}) in the structural form for *TRANSFERnat* in equation (3). An indirect effect arises when foreign subsidiaries are more likely to acquire technology internationally (as can be established through the structural form estimation for *BUYinat* in equation (2)) **AND** acquiring technology internationally affects the probability to transfer technology locally (as can be checked through the structural form estimation for *TRANSFERnat* in equation (3)). Hence, the **indirect effect through *BUYinat*** is obtained from combining the

¹⁸ The generalized residual for *BUYinat* from (2) ($sc(BUYinat)$) is included to correct for the possible correlation in error terms of *TRANSFERnat* and *BUYinat*.

coefficient for *FSUB* in *BUYinat* (b_b) from equation (2) and the coefficient of *BUYinat* in *TRANSFERnat* (f) from equation (3).¹⁹

4.2 Results

We start by discussing the reduced form for *TRANSFERnat* (see equation (4) in Table 2). Our main interest is the coefficient for *FSUB*, which provides the **total effect** of foreign subsidiaries on *TRANSFERnat*. This coefficient turns out to be negative, suggesting that foreign subsidiaries are less likely to transfer technology to the local economy, all else equal. However, the effect is not significant (at 18% only). The capacity of the firm to appropriate the benefits from its innovations (*PROT*) gives the firm a better position as seller on the technology market, leaving a significant positive coefficient for *PROT* in *TRANSFERnat*. Also firm size is positive, although not significant. For the industry dummies (not reported), machinery and printing have a significantly lower probability of transferring technology locally. The results from the Heckman correction procedure for sample selection bias on *INNOV* in *TRANSFERnat* confirms that foreign subsidiaries are more likely to be innovative, but yields no significant correction coefficient in (4).²⁰

Insert Table 2 here

The insignificant negative total effect for foreign affiliates on the likelihood of local technology transfers is the result of a direct and an indirect effect with opposite signs. The **direct effect** for *FSUB* is obtained from the structural equation for *TRANSFERnat* in equation (3) and shows a negative and highly significant coefficient for *FSUB*. This suggests that foreign

¹⁹ In addition, there is also possibly an indirect effect through *MAKE* through *BUYinat* when foreign subsidiary are more likely to have a R&D capacity, which makes them more likely to acquire technology internationally which in turn affects *TRANSFERnat*. This indirect effect is obtained from combining the coefficient for *FSUB* in *MAKE* (b_m) from (1) and the coefficient from *MAKE* in *BUYinat* (d_b) from (2) and the coefficient from *BUYinat* in *TRANSFERnat* (f) from (3). In extension, we also have an indirect effect from *MAKE* running directly on *TRANSFERnat*. Note that the total effect could be fully deduced from the structural form estimates. We nevertheless choose to report the reduced form results as well, for ease of presentation.

²⁰ Size significantly and positively affects *INNOV*, although at a diminishing rate. A lack of willingness to pay for innovations (*OBSTneed*) and a lack of innovative personnel (*OBSTlack*) significantly prohibits innovation. However firms perceiving costs and risks as barriers to innovation (*OBSTcost*) are more likely to innovate. This result suggests that this variable seems to capture awareness to obstacles rather than effectiveness in blocking innovative

subsidiaries are protecting their know-how more efficiently than local firms and/or have less interest to share their know-how in order to access local know-how. The **indirect effect** for *FSUB* through *BUYinat* is positive. As the coefficient of *BUYinat* in the structural equation (3) for *TRANSFERnat* shows, firms who acquire technology internationally are significantly more likely to transfer technology locally. Furthermore, from the structural equation (2) for *BUYinat* we see that foreign subsidiaries are significantly more likely to acquire technology internationally, all else equal. In addition, equation (1) shows that foreign subsidiaries are significantly more likely to have own R&D activities. But having R&D activity does not affect the probability of acquiring technology internationally, as the insignificant coefficient of *MAKE* in the structural equation (2) for *BUYinat* indicates. Therefore, there is no significant indirect effect running through *MAKE*. Including *MAKE* directly in *TRANSFERnat* also leaves no significant effect²¹. Firms that are more open to publicly available external information, being active in screening and scanning external innovations, are more likely to acquire technology internationally, as the significant positive coefficient for *EXTINF* in *BUYinat* suggests. Also firm size leads to a significantly higher probability for *BUYinat*, be it at a diminishing rate as the *SIZEsq* term indicates.²²

