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

by

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Abstract

The use of FDI 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 MNEs 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 at the same time transfer their know-how to the local economy. Using direct firm level evidence from Belgian CIS-survey data on the occurrence of technology transfers, we find that foreign subsidiaries are indeed more likely to acquire technology internationally. But once controlled 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. In summary, the main result of this paper is that it is not so much the multinational character of the firms, but rather their access to the international technology market that is important for generating external knowledge transfers to the local economy.

JEL Classification: D21, L16, F23, O23

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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 prosperity of a country is expected to rise with the ability to access available new knowledge which is relevant for the innovation process. Hence, it is important to stimulate the channels through which external technological information flows. The models of endogeneous innovation-driven growth (a.o. Grossman & Helpman (1991)) have placed the subject of knowledge spillovers at the forefront of research.

There is no reason for knowledge spillovers to be confined to domestic borders. Building further on endogeneous growth models, the current empirical literature identifies the international transfer of technology as an important source for growth (e.g. Helpman (1997)). Eaton and Kortum (1997) for instance find domestic productivity growth to be mainly related to foreign innovations. Different channels are 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, since the production and/or research activities undertaken by multinational affiliates can confer "spillover" benefits to the local economy. The empirical evidence on spillover benefits from FDI, relying on indirect measures for spillovers, have generally failed to find robust evidence of positive knowledge spillovers from multinational investment (see Mohnen (2001) for a review). Despite the body of empirical research on the topic, and given the widespread belief among policymakers 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 will be interesting sources of technology transfers to the local economy requires both that foreign subsidiaries source international technology and that they transfer this technology to the local market. But little is known about the conditions and mechanisms through which Multinational Firms do indeed transfer technology. Without a clearer understanding of this, it is difficult to know what sorts of FDI are consistent with growth and to distinguish positive from negative effects of FDI.

This paper goes further than the existing literature which relies on indirect measures for international spillovers through FDI. In this paper we explore direct measures of technology transfers, obtained from survey data on Belgian manufacturing firms from the Eurostat Community Innovation Survey. We identify which firms transfer technology to the local economy, comparing foreign subsidiaries with domestic firms. At the same time, the data allow to identify whether these firms have acquired technology internationally. Various embodied and disembodied technology transfer and acquisition mechanisms are considered, both from external partners and internal transfers from headquarters to foreign affiliates. Therefore we are able to disentangle the two conditions for having foreign subsidiaries as mechanisms for international technology spillovers. First they need to source international know-how and second, they transfer know-how to the local economy.

The main results of the paper are that companies that are sourcing 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 be locally networked and transfer technology locally.

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 relationship.

The outline of the paper is as follows. In the next section we briefly review the literature. Section 3 lays out the research question and discusses the sample. In Section 4 we present the main results of our analysis on the determinants of local technology transfers from manufacturing firms located in Belgium. Section 5 concludes.

2. Technology transfers to the local economy

As channels of international technology spillovers are typically considered international trade in goods and foreign direct investment (see Mohnen (2001) for a review). But international knowledge flows may also be traced through foreign technology payments, i.e. licensing fees, royaltees on copyrights, payments for consulting services, the financing of R&D outsourced abroad and the acquisition of international targets in technology sourcing M&As. And there are also spillovers without counterpayments such as through international migration of people, informal international contacts, international conferences or trade fairs, international research collaborations.

Most empirical studies follow Coe and Helpman (1995) in measuring international R&D spillovers via trade flows (a.o. Engelbrecht (1997), Keller (1998)). The results from these studies are mixed: a number of studies using trade or no weights to aggregate foreign R&D find mostly weak or insignificant returns to foreign R&D, while Coe and Helpman (1995) find strong significant foreign R&D elasticities More recently, empirical and theoretical models in International Trade have started to focus on the effects of MNEs on output growth (see a.o. Lichtenberg and van Pottelsberghe (1998), Barell & Pain (1999), Baldwin et al (1999), Braconier et al (1999). The empirical studies use FDI flows as weights when summing the stock of foreign R&D, based on the notion that FDI increases the proximity between sender and receiver of know-how and hence leads to higher spillovers. 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 data with data on inward and outward FDI 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.

Another strand of 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. Note that 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 contributions to the literature on multinationals and host country benefits, Caves (1974) distinguishes 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. Fors (1997), using Swedisch data finds that parent R&D significantly influences host output growth. But most of the firm level studies are for developing countries ((a.o. Blomström (1986), Fikkert (1997), Aitken & Harrison (1999) Blömström and Sjöholm (1999)). These studies have generally failed to find robust evidence of positive knowledge spillovers from multinational investment (see Blömström & Kokko (1998) for a review). Finding positive spillover effects seems to require similarity between sender and receiver and an absorption capacity of the receiver. Firms and countries must engage in own R&D to learn and to be able to absorb foreign knowledge.

Rather then assessing technology transfers through FDI or 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. With patent data internationally comparable and accessible, citation information can be used to trace knowledge spillovers[1]. Patent citations can be used to assess both inter-firm transfers between subsidiaries and local firms and intra-firm transfers between parents and affiliates. Brandstetter (2000) uses patent citations to foreign subsidiaries by local firms to measure international knowledge spillovers. Using firm level 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 indigineous US firms and by the indigineous US firms to the investing Japanese firm Almeida (1996) using patent citations on foreign subsidiaries in the US semiconductor industry, finds that patents belonging to foreign firms are cited by local US firms more than expected, supporting positive technology transfers through FDI. Patent citation evidence on internal technology transfers between affiliated partners, typically from headquarters to subsidiaries, is less common. Frost (1998), using USPTO data for 1980-1990, found evidence for the importance of headquarter patents for the innovations of subsidiaries. However, patent citations are only a partial measure for technology transfers if only because not all innovations are patented. Survey level evidence provides more direct, but subjective, evidence of technology transfers arising through affiliates of foreign firms. Mansfield and Romeo (1980) found that two third of UK 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. Research Question and Sample

3.1. Research Question

Our research aims to contribute to the understanding of the relationship between FDI and host market growth by focusing on the issue of the existence of technology transfers through FDI. Previous research suggests that MNEs can be considered as an interesting mechanism for international know-how diffusion. The local economy can access international technology through foreign subsidiaries located within its boundaries. Technology transfers within and across firms and national boundaries remain a black box for researchers. For FDI to be a channel for international spillovers, we need to assess first whether foreign subsidiaries are sourcing technology internationally and second, that foreign subsidiaries transfer know-how to the local economy.

