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Does trade participation limit domestic firms' productivity gains from inward foreign direct investment?

René Belderbos, Vincent Van Roy and Leo Sleuwaegen

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René Belderbos
KU Leuven, UNU-MERIT and Maastricht University

Vincent Van Roy
KU Leuven

Leo Sleuwaegen
KU Leuven

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ABSTRACT

We examine to what extent domestic firms reap differential productivity gains from the presence of manufacturing affiliates of multinational firms in the home country (FDI spillovers), in the context of simultaneous participation in international trade through exporting and importing. FDI spillovers can occur within the industry (horizontal) and across industries due to client (forward) or supplier (backward) linkages of multinational firms, but the mechanisms underlying spillover effects may be attenuated if local firms are less reliant on inputs, clients, and competition in the domestic market. Fixed effects panel analyses on a sample of 4594 domestic Belgian firms during 2000-2007 reveal positive effects from horizontal, backward, and forward FDI spillovers on the productivity levels of domestic firms, as long as these firms do not engage in international trade. Horizontal spillovers from FDI are weaker for firms engaging in trade, while forward FDI spillovers do not benefit importing firms. Two-way traders benefit least from FDI spillovers. Forward and backward spillovers, are enhanced by human capital levels in local firms, while horizontal spillovers are reduced. The findings are broadly consistent with the notion that trade engagement and inward FDI can be substitutes in their effects on domestic firms' productivity.

Correspondence: KU Leuven, Department of Management, Strategy and Innovation,
Naamsestraat 69, B-3000 Leuven, Belgium
email: rene.belderbos@kuleuven.be, phone-number: +3216326912

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1. Introduction

Foreign direct investment (FDI) and trade are major conduits of international technology transfer and knowledge spillovers. Affiliates of multinational firms generally report higher productivity levels compared to their domestic firm counterparts (De Backer and Sleuwaegen, 2003; Driffield, 2001; Girma et al., 2001). This makes them an important source of potential knowledge spillovers to domestic firms, through diffusion of superior manufacturing practice and technology, increased competition encouraging domestic firms to become more efficient, and supplier and buyer relationships with domestic firms (Görg and Strobl, 2001; Görg and Greenaway, 2004; Havranek and Irsova, 2011; Anwar and Nguyen, 2014; Belderbos et al., 2001).

A second channel of international knowledge spillovers is through international trade, with both importing and exporting potentially associated with learning, knowledge spillovers and productivity enhancements. The import of intermediated inputs can positively affect firm productivity through learning-by-importing effects (Wagner, 2012), related to access to a wider variety of inputs and equipment that are of better quality than those of the domestic counterparts (Amiti and Konings, 2007; Bas and Strauss-Kahn, 2014) and the exploitation of superior technologies embedded in these inputs (Halpern et al., 2015). Learning through export channels (learning-by-exporting) occurs if engagement in export markets exposes the firm to new and more rigorous demands of foreign clients and if foreign clients provide (technical) assistance in order to improve product designs and quality (e.g. Keller, 2010; De Loecker, 2013).

While both channels of knowledge spillovers and transfers have received ample attention in the literature, their simultaneous effects and potential interactions have not received due attention. A limited number of studies considered possible interactions at the level of the industry or country, but not at the level of the firms.[1] Analyzing interactions at the micro-level is important because substitution or complementarity between trade and FDI spillovers is likely to be heterogeneous among firms with different patterns of trade participation. Hence, analysis at the

[1] E.g. Souare (2014) examined the contribution of international trade and FDI to productivity growth in Canadian manufacturing industries, while Pietrucha and Zelazny (2019) study this relationship at country level.

industry or country level by aggregating over heterogeneous firms may obscure relevant patterns of interaction between FDI and trade.

In this paper, we examine the relationship between FDI and trade knowledge spillovers at the level of individual firms. More in particular, we analyze to what extent these two channels of learning and knowledge spillovers are substitutes, and whether substitution patterns depends on the specific trade involvement (import, export, or two-way trade) and type of FDI spillovers (backward, forward, or horizontal spillovers). Substitution may arise when firms that trade internationally may benefit less from FDI spillovers in the host country in comparison to purely domestic firms, as trading firms can obtain similar spillovers through their relationships with foreign partners and have less engagement with multinational enterprises (MNEs) operating in their country. Exporting firms may learn from foreign clients rather than from the backward linkages of foreign MNEs at home; importing firms are more likely to benefit from higher quality inputs supplied by firms abroad rather than by the forward linkages of multinational suppliers in the home country; and exporting firms are less likely to be affected by domestic competition and horizontal spillovers, as their core markets are abroad.

We test these relationships by employing fixed effects panel analysis on a representative sample of 4594 domestic Belgian firms during the period 2000-2007. Specifically, we examine the significance and impact of the three different FDI spillover channels for different groups of firms: purely domestic oriented firms (firms with no trade engagement), firms that export (only), firms that import (only), and firms with full trade involvement (both export and import). We also examine whether FDI spillovers are more salient for firms with higher human capital. Belgium is a particularly interesting country to examine given relatively high levels of productivity, trade intensity (80 percent of GDP), and the high share of manufacturing output controlled by foreign multinationals (about 50 percent).

The remainder of the paper is organised as follows. The next section reviews the relevant literature and discusses how heterogeneity in trade participation of domestic firms may affect the spillovers from inward foreign investment and presents the contribution and research conjectures of our study. Section 3 proposes an empirical approach to test for this heterogeneity in FDI spillovers due to trade relationships and presents the statistical model and data against which the model is tested. Section 4 present the estimation results. Various robustness tests are presented in section 5. Section 6 provides a further interpretation of the results and concludes.

2. Previous Literature

To gain more detailed insights on international channels of knowledge transfers, spillovers and firm productivity, we review the strands of literature on foreign direct investment and international trade.

Inward foreign direct investment and productivity

The presence of affiliates of foreign MNEs is often seen as a conduit for transfer of technology and knowledge