Insert table 3 here

Table 3 summarizes the findings for the effects of foreign subsidiaries. Based on the coefficients from Table 2, it reports the marginal probabilities for the *FSUB* coefficient on *TRANSFERnat*, and this for the total effect as well as the decomposition into its direct and indirect effects. The main result from the analysis so far is that foreign subsidiaries are more likely to have

purposes, see also Veugelers & Cassiman (1999). Significant negative industry dummies are obtained for textiles, clothing, printing & publishing, while rubber & plastics have a significant positive coefficient.

²¹These insignificant results for *MAKE* was already suggested by the non-significance of the explanatory variables for *MAKE* in the reduced form of *TRANSFERnat*. The weak role the R&D dummy is displaying in the results can be related to the poor proxy we have available. This variable is only a dichotomous variable, and the inclusion of other innovative profile variables, such as *EXTINF* and *PROT*, is already partly capturing specific aspects of innovative capacity.

²²No industry dummies are significant at the 5% level in *BUYinat*. For *MAKE* only the electr(on)ic equipment industry shows a significantly positive coefficient. The obstacle-identifiers for *MAKE* are all significant: a lack of technological information leads firms to ignore external sourcing, resorting more to internal development of

an own R&D capability and are more likely to acquire technology internationally. Despite the fact that acquiring technology internationally leads to a higher probability of transferring technology locally, this effect is not strong enough to compensate for the direct negative effect which belonging to a foreign based multinational firm has on local technology transfers. Therefore, overall foreign subsidiaries are not more likely to transfer technology locally as compared to indigenous firms.²³ These results are robust across alternative specifications.²⁴

When estimating the model on the individual technology transfer mechanisms separately, they all display a similar pattern of a significantly negative direct effect and a significantly positive indirect effect of *FSUB*. But it is interesting to note that for “personnel mobility” there is a highly significant (<1%) negative total effect, due to a strong negative indirect effect, suggesting that foreign subsidiaries are especially more likely to prevent knowledge from leaking out by minimizing personnel exit. This is reminiscent of the empirical evidence available on higher wages being paid by foreign affiliates, minimizing employee mobility (o.a. Globerman *et al.* (1994), Fosfuri *et al.* (2001)).

5. Extensions

5.1 Local technology cooperation

The reported incidence of technological cooperation with local partners is much higher in the sample than the reported local transfers of technology. Unfortunately we are unable to verify whether and to

innovations. On the opposite, firms who perceive a lack of qualified innovation personnel are constrained in using internal sourcing to develop innovations. Costs and risks again show up positively in determining *MAKE*.

²³ Although the Wald chi-sq test is significant, the overall predictive power of the regressions on *TRANSFERnat* is poor, as the percentage of correctly predicted cases indicates. While overall 82.1% are correctly predicted in the structural form (80.7% in the reduced form), the model has a tendency to overestimate the 0 cases: only 12.9% of the positive cases for *TRANSFERnat* are correctly predicted in the structural form (8.6% in the reduced form), which is not so surprising given the overall low frequency of occurrence for *TRANSFERnat*.