Compared to local firms, firms that form part of a foreign based multinational group are more likely to acquire internationally available technology. The eclectic theory on MNEs (eg Dunning (1988)) typically characterizes the MNE as possessing a superior 'knowledge base', which is an ownership specific advantage that can be exploited in other markets through FDI, leading to transfers of know-how to the subsidiary from the parent or other affiliated firms. In addition, subsidiaries may have easier access to externally available international technology, using their group's network of establishments worldwide

[1] 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.

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

While belonging to a multinational enterprise may provide access to an international base of know-how, this access does not automatically imply a transfer to the local market. This raises the question on the motives of subsidiaries to transfer technology locally. In case of licensing out or R&D contracting, the monetary returns are an obvious driver. But, as the eclectic theory indicates, the MNE has typically chosen to internalize the transfer of technology through FDI rather than selling its technological advantage to a local partner to avoid transaction costs and control competition. From this perspective, MNEs, may be less likely to transfer technology locally. But there is also a vast amount of know-how transferred through informal contacts, personnel mobility etc.. While part of this know-how flows involuntarily, reflecting the imperfect appropriability of know-how, firms are also found to actively nurture these informal flows. The motivation for the sender lies in the reciprocal access to know-how, i.e. firms transfer know-how to be able to acquire technology in return (o.a. von Hippel (1988), Schrader (1991)). The growing emphasis on the importance of networking and the formation of alliances is driven by this mutual technology access motive. Teece (1997) and Mowery (1992), for example, emphasize that 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 (Pisano (1990)), reducing transaction costs typically associated with market transactions (Oxley (1997)). Therefore, we expect cooperative agreements between local firms and subsidiaries to include an important technology transfer component.

In this paper, we want to link international technology acquisition to local technology transfer, testing whether foreign subsidiaries can more easily source technology internationally and whether foreign subsidiaries are more likely to transfer technology locally. Our analysis focuses on the question whether multinationals per se are important for realizing technology transfers to the local economy, or whether this relies on these firms buying on the international technology market. Of course, MNEs are but one mechanism through which international know-how diffuses. The local economy can benefit from international know-how through their own local firms buying technology internationally. This allows us to examine whether indigineous firms that buy technology internationally are interesting alternative targets for the local economy for know-how diffusion.

3.2. The sample

The only attempt in the literature to open up the black box on spillovers through FDI which trace know-how flows *within* and *across* firm and national boundaries, uses patent citations (see e.g. Frost (1998),

[2] For some recent studies, see the Research Policy Special Issue on the Internationalization of Industrial R&D, 1999, 2-3.

Almeida (1996), Brandstetter (2000) all on USPTO data). But given the vast amount of information that is transferred without writing it down in patent applications or even in formal contracts, more qualitative direct firm level survey data remain an important source of information. Our data set, which is the Belgian subsample of EUROSTAT's Community Innovation Survey for 1993, provides direct survey evidence on the occurrence of international technology acquisition and local technology transfers at the firm level. The advantage of our data is that they are direct and firm-specific. A possible limitation is that they do not provide evidence on the importance of these flows. Furthermore, it only records local transfers as perceived by the sender. The Community Innovation Survey contains several questions on the technology transfer and technology acquisition behavior of innovating firms [3]. 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 for transfers and for acquisitions, were : licensing, R&D contracting, consulting, acquiring&selling (part of) companies, personnel mobility and other informal forms[4]. This information allows us to link national transfers of technology to international technology acquisition.

While the core of the analysis is presented in section 4, with an econometric analysis on which firm characteristics drive transfers to the local economy, this section presents the sample and some descriptive statistics connecting technology transfers to the local economy with buying on the international technology market, see also Table A.1. Of the total Belgian sample, 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 affiliative firms. Size is strongly and significantly correlated with the international orientation, with foreign subsidiaries being on average more than double the size of local firms. With respect to the distribution of firm types across industries, we find that local firms are overrepresented in food, textiles & clothing, wood & paper and, metals. Foreign subsidiaries are overrepresented in chemicals & pharmaceuticals, electronics, and, cars.

In line with the industry distribution and size correlation, belonging to an international group is also strongly associated with innovation. The dummy variable *INNOV* takes the value of 1 for firms that claimed to have introduced new or improved products or processes in 90-92 and reported a positive budget for innovation. 55% of Belgian firms claim to be innovation active. This includes the headquarter-

[3] 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 1335 Belgian manufacturing firms was selected and the 13-page questionnaire was sent out to them. 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)).

[4] 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 results, but slightly reduced the significance.

type firms, which all innovate. For foreign subsidiaries in Belgium, the percentage of firms claiming to be innovation active is 82%. This observation confirms that affiliates are indeed innovation-active. These innovations are typically not simply imported but are associated with own permanent R&D activities, since 70% of foreign subsidiaries in the sample are permanently active in R&D. Again all Belgian headquarters are permanently R&D active. The dummy variable *MAKE* takes the value of 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. Note that this implies we may have a sample selection bias which we will deal with in the econometric analysis of section 4.

3.3. Local transfers of technology

Table 1 shows that pure transfers of technology that remain in the local market (*TRANSFERnat*) are relatively infrequent: only 80, or 18% of, 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. Transfers through licensing (20), R&D contracting (25) and company sell-offs (10) are less frequent. The most frequent mechanism reporting being used to transfer technology locally are “other, informal contacts” (43) followed by consulting advice (38) and personnel mobility (35). This underscores the importance of informal transfers not necessarily related to counterpayments.