²⁴ We check the sensitivity of our results to sample selection, error-in-variables and including directly or indirectly *MAKE*. The results without Heckman correction procedure for *TRANSFERnat* are similar, be it that the significance levels are improved leaving a negative total effect of *FSUB* which is significant at 10%. We also checked the scenario without the correction for correlation among error terms between *BUYinat* and *TRANSFERnat*, which implies excluding *sc(BUYinat)* in the structural form for *TRANSFERnat*, which was significant in the basic scenario. This does not affect the significance level, but does affect the size of the coefficient for *BUYinat*, which suggests indeed that the correlation in error terms affects the point estimate of the coefficient for *BUYinat*. It also affects the size and significance of the coefficient for *FSUB*, leaving a direct effect which is still negative but only significantly at 16%. Given the weak results for *MAKE* we also checked the results when *MAKE* would be completely ignored in the analysis. The working paper version of this paper reports these results (Veugelers & Cassiman (2001)).

what extent know-how is transferred to the local economy in such cooperative agreements. Even though these transfers should in principle be recorded in *TRANSFERnat*, both variables are not strongly correlated.²⁵ Therefore, we use *COOPnat* as alternative dependent variable for transfers to the local market. The error terms of the two variables for local technology transfer, *TRANSFERnat* and *COOPnat*, are very likely to be correlated, if only because of omitted common factors such as measurement error. Hence, we use a bivariate probit analysis for *TRANSFERnat* and *COOPnat*. The results are reported in Table A.2 in the Appendix

The bivariate probit results confirm our previous results on *TRANSFERnat*. We find again from the structural equations a **direct effect** for *FSUB* that is negative both for *TRANSFERnat* and *COOPnat*. This contrasts with an **indirect effect** that is positive. Firms that are acquiring technology internationally are more likely to transfer technology to the local economy, both through *TRANSFERnat* and *COOPnat*. Given that foreign subsidiaries were more likely to acquire technology internationally, this implies a positive indirect effect for *FSUB*. For cooperation with local partners, there is in addition a significant indirect effect through *MAKE*. Firms that have a R&D activity are more likely to cooperate in R&D with local partners. Since foreign subsidiaries are more likely to be engaged in R&D, this creates an indirect positive effect for *FSUB* in *COOPnat*. The results from the reduced form imply that for *TRANSFERnat* the positive indirect effects are not strong enough to offset the negative direct effect for *FSUB*, such that, in total, foreign subsidiaries are significantly less likely to transfer technology locally. This confirms the results from section 4.2. For *COOPnat* however, the positive indirect effect combining the effects of international technology acquisition and R&D activities are stronger, leaving an insignificant total effect²⁶. Any conclusions on the use of local cooperative agreements as technology transfer mechanisms can at this stage only

²⁵ The Pearson correlation coefficient between *COOPnat* and *TRANSFERnat* is 0.25, significant at 1% level. See also footnote 10.

²⁶ The **total effect** coefficient for *FSUB* in the reduced form estimation for *COOPnat* is sensitive to the model specification. The univariate probit results for *COOPnat* indicate a significantly negative direct effect for *FSUB* together with a significant positive indirect effect, which is similar to the results reported in Table A.2. Overall however, the total effect for *COOPnat* is significantly negative. For the univariate probit results for *COOPnat*, the sample selection correction turned out to be significant (not reported here, but see Veugelers & Cassiman (2001)). With selection being relevant for *COOPnat*, the univariate probit results with sample selection may be preferred for *COOPnat* over the bivariate probit which does not include a sample selection correction. For *TRANSFERnat*, the variable which is the focus of the analysis, selection does not seem to bias the univariate probit results, (see Table 2), leaving robust results for *TRANSFERnat* over both specifications.

be tentative, given the absence of a direct identification of the direction of flows of know-how within such agreements. The positive indirect effect which foreign subsidiaries generate through *MAKE* could be suggesting the use of an internal R&D capability to be better able to absorb know-how in cooperative agreements as part of the global technology sourcing strategy of the MNE, rather than for the transfer of know-how in local cooperative agreements.

5.2 *Internal transfers from headquarters to subsidiaries*

A final extension further explores the nature of international technology acquisitions. A robust finding throughout the analysis has been that foreign subsidiaries are more likely to acquire technology internationally. This can be due to the internal transfers of technology that are occurring from the parent to the subsidiary, but could also be due to a larger access to external international sources of technology. Unfortunately, we cannot disentangle *BUYinat* into internal and external acquisition, but the survey contains a set of questions relating to the importance of different sources of information for the innovation process of the firm. This includes for foreign subsidiaries the importance of parents or affiliated companies as sources of information for their innovations. We split the foreign subsidiaries in the sample according to whether they report these internal sources to be important or crucial for their innovations or not.²⁷ We estimate the reduced form and the structural form for local transfer (*TRANSFERnat* and *COOPnat*), including a separate dummy for each type of foreign subsidiary rather than including *FSUB* and correcting for international technology access through *BUYinat*, as in the previous section.

The results are very much in the line with the results reported before.²⁸ Foreign subsidiaries for which the internal transfers of technology from foreign affiliated partners are not important have a significantly negative total effect for local transfers. This is due to a significant negative direct effect. For foreign subsidiaries for which these transfers are important or crucial, both the direct effect and the total effect never show up significantly negative. In summary, the results indicate that especially affiliates operating independently from their international network of affiliated companies

²⁷ On average, 61.5% of innovation active foreign subsidiaries report internal within group transfers to be important or crucial as a source of information for their innovative activities.

fail to be interesting sources for technology transfers to the local economy. This again suggests the importance of access to international technological know-how as a prerequisite for generating transfers to the local economy.

6. Conclusions and Discussion

External knowledge is an important input for the innovation process of firms. Increasingly, this external knowledge is likely to originate from outside their national borders. This explains the preoccupation of policy makers with stimulating local technology transfers coming from international firms. In the existing literature this has typically been framed in a promotion policy for FDI, which is presumed to generate transfers of international technology to the host country. Using Belgian company data from the EUROSTAT Community Innovation Survey, this paper examines, on the basis of direct firm level evidence on technology transfers, whether foreign subsidiaries acquire technology internationally and whether they transfer technology to the host economy.

Some important results emerge. First, foreign affiliates have a higher probability of being innovation active and having an own R&D base. In addition, they are more likely to source technology internationally, typically from their parent company. Second, firms sourcing technology internationally are more active in transferring technological know-how to local firms. Transacting on the local technology market allows firms to better appropriate the rents from their enhanced know-how by generating monetary returns in formal transactions, or perhaps more importantly, by increasing their access to external know-how in reciprocal informal transfers and cooperative agreements. Third, having controlled for the acquisition of technology internationally, foreign subsidiaries have a significantly lower probability of transferring know-how locally. This negative direct effect can be related to a higher appropriation of know-how within multinational firms. MNEs prefer FDI over licensing to a local firm, because this allows a better control of know-how flows. They especially minimize spillovers by having a low personnel exit rate. In addition, foreign subsidiaries may have lower incentives to transfer technology locally, especially when the host market is not an attractive candidate for providing reciprocal access to know-how as compared to

²⁸ The detailed results are available in Veugelers and Cassiman (2001).

other location sites. Fourth, the significant positive indirect effect for foreign subsidiaries through their higher international technology sourcing is not strong enough to compensate for the negative direct effect, at least for the Belgian sample. This leaves a total effect, which is negative, although not significant. Finally, cooperation between foreign subsidiaries and local firms is an important channel for the host country to benefit from technology transfers. At least, it is reported more frequently than local transfers of technology. The common policy stance favoring their formation through special legal provisions or subsidizing them through special programs seems attractive for stimulating access to external know-how. But since cooperation typically involves a reciprocal relationship, one cannot ignore the simultaneity of acquiring and transferring know-how within such cooperative agreements.

In summary, if companies operating within an international network of affiliated companies are interesting sources for local technology transfers, as most of the literature suggests, this is only if the negative direct effect for foreign affiliates is overcome by a strong enough international sourcing activity. Hence, our results seem to suggest that Belgium as an open economy will gain from those foreign affiliates who are actively sourcing technology internationally and those who are interested in local networking for exchanging know-how. An important implication of our results is that the trend towards subsidiaries with a more pivotal role in the multinational's innovation strategy, and with more discretion to use the MNE structure to source know-how globally, can therefore be expected to generate more technology diffusion to the local economy.