Insert Table 1 here

Another mechanism through which technology can be transferred is cooperation in R&D. The survey allows us to check whether partners in a cooperative agreement are national or international. Cooperation with local partners, *COOPEXnat*, includes competitors, vertically linked firms and research institutes, but excludes affiliated partners, since we want to focus on external transfers to the local economy [5]. In comparison to *TRANSFERnat*, cooperation with local partners occurs more often (33.7%). 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 .[6], nor whether these transfers are important. In any case, cooperation, providing mutual access to partner’s know-how, is a simultaneous transfer and 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 concern of subsidiaries engaged in local cooperative agreements. [7]

[5] The reported results are insensitive to this exclusion, using COOPnat rather than COOPEXnat.

[6] 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, informal” means should be picking up this mechansim. However, of the 150 firms who report COOPEXnat, only 47 reported positively on TRANSFERnat, from which only 29 also report “other forms of transfer” included in TRANSFERnat

[7] For the Belgian firms these numbers are resp 32% and 76%.

BUYinat is a dummy variable that takes the value of 1 if the firm has reported having acquired technology from a firm located outside Belgium. This holds for 58% of all innovative sample firms. The most frequently reported mechanism is again "other informal forms" (143) closely 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: 76% of all innovation active foreign subsidiaries are 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.[8]

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. One would expect that Belgium being host to multinational companies might benefit from the superior access that these firms have to the international technology market. In this case, FDI is indeed a channel of international technology spillovers for the local economy. Restricting attention to companies that acquire technology internationally, a higher frequency of transferring technology nationally emerges (see Table 1). About 25% of firms which acquire technology internationally are simultaneously transferring technology nationally. This should be compared to the average 18% of firms transferring locally. They also have a higher frequency of national cooperation : 43% of the companies that acquire technology internationally will also cooperate with national partners, as compared to 34% for the total sample. However, especially local Belgian firms when they acquire technology internationally, are more active in local technology transfer: 29% of the local firms that buy technology internationally, transfer technology locally. For foreign subsidiaries the frequency of local technology transfer is only marginally higher in the subgroup of subsidiaries who are internationally acquiring technology. The incidence of local cooperation increases both for Belgian firms and foreign subsidiaries that acquire technology internationally.

These first descriptive results are already indicative of the importance of access to the international technology market, rather than being part of a multinational concern, for explaining technology transfers to the host country, a result that will be further explored in the econometric analysis of section 4.

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

In this section we explore the importance of the firms' multinational profile for local technology transfers in a multivariate regression analysis. A probit analysis on the likelihood of local technology transfers (*TRANSFERnat)* is performed. Recall that the occurrence of local technology transfers is not widespread. Given the higher frequency of occurrence of cooperative agreements with local partners, we will also

[8] 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.

discuss *COOPEXnat* as possible mode of local technology transfer, although we have no direct evidence on whether and to which extent technology is indeed transferred to the local partner in such cooperative agreements. Central in the analysis will be the explicit transfer variable *TRANSFERnat,* since this is a direct measure for spillovers. However, since cooperative agreements may be picking up technology transfers beyond those recorded in *TRANSFERnat*, see footnote 6, we will also discuss *COOPEXnat*, but only in the extensions in section 4.3. The Appendix contains a detailed description of the variables included.

4.1. The 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 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 foreign subsidiaries are more likely to be innovative (see Table 1). We use a Heckmann correction procedure specific for probits.

In addition to whether foreign subsidiaries will be more or less likely to transfer technology locally, we want to examine why foreign subsidiaries would be different. More particularly we want to examine 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 the differential international technology buying behavior for foreign subsidiaries. This implies including *BUYinat* as explanatory variable in *TRANSFERnat* and exploring which firm characteristics including *FSUB,* determine *BUYinat*. 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 between *BUYinat* and *TRANSFERnat*. Such correlation causes a biased estimate of the coefficient for *BUYinat* in *TRANSFERnat*, which is of central concern in the analysis. This correction is done by including the generalized residual from regressing *BUYinat* on its determinants (Gouriéroux et al (1987)). One firm characteristic beyond FSUB which we expect to be important in explaining *BUYinat*, is the internal R&D capability of the firm, as captured by the dummy *MAKE*. 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. 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*. Again we analyze the characteristics driving *MAKE* , which includes examining whether *FSUB* are more likely to have an own R&D capacity.

In summary, the proposed model allows to not only identify the total effect of *FSUB* on *TRANSFERnat*, but also to decompose this total effect into a direct component and an indirect component running through *BUYinat* and *MAKE*, while correcting for sample selection for *INNOV* and a possible error-in-variables bias for *BUYinat* and *MAKE.* This leads to the following set of equations:

Sample selection

$INNOV = a_iZ+b_iFSUB + c_iZ_{INNOV} + e_{innov}$ (0)

Structural Form

$MAKE = a_mZ+b_mFSUB + c_{mm}Z_{MAKE} + e_{make}$ (1)

$BUYinat = a_bZ+b_bFSUB + c_{bb}Z_{BUYinat} + d_bMAKE +e_bsc(MAKE)+ e_{buyinat}$ (2)

$TRANSFERnat = a_{st}Z+b_{st}FSUB + c_{stt}Z_{TRANSFERnat} + f_tBUYinat + g_tsc(BUYinat) + e_{stransnat}$ (3)

With

Z= (SIZE, SIZEsq, SECTORDUMMIES)

Z_{INNOV}= (OBSTneed, OBSTcost, OBSTlack)

Z_{MAKE}= (OBSTinfo, OBSTcost, OBSTlack)

$Z_{BUYinat}$= (EXTINF)

$Z_{TRANSFERnat}$=(PROT)

Sc(MAKE)=generalized residual from (1)

Sc(BUYinat)=generalized residual from (2)

Reduced form

$TRANSFERnat = a_{rt}Z+b_{rt}FSUB + c_{rtt}Z_{TRANSFERnat} + c_{bt}Z_{BUYinat} + c_{mt}Z_{MAKE} + e_{rtransnat}$ (4)

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

Similarly we include as explanatory variables for *MAKE, FSUB*, 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, resorting to an R&D strategy which relies on internal R&D inputs only. Note that both *INNOV* and *MAKE* are estimated using the full sample, while *TRANSFERnat* and *BUYinat* are only available for innovative firms. [9]

For *BUYinat* we include next to *FSUB* and the size and sector variables, the internal R&D capacity of the firm as proxied by the *MAKE* dummy. But since the error terms of *MAKE* and *BUYinat* are possibly correlated, we include in the *BUYinat* regression the generalized residual for *MAKE* from (1) (*sc(MAKE))*. As additional explanatory variable for *BUYinat* we include the firm's openness to generally available external know-how through publications, patent information, seminars, conferences, trade shows (*EXTINF*). Openness serves as a catalyst for external sourcing providing awareness on available external technological know-how [10].

In addition to whether the firm belongs to a foreign based multinational (*FSUB*), the following control variables are included as explanatory variables for *TRANSFERnat* in the structural form estimation (3). To test the importance of international spillovers, we include whether the firm buys on the international technology market (*BUYinat*). The generalized residual for *BUYinat* from (2) (*sc(BUYinat))* is included to correct for the possible correlation in error terms of *TRANSFERnat* and *BUYinat*. Firms that are larger in size, such as subsidiary firms in the sample, 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 is better in protecting the rents from innovation, it is expected to be better able to sell its know-how. 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* (4), contains all exogeneous common and specific explanatory variables for *MAKE*, *BUYinat* and *TRANSFERnat*.

We can now decompose the total effect of *FSUB* on *TRANSFERnat* into a direct and an indirect effect. The **Total Effect** is obtained from the reduced form for *TRANSFERnat* (4) through the coefficient of *FSUB* (b_{rt}). The **Direct Effect** is obtained from the structural form for *TRANSFERnat* (3) through the coefficient for *FSUB* (b_{st}) . The **Indirect Effects through *BUYinat*** arises when foreign subsidiaries are more likely to acquire technology internationally and acquiring technology internationally affects the probability to transfer technology locally. The indirect effect is hence obtained from combining the coefficient for *FSUB* in *BUYINAT* (b_b) from (2) and the coefficient of *BUYinat* in *TRANSFERnat* (f_t) from (3). There is also an **Indirect Effect through *MAKE* through *BUYinat*** since foreign subsidiary are more likely to have a permanent 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_t) from (3).

Both the structural form (3) and the reduced form (4) estimation of *TRANSFERnat* is estimated with the Heckmann correction for *INNOV* using (0). In order to avoid having to use recursively the Heckman correction term, we do not include the Heckman correction procedure for *BUYinat*, but note that *MAKE* is estimated on the full sample. We also check the scenario with a Heckman correction for

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[9] The 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 permanent R&D activities. Hence the 25 headquarter firms had to be eliminated in the analysis.

[10] It is highly unlikely that all control variables are truly exogenous and uncorrelated with the error terms. However, to keep the analysis tractable, we only correct for those variables whose coefficients are central to the analysis.

BUYinat, in which case we do not correct for the correlation between e_{make} and $e_{buyinat}$. We also check the scenarios without sample selection, the case of no correlation between $e_{buyinat}$, $e_{stransnat}$ e_{make} , and where *MAKE* directly influences *TRANSFERnat*. These robustness checks are discussed in section 4.3

4.2 The 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 innovation (*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 & publishing have a significantly lower probability of transferring technology locally. The Heckmann correction procedure for sample selection bias on *INNOV* in *TRANSFERnat*, although not yielding a rho coefficient which is significantly different from zero, confirms that foreign subsidiaries are more likely to be innovative[11]

Insert Table 2 here

The insignificant total effect for *FSUB* is the result of a direct and an indirect effect with opposite signs. The direct effect for *FSUB* on *TRANSFERnat* is obtained from the structural equation (3) which shows a negative and highly significant coefficient for *FSUB*. This suggest that foreign subsidiaries are less likely to transfer technology locally as compared to Belgian firms, after correcting for the indirect effect through *BUYinat*. This indirect effect through *BUYinat* is positive. As the coefficient of *BUYinat* in (3) shows, firms who acquire technology internationally are more likely to transfer technology locally. Furthermore, from equation (2) we see that foreign subsidiaries are significantly more likely to acquire technology internationally. Hence, the indirect effect of *FSUB* on *TRANSFERnat* through *BUYinat* is positive. This indirect effect can be further extended by including *MAKE*. Foreign subsidiaries are significantly more likely to have an own permanent R&D activity as equation (1) shows. But having a permanent R&D activity does not affect the probability of acquiring technology internationally, as the insignificant coefficient of *MAKE* in (2) indicates. Therefore there is no significant indirect effect running through *MAKE*. Including *MAKE* directly in *TRANSFERnat* also leaves no significant effect on *TRANSFERnat*, which was already suggested by the non-significance of the explanatory variables for *MAKE* in the reduced form of *TRANSFERnat*. The weak role which the permanent R&D dummy is displaying in the results can be related to the poor proxy we have available. This variable is only a

[11]Size affects significantly positively *INNOV*, although at a diminishing rate. A lack of willingness to pay for innovations (*INFOneed*) and a lack of innovative personnel (*INFOlack*) significantly prohibits innovation. However firms which perceive costs and risks as barriers to innovation (*INFOcost*) are more likely to innovate. This result suggests that this variable seems to capture awareness to obstacles rather than effectiveness in blocking innovative purposes, see also Veugelers & Cassiman (1999).

dichotomous variable, and the inclusion of other innovative profile variables, which are already partly capturing specific aspects of innovative capacity, such as *EXTINF* and *PROT*. The variable *EXTINF* shows up significantly positive in *BUYinat*, suggesting that firms who have an organisation that is more open to publicly available external information, being active in screening and scanning external innovations, are more likely to acquire technology internationally. Firm size which showed no direct effect on *TRANSFERnat*, leads however to a significantly higher probability for *BUYinat* and also for *MAKE*, be it at a diminishing rate as the *SIZEsq* term indicates. [12]

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 keep personnel, thus preventing knowledge from leaking out.[13] Foreign subsidiaries are also less likely to contract out R&D to local firms, as compared to domestic firms, since R&D contracting displays a total negative effect which is significant at 5%.