Before the results of this study are molded into solid conclusions about MNEs' innovation strategies and host governments' innovation policy, more work is needed to test the robustness of these results. First, technology transfers to the local economy might occur through many other formal and informal channels in addition to the ones perceived by the sender and recorded in our sample. Second, our data reveal only whether or not a firm is active in transferring technology locally. Information about the intensity of these technology transfers would be necessary for any definitive conclusions about the importance of the degree of international exposure for local technology transfers. Furthermore, the analysis should be extended beyond whether technology flows occur or

not, towards assessing the efficiency of such flows and their impact on innovative performance and growth. Indeed, even if MNEs are less likely to transfer know-how to the local economy, the transferred know-how may be more valuable to local producers. Finally, the full EUROSTAT CIS-I data would allow us to compare results across EC countries. This would give us the opportunity to go beyond the Belgian sample and identify possible host market characteristics that might influence the results.

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TABLE 1 : LOCAL TECHNOLOGICAL TRANSFER AND INTERNATIONAL TECHNOLOGY ACQUISITION

	TOTAL N=445	FSUB=0 N=281	FSUB=1 N=164
TRANSFERnat	80 (18.0%)	52 (18.5%)	28 (17.1%)
COOPnat	150 (33.7%)	82 (29.2%)	68 (41.5%)
BUYinat	259 (58.2%)	135 (48.0%)	124 (75.6%)
TRANSFERnat as % of firms with BUYinat	24.7%	28.9%	20.2%
COOPnat as % of firms with BUYinat	43.2%	39.3%	47.6%

TABLE 2: ECONOMETRIC RESULTS

	<i>MAKE</i>	<i>BUYinat</i>	<i>TRANSFER nat (structural)</i>	<i>TRANSFER nat (reduced)</i>
VARIABLE	(1)	(2)	(3)	(4)
Constant	-0.961*** (0.307)	-1.259** (0.494)	-2.105*** (0.452)	-1.111 (0.906)
<i>SIZE</i>	0.00075*** (0.00027)	0.00081*** (0.00028)	-0.000040 (0.00021)	0.00024 (0.00026)
<i>SIZESQ</i>	-5.22E-08*** (1.95E-08)	-6.11E-08*** (2.15E-08)	2.24E-08 (1.6E-08)	-3.31E-09 (1.89E-08)
<i>FSUB</i>	0.640*** (0.145)	0.411* (0.248)	-0.582*** (0.225)	-0.372 (0.279)
<i>PROT</i>			0.113 (0.109)	0.230** (0.107)
<i>EXTINF</i>		0.362*** (0.106)		0.136 (0.130)
<i>OBSTinfo</i>	0.153* (0.084)			-0.069 (0.143)
<i>OBSTcost</i>	0.256*** (0.083)			-0.078 (0.206)
<i>OBSTlack</i>	-0.239*** (0.089)			-0.019 (0.200)
<i>BUYinat</i>			2.235*** (0.759)	
<i>ScBUYinat (3)</i>			-0.964** (0.462)	
<i>MAKE</i>		-0.092 (0.835)		
<i>ScMAKE (4)</i>		0.238 (0.495)		
Wald χ^2	124.6***	70.55***	62.48***	33.3**
Number of observations	572	400	358	
Heckman ²⁹ Correction ρ (rse & sign level for χ^2 test $\rho=0$)			0.288 (.427)	-0.052 (.927)

Robust standard error in brackets and significance level (***)significant at 1%, **significant at 5%, *significant at 10%. All regressions include as independent variables the 14 industry dummies. To save on space, these coefficients are not reported. Belgian Headquarter firms deleted from the sample. Due to missing values for independent variables, the number of observations differs from the total sample reported in Table 1 (see also footnote 16).