The main result from the analysis so far is that foreign subsidiaries are more likely to have a permanent own R&D capability and are more likely to acquire technology internationally. Despite that internationally acquiring technology leads to a higher probability to transfer 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, such that overall foreign subsidiaries are not more likely to transfer technology locally. These results do not seem to confirm the traditional results of the literature on multinationals, where MNEs are taken to be an important channel of technology transfers. It suggests that companies operating within an international network of affiliated companies are not necessarily interesting sources for local transfers. What seems to be important for local technology transfers is having an international network that provides access to international technology. These results are very robust across alternative specifications as the next section will demonstrate [14].

[12] The obstacle-identifyers for MAKE are all significant: a lack of technological information leads firms to ignore external sourcing, resorting more to internal development of 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, suggesting higher awareness as supra in INNOV. But also the high costs associated with acquiring external technology and the risk that the acquired technology may not "deliver" to the receiving firm as expected, may turn firms away from external sourcing, relying on internal sourcing (see Veugelers & Cassiman (1999)).

[13] For a model on technology spillovers from FDI through worker mobility, see Fosfuri et al (2001).

[14] Although the Wald chi-sq test is significant, the overall predictive power of the regressions on *TRANSFERnat* is poor, as the % 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.* For COOPEXnat, the percentage correctly predicted cases is 68.2% for the structural form (56.4% for the reduced form), while 63.3% of the positive cases are correctly predicted in the structural form (66.7% in the reduced form). Also for MAKE and BUYinat the percentage correctly predicted case is much higher overall, as well as for the positive cases.

4.3 Alternative Specifications and Extensions

4.3.1 Robustness checks

The first row of Table 3 repeats the basic results from Table 2, this time reporting marginal probabilities for easy comparison and interpretation[15]. The following rows report alternative specifications of the model. Overall the main results are very robust to the alternative specifications examined. The previous section could not provide strong evidence for a sample selection bias for *INNOV*. Therefore we checked the results without Heckmann correction procedure for *TRANSFERnat*. (row (2)) This leaves similar results, be it that the significance levels are improved leaving a negative total effect which is significant at 10%.

Insert table 3 here

Ignoring the possible correlation among error terms between *BUYinat* and *MAKE* implies estimating *BUYinat* without *sc(MAKE)*, which was not significant in the basic scenario (3). In this case (row (3)), *MAKE* is significantly positive in *BUYinat*, albeit only at 7%. This implies that the positive indirect effect from *FSUB* is further strenghtened since foreign subsidiaries are more likely to have a permanent R&D activity, which stimulates their buying of international technology which in turns leads to a higher probability of local technology transfers. Despite the augmented positive indirect effect through *MAKE*, the total effect of *FSUB* remains negative. Taking uncorrelated error terms between *BUYinat* and *MAKE* implies for the reduced form (4) that not the specific explanatory variables from *MAKE*, but *MAKE* directly is included. However, in line with its insignificant explanatory variables also *MAKE* fails to be significant in explaining *TRANSFERnat*. Given the weak results for *MAKE* we also include the results when *MAKE* would be completely ignored in the analysis (row (4)). The positive coefficient for *FSUB* in *BUYinat* remains positive after excluding *MAKE* in *BUYinat,* but reduces the significance of the estimate[16]. It only marginally affects the structural and reduced form for *TRANSFERnat*.

Finally we check 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 (row (5)). 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%.

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[15] Given that all the variables of interest are dummies this is for a discrete change in the dummy from 0 to 1.

[16] When we exclude MAKE in BUYinat, we correct for a possible sample selection through the Heckman correction for INNOV using (0).

4.3.2. Local technology cooperation

As indicated before, the incidence of technological cooperation with local partners is much higher than the reported local transfers of technology. Such cooperative arrangements can be interpreted as an alternative mechanism through which know-how is exchanged. Unfortunately we are unable to verify whether and to which extent know-how is transferred to the local economy in such cooperative agreements. Although local know-how will also be sourced in cooperative agreements, the hope is that such cooperative agreements simultaneously imply a transfer of know-how to the local partner. Even though these transfers should in principle be recorded in TRANSFERnat, both variables are not strongly correlated[17]. Therefore, we report the results using *COOPEXnat* as alternative dependent variable. Columns (5) and (6) in Table 2 report the structural and reduced form estimation for *COOPEXnat*. The results are similar to *TRANSFERnat.* As (5) shows, the direct effect of *FSUB* is significantly negative, but firms who *BUYinat* are more likely to cooperate with a local partner. Despite that foreign subsidiaries are more likely to acquire technology internationally, the total effect on *TRANSFERnat* is negative and significant, as (6) shows. The correction procedure for *INNOV* shows a Heckman correction rho which is significantly different from zero.

Insert Table 4 here

The error terms of the two variables for local technology transfer, *TRANSFERnat* and *COOPEXnat*, are very likely to be correlated, given omitted common factors such as measurement error, in which case a bi-variate probit analysis is appropriate. The results reported in Table 4 show a rho value for correlation among error terms, which is significantly different from zero both in the structural and in the reduced form estimation, underscoring the importance of correction for the correlation in error terms among *TRANSFERnat* and *COOPEXnat*. But the main results are confirmed in the bivariate probit. We find again a direct effect for *FSUB* which is negative both for *TRANSFERnat* and *COOPEXnat*. This contrasts with an indirect effect which is positive. We find again that firms which are acquiring technology internationally are more likely to both *TRANSFERnat* and *COOPEXnat* which yields a positive indirect effect for *FSUB* given that foreign subsidiaries were more likely to acquire technology internationally. In addition, there is a significant indirect effect through *MAKE* for *COOPEXnat*: Firms that have a permanent R&D activity are more likely to cooperate in R&D with local partners. Since foreign subsidiaries have a higher probability to be permanently engaged in R&D, this creates an indirect positive effect for *FSUB* in *COOPEXnat*. There is no significant indirect effect of *MAKE* through *BUYinat*. All this implies that for *TRANSFERnat* the positive indirect effects are not strong enough to compensate the negative direct effect for *FSUB*, such that in total foreign subsidiaries are significantly less likely to transfer technology locally, as found supra. For *COOPEXnat*, the positive indirect effect combining the effects of international technology acquisition and permanent R&D activities are stronger leaving a total effect which is no longer negative, but nevertheless fails to show up significantly positive.