²⁹ The regression results for the Heckman correction for INNOV=.255(.210) + 0.0015(.0002)***SIZE -9.95E-08(1.59E-08)***SIZESq +0.459(.106)***FSUB -.396(.057)***OBSTneed +0.485(.065)***OBSTcost - 0.241(.059)***OBSTlack+industry dummies (N=540)

TABLE 3: THE DIRECT AND INDIRECT EFFECT OF FSUB ON TRANSFERnat

TOTAL EFFECT = coefficient of FSUB in Reduced Form for TRANSFERnat (4)	-0.089 (.100)
DIRECT EFFECT =coefficient of FSUB in Structural Form for TRANSFERnat (3)	-0.065**(.032)
INDIRECT EFFECT via BUYINAT = coefficient of BUYinat in Structural Form for TRANSFERnat (3)	0.418***(.146)
coefficient of FSUB in Structural Form for BUYinat (2)	0.156* (.091)
INDIRECT EFFECT via MAKE in BUYINAT= coefficient of MAKE in Structural Form for BUYinat(2);	-0.035 (.320)
coefficient of FSUB in Structural form for MAKE (1)	0.249***(.054)

Note: Reported are the Marginal effects for a discrete change of the dummy variables from 0 to 1

Appendix

TABLE A.1: Definition of Variables	
FIRM SPECIFIC VARIABLES	
<i>FSUB</i>	Dummy variable with value 1 when the company is a subsidiary with foreign headquarters
<i>COOPnat</i>	Dummy variable with value 1 for innovative firms that have cooperation in R&D with a Belgian non-affiliated partner, where both parties have an active involvement.
<i>TRANSFERnat</i>	Dummy variable with value 1 for innovative firms transferring technology to Belgium through licensing and/or through R&D contracting and/or through consultancy services and/or sale of another enterprise and/or mobility of skilled employees and/or other forms of transfer.
<i>BUYinat</i>	Dummy variable with value 1 for innovative firms acquiring technology from outside Belgium through licensing and/or through R&D contracting and/or through consultancy services and/or purchase of another enterprise and/or hiring skilled employees and/or other forms of acquiring technology.
<i>SIZE</i>	Firm Sales in 10 ¹⁰ BEF.
<i>SIZEsq</i>	Firm Sales in 10 ¹⁰ BEF squared.
<i>INNOV</i>	Dummy variable with value 1 when the firm developed or introduced new or improved products or processes in the last 2 years AND reported a positive budget for innovation expenditures.
<i>MAKE</i>	Dummy variable with value 1 when the firm has own permanent R&D activities.
<i>EXTINF</i>	Average of scores of importance of following information sources for innovation process (number between 1 (unimportant) and 5 (crucial)): Patent information; Specialized conferences, meetings and publications; Trade shows and seminars (rescaled between 0 and 1).
<i>PROT</i>	<i>PROT</i> is Average of scores of effectiveness of following methods for protecting new products/processes (number between 1 (unimportant) and 5 (crucial)): Patents; Registration of brands, copyright; Secrecy; Complexity; Lead time (rescaled between 0 and 1).
<i>OBSTcost</i>	Average of scores of Importance of Cost and Risk Obstacle for innovation by the firm (<i>Risks too high, no suitable financing available, high costs of innovation, pay-back period too long, innovation cost hard to control, uncertainty about introduction times</i>)
<i>OBSTinfo</i>	Average of scores of Importance of Lack of Information for Innovation as an Obstacle to innovation by the firm (<i>lack of information on technology, lack of market information</i>)
<i>OBSTlack</i>	Average of scores of Importance of Lack of Personnel for Innovation as an Obstacle to innovation by the firm (<i>lack of qualified personnel, lack of personnel to innovate</i>)
<i>OBSTneed</i>	Average of scores of Importance of No Need for Innovation as an Obstacle to innovation by the firm (<i>no need for innovation because of earlier innovations, little interest for innovations by customers</i>)
INDUSTRY DUMMIES	
<i>STEEL</i>	STEEL = 1 if firm is in Steel sector (NACE Codes: 22).
<i>MIN</i>	MIN = 1 if firm is in Minerals (NACE Codes: 24).
<i>CHEM</i>	CHEM = 1 if firm is in Chemicals (NACE Codes: 24, 25exc 2571-2572).
<i>FARMA</i>	FARMA = 1 if firm is in Pharmaceuticals (NACE Codes 2571-2572).
<i>MET</i>	MET = 1 if firm is in Metals (NACE Codes: 31).
<i>MACH</i>	MACH = 1 if firm is in Machinery (NACE Codes: 32).
<i>ELEC</i>	ELEC = 1 if firm is in Electrical Equipment Industry (NACE Codes: 33,

	34, 37).
<i>TRANS</i>	TRANS = 1 if firm is in Transportation Equipment (NACE Codes: 35,36).
<i>FOOD</i>	FOOD = 1 if firm is in Food & Drink Business (NACE Codes: 41, 42).
<i>TEXT</i>	TEXT = 1 if firm is in Textiles (NACE Codes: 43).
<i>CLOTH</i>	CLOTH = 1 if firm is in Clothing, Shoes & Leather(NACE Codes: 44, 45).
<i>WOOD</i>	WOOD = 1 if firm is in Wood & Furniture (NACE Codes: 46).
<i>PRINT</i>	PRINT = 1 if firm is in Paper & Printing (NACE Codes: 47).
<i>RUBB</i>	RUBB= 1 if firm is in Rubber & Plastics (NACE Codes: 48).

TABLE A.2

BIVARIATE PROBIT Results for TRANSFERnat and COOPnat

	<i>TRANSFERnat</i> <i>((structural)</i>	<i>COOPnat</i> <i>(structural)</i>	<i>TRANSFERnat</i> <i>(reduced)</i>	<i>COOPnat</i> <i>(reduced)</i>
VARIABLE	(1)	(2)	(3)	(4)
Constant	-2.023*** (0.564)	-2.257*** (0.501)	-1.308*** (0.506)	-1.277 (0.475)
<i>SIZE</i>	-0.00011 (0.00026)	-0.00035 (0.00022)	0.00024* (0.00015)	0.00026* (0.00015)
<i>SIZESQ</i>	2.55E-08 (1.95E-08)	3.40E-08** (1.79E-08)	-0.05E-08 (1.15E-08)	-1.56E-08 (1.23E-08)
<i>PROT</i>	0.127 (0.108)	-0.037 (0.099)	0.246** (0.107)	0.089 (0.095)
<i>FSUB</i>	-0.644** (0.278)	-0.618*** (0.248)	-0.337** (0.179)	0.041 (0.166)
<i>BUYinat</i>	2.173*** (.915)	2.334*** (0.805)		
<i>ScBUYinat (3)</i>	-0.915* (.549)	-1.177 (0.483)		
<i>MAKE</i>	0.064 (0.944)	1.751** (0.832)		
<i>ScMAKE (4)</i>	-0.036 (0.538)	-0.673 (0.473)		
<i>EXTINF</i>			0.141 (0.120)	0.262** (0.113)
<i>OBSTinfo</i>			-0.069 (0.146)	-0.043 (0.114)
<i>OBSTcost</i>			-0.045 (0.127)	0.076 (0.114)
<i>OBSTlack</i>			-0.019 (0.132)	-0.081 (0.119)
Wald χ^2	135.74*** N=377		110.73*** N=377	
ρ (sign level for χ^2 test rho=0)	0.369***		0.395***	

Robust standard error in brackets and significance level (***)significant at 1%, **significant at 5%, *significant at 10%) . All regressions include as independent variables the 14 industry dummies. To save on space, these coefficients are not reported. Belgian Headquarter firms deleted from the sample.