[17] The Pearson correlation coefficient between COOPEXnat and TRANSFERnat =0.25, significant at 1% level.

Overall, the evidence for foreign subsidiaries seem to be more favorable for local cooperation. However, the positive indirect effect which foreign subsidiaries generate through *MAKE* could also be suggesting the use of an internal R&D capacity to be better able to absorb know-how, rather than for the transfer of know-how in local cooperative agreements. Conclusions on the use of local cooperative agreements should wait for a more direct identification of the direction of flows of know-how.

4.3.3. Internal transfers from headquarters to subsidiaries

A final extension further explores the nature of these international technology acquisitions. A robust finding throughout the analysis has been that foreign subsidiaries are more likely to acquire technology internationally, causing a positive indirect effect for *FSUB*. 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 larger access to external international sources of technology.

Insert Table 5 here

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 parent or affiliated companies as sources of information for their innovations. This allows to split the foreign subsidiaries according to whether they report these internal sources to be important or crucial for their innovations or not: *IFSUB* and *NIFSUB* respectively. Note that 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. Rather than including *FSUB* and *BUYinat* in local transfer (*TRANSFERnat* and *COOPEXnat*), we estimate the reduced form and the structural form including *IFSUB* and *NIFSUB* [18]. The results are very much in the line with the results reported before. The total effect for *FSUB* is only significantly negative for *NIFSUB*, i.e. foreign subsidiaries for which the internal transfers of technology from foreign affiliated partners are not important. For foreign subsidiaries for which these transfers are important to crucial, both the direct effect and the total effect never show up significantly negative. In summary, the results suggest that companies operating within an international network of affiliated companies could be interesting sources for local technology transfers, but only when they can benefit from internal transfers of technology from their parents or from other international sources

5. Conclusions

External knowledge is an important input for the innovation process of firms. Increasingly, this knowledge is likely to originate from outside of their national borders. This explains the preoccupation of policymakers in stimulating local technology transfers coming from international firms. In the existing literature this has typically been framed as a search for multinational firms, which are presumed to transfer international technology to the host country. Using Belgian company data from the Eurostat Community Innovation Survey, this paper examines directly the technology flows occurring through foreign subsidiaries and/or firms acquiring internationally available know-how and assesses their impact on the likelihood of technology transfers to the host economy.

At least three important results emerge. First, firms belonging to an international network of affiliates have a higher probability of having a permanent R&D base and are more likely to source technology internationally. Second, access to international technology is an important driver for local technology transfers. Having controlled for the acquisition of technology internationally, foreign subsidiaries have a significant negative direct effect on local technology transfers. The significant positive indirect effect for foreign subsidiaries through their higher international technology sourcing is not strong enough to compensate for this negative direct effect in the sample, leaving a total effect for foreign subsidiaries on local technology transfers which is negative. Hence, 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 they have larger international sourcing activities. Our results suggest that in order to stimulate local technology transfers, local firms with the capacity to source technology internationally should not be ignored. Unfortunately, local firms are less likely to have an international network from which they acquire technology, as compared to foreign subsidiaries. Third, cooperation with local partners 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, this implies that the issue of simultaneously receiving and transferring know-how cannot be ignored. This motive for reciprocal access is not only relevant for cooperation but also for the large component of other informal technology transfers in the total set of transfer mechanisms considered in the analysis.

In summary, these results seem to suggest that Belgium as an open economy is likely to gain from internationally operating firms, but only to the extent that these firms have a higher probability of sourcing technology internationally. It is this higher probability of international technology sourcing which has a significant positive effect on the probability of local transfers. An important implication of these 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. However, since foreign subsidiaries are typically more engaged in international networks exchanging know-how, they may be less interested in local networks for exchanging know-how. Host markets should therefore ensure

[18] Given that for foreign subsidiaries most of the international technology acquisition is internal, cf supra, makes it difficult to include simultaneously the internal transfer measures and BUYinat, as measure of external international technology acquisition.

sufficient interest for foreign subsidiaries to enter into local networks, which implies offering reciprocal access to know-how.

Before the results of this study are molded into firm conclusions about MNE's innovation strategies and host government's 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 only reveals 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. More importantly, 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. Furthermore, the Eurostat CIS-I data allow us to compare results across EC countries. This would give us the opportunity to go beyond the Belgian sample and identify possible host markets characteristics which might influence the results.

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Tables

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%)
COOPEXnat	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%
TRANSFERnat as % of firms with **MAKE**	20.1%	21.2%	18.7%
COOPEXnat as % of firms with **BUYinat**	43.2%	39.3%	47.6%
COOPEXnat as % of **MAKE**	42.8%	39.7%	46.8%

TABLE 2: ECONOMETRIC RESULTS

Binomial Probit Model; Maximum Likelihood Estimates; Robust estimations; (Belgian Headquarter firms deleted). Robust standard error in brackets and significance level (***significant at 1%, **significant at 5%, *significant at 10% † significant at 15%)

All regressions include as independent variables the 14 industry dummies. To save on space, these coefficients are not reported.

	MAKE	*BUYinat*	*TRANSFER nat (structural)*	*TRANSFER nat (reduced)*	*COOPEX nat (structural*	*COOPEX nat (reduced)*
VARIABLE	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-0.961*** (0.307)	-1.259** (0.494)	-2.105*** (0.452)	-1.111 (0.906)	-1.024** (0.485)	-0.243 (0.374)
SIZE	0.00075*** (0.00027)	0.00081*** (0.00028)	-0.000040 (0.00021)	0.00024 (0.00026)	- 0.000351* (0.000192	0.00005 (0.00015)
SIZESQ	-5.22E-08*** (1.95E-08)	-6.11E-08*** (2.15E-08)	2.24E-08 (1.6E-08)	-3.31E-09 (1.89E-08)	3.87E-08** (1.6E-08)	5.31E-09 (1.25E-08)
FSUB	**0.640*** (0.145)**	**0.411* (0.248)**	**-0.582*** (0.225)**	**-0.372 (0.279)**	**-0.566*** (0.175)**	**-0.263** (0.138)**
PROT			0.113 (0.109)	0.230** (0.107)	-0.022 (0.089)	0.092 (0.089)
EXTINF		0.362*** (0.106)		0.136 (0.130)		0.138 (0.110)
OBSTinfo	0.153* (0.084)			-0.069 (0.143)		0.039 (0.100)
OBSTcost	0.256*** (0.083)			-0.078 (0.206)		-0.157 (0.108)
OBSTlack	-0.239*** (0.089)			-0.019 (0.200)		0.077 (0.092)
BUYinat			**2.235*** (0.759)**		**2.537*** (0.805)**	
ScBUYinat (3)			-0.964** (0.462)		-1.366*** (0.455)	
MAKE		**-0.092 (0.835)**				
ScMAKE (4)		0.238 (0.495)				
Wald χ^2	124.6*** N=572	70.55*** N=400	62.48*** N=358 uncens/ 182cens	33.3** N=358 uncens/ 182cens	35.77** N=358 uncens/ 182cens	10.38*** N=358 uncens/ 182cens
% correct predictions (% correct prediction for DV=1)	73.1% (66.7%)	70.3% (77.7%)	82.1% (12.9%)	80.7% (8.6%)	68.2% (63.5%)	56.4% (66.7%)
Heckman Correction ρ (rse & sign level for χ^2 test rho=0)			0.288 (.427)	-0.052 (.927)[19]	-0.758** (.168)	-0.954* (.094)[20]

[19] 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

[20] The regression results for the Heckman correction for INNOV=.088(.254) + 0.0016(.0002)***SIZE –1.05E-07(1.55E-08)***SIZEsq +0.477(.114)***FSUB -.276(.105)***OBSTneed +0.481(.065)***OBSTcost -0.284(.065)***OBSTlack+industry dummies

TABLE 3:

ALTERNATIVE RESULTS ON DIRECT AND INDIRECT EFFECT FOR FSUB ON TRANSFERNAT

Reported are the Marginal effect for a discrete change of the dummy variable from 0 to 1

SCENARIO	TOTAL EFFECT	DIRECT EFFECT	INDIRECT EFFECT VIA BUYinat (A)	INDIRECT EFFECT VIA BUYinat (B)	INDIRECT EFFECT VIA MAKE in BUYinat
***(1) BASIC SCENARIO from Table 2*: Sc(MAKE) included in BUYinat; Heck Correct in TRANSFERnat**	**-0.089 (.100)**	**-0.065** (.032)**	**0.418*** (.146)**	**.156* (.091)**	**-0.035 (.320)**
(2) No Heck Correct in TRANSFERnat	**-0.078* (.042)**	**-0.133*** (.043)**	**0.425*** (.131)**	**.156* (.091)**	**-0.035 (.320)**
(3) Sc(MAKE) not included, but MAKE included as identifyer in BUYinat	**-0.072 (.058)**	**-0.067** (.033)**	**0.383*** (.147)**	**.156*** (.059)**	**.107* (.059)**
(4) MAKE & Sc(MAKE) not included; Heck Correct in BUYinat	**-0.081 (.063)**	**-0.061** (.030)**	**0.447*** (.164)**	**.125 (.081) †**	
(5) Sc(BUYinat) not included in structural form for TRANSFERnat;	**-0.089 (.100)**	**-0.077† (.054)**	**0.150*** (.056)**	**.156* (.091)**	**-0.035 (.320)**

***(6) BASIC SCENARIO from Table 2*: Sc(MAKE) included in BUYinat; Heck Correct in COOPEXnat**	**-0.105** (.054)**	**-0.188*** (.054)**	**0.779*** (.132)**	**.156* (.091)**	**-0.035 (.320)**

TOTAL EFFECT= coefficient of FSUB in Reduced Form for TRANSFERnat (4)

DIRECT EFFECT= coefficient of FSUB in Structural Form for TRANSFERnat (3)

INDIRECT EFFECT via BUYINAT (A)= coefficient of BUYinat in Structural Form for TRANSFERnat (3)

INDIRECT EFFECT via BUYINAT (B)= coefficient of FSUB in Structural Form for BUYinat (2)

INDIRECT EFFECT via MAKE in BUYINAT= coefficient of MAKE in Structural Form for BUYinat(2); Note that the marginal effect of FSUB in the structural form for MAKE (1) is for all scenarios 0.249(.054)***

TABLE 4:

BIVARIATE PROBIT for TRANSFERnat&COOPEXnat

(no Heckman Correction; sc(MAKE) and MAKE included in BUYinat and TRANSFERnat/COOPexnat) N=377

SCENARIO	TOTAL EFFECT	DIRECT EFFECT	INDIRECT EFFECT VIA BUYinat (A)	INDIRECT EFFECT VIA BUYinat (B)	INDIRECT EFFECT VIA MAKE In BUYinat	INDIRECT EFFECT VIA MAKE (A)	INDIRECT EFFECT VIA MAKE (B)
TRANSFERnat	**-0.336*** (.179)**	**-0.644**** (.278)**	**2.172**[21] (.915)**	**.411* (.248)**	**-0.092 (.835)**	**0.064 (.944)[22]**	**0.640*** (.145)**
COOPEXnat	**0.041 (.166)**	**-0.618** (.248)**	**2.334*** (.806)**	**.411* (.248)**	**-0.092 (.835)**	**1.751** (.832)**	**0.640*** (.145)**

Reduced form: Wald chi2= 110.73***; ρ = .395(.089)***; Structural form: Wald chi2= 135.74***; ρ = .369(.093)***

TOTAL EFFECT= coefficient of FSUB in Reduced Form (4)

DIRECT EFFECT= coefficient of FSUB in Structural Form (3)

INDIRECT EFFECT via BUYINAT (A)= coefficient of BUYinat in Structural Form (3)

INDIRECT EFFECT via BUYINAT (B)= coefficient of FSUB in Structural Form for BUYinat (2)

INDIRECT EFFECT via MAKE (A)= coefficient of MAKE in Structural Form (3)

INDIRECT EFFECT via MAKE (B)= coefficient of FSUB in Structural Form for MAKE (1)

INDIRECT EFFECT via MAKE in BUYINAT= coefficient of MAKE in Structural Form for BUYinat(2);

[21] coefficient of scBUYinat from (3): -0.915(.549)* in TRANSFERnat and -1.177(.483)** in COOPexnat

[22] coefficient of scMAKE from (4): -0.036(.537) in TRANSFERnat and -0.673(.472) in COOPexnat

TABLE 5:

BIVARIATE PROBIT for TRANSFERnat&COOPexnat (no Heckman Correction; MAKE endogeneous in TRANSFERnat/COOPexnat); N=379

	TOTAL EFFECT IFSUB	**TOTAL EFFECT NIFSUB**	**DIRECT EFFECT IFSUB**	**DIRECT EFFECT NIFSUB**	**INDIRECT EFFECT VIA MAKE**
TRANSFERnat [23]	**-0.135 (.202)**	**-0.724*** (.288)**	**-0.124 (.329)**	**-0.752** (.318)**	**0.158 (.917)**[24]
COOPexnat	**0.091 (.191)**	**-0.046 (.213)**	**-0.361 (.312)**	**-0.350 (.247)(15%)**	**2.131*** (.831)**

Reduced form: Wald chi2= 116.43***; ρ = .409(.089)***; Structural form: Wald chi2= 123.15***; ρ = .412(.089)***

[23] In reduced form also SIZE & PROT are significant (<10%) both in TRANSFERnat and COOPexnat; In structural form PROT remains significant in TRANSFERnat.

[24] coefficient of scMAKE from (4): 0.067(.530) in TRANSFERnat & -0.719(.481) in COOPexnat

Appendix

Variables Description	
FIRM SPECIFIC VARIABLES	
FSUB	Dummy variable with value 1 when the company is a subsidiary with foreign headquarters
IFSUB	Dummy variable with value 1 when the company is a subsidiary with foreign headquarters and reports information from affiliated firms as important to crucial for its innovations.
IFSUB	Dummy variable with value 1 when the company is a subsidiary with foreign headquarters and reports information from affiliated firms as not to be important to crucial for its innovations.
COOPEXnat	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.
TRANSFERnat	Dummy variable with value 1 for innovative firms transferring technology to a firm located in 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.
BUYinat	Dummy variable with value 1 for innovative firms acquiring technology from a firm located 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.
SIZE	Firm Sales in 10^{10} BEF.
SIZEsq	Firm Sales in 10^{10} BEF squared.
INNOV	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
MAKE	Dummy variable with value 1 when the firm has permanent R&D activities.

EXTINF	Average of scores of importance of following information sources for innovation process (number between 1 (unimportant) and 5 (crucial)): 1. Patent information 2. Specialized conferences, meetings and publications 3. Trade shows and seminars. (rescaled between 0 and 1)
PROT	*PROT* is Average of scores of effectiveness of following methods for protecting new products/processes (number between 1 (unimportant) and 5 (crucial)): 1. Patents 2. Registration of brands, copyright 3. Secrecy 4. Complexity 5. Lead time (rescaled between 0 and 1)
OBSTcost	Average of scores of Importance of Cost and Risk Obstacle for innovation by the firm *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*
OBSTinfo	Average of scores of Importance of Lack of Information for Innovation as an Obstacle to innovation by the firm *lack of information on technology* *lack of market information*
OBSTlack	Average of scores of Importance of Lack of Information for Innovation as an Obstacle to innovation by the firm *lack of qualified personnel* *lack of personnel to innovate*
OBSTneed	Average of scores of Importance of No Need for Innovation as an Obstacle to innovation by the firm *no need for innovation because of earlier innovations* *little interest for innovations by customers*
INDUSTRY DUMMIES	
STEEL	STEEL = 1 if firm is in Steel sector (NACE Codes: 22).
MIN	MIN = 1 if firm is in Minerals(NACE Codes: 24).
CHEM	CHEM = 1 if firm is in Chemicals (NACE Codes: 24, 25exc 2571-2572).
FARMA	FARMA = 1 if firm is in Pharmaceuticals (NACE Codes2571-2572).
MET	MET = 1 if firm is in Metals (NACE Codes: 31).
MACH	MACH = 1 if firm is in Machinery (NACE Codes: 32).
ELEC	ELEC = 1 if firm is in Electrical Equipment Industry (NACE Codes: 33, 34, 37).
TRANS	TRANS = 1 if firm is in Transportation Equipment (NACE Codes: 35,36).
FOOD	FOOD = 1 if firm is in Food & Drink Business (NACE Codes: 41, 42).
TEXT	TEXT = 1 if firm is in Textiles (NACE Codes: 43).
CLOTH	CLOTH = 1 if firm is in Clothing, Shoes & Leather(NACE Codes: 44, 45).
WOOD	WOOD = 1 if firm is in Wood & Furniture (NACE Codes: 46).
PRINT	PRINT = 1 if firm is in Paper & Printing (NACE Codes: 47).
RUBB	RUBB= 1 if firm is in Rubber & Plastics (NACE Codes: 48).

Table A.1: Summary Statistics

Full sample

	TOTAL (N=714)	FSUB=0 (N=514)	FSUB=1 (N=200)
INNOV	445 (62.3%)	281 (54.7%)	164 (82.0%)
MAKE	318 (44.5%)	179 (34.8%)	139 (69.5%)
OBSTlack	2.26	2.29	2.19
OBSTneed	2.16	2.20	2.07
OBSTinfo	2.43	2.47	2.35
OBSTcost	2.80	2.79	2.83
Size	468	350.7	767.2

INNOV=1 only

	TOTAL (N=445)	FSUB=0 (N=281)	FSUB=1 (N=164)
OBSTlack	2.21	2.24	2.16
OBSTneed	2.02	2.02	2.02
OBSTinfo	2.46	2.5	2.40
OBSTcost	2.89	2.87	2.94
EXTINF	2.85	2.77	2.99
PROT	2.66	2.52	2.87
SIZE	699.6	586.5	894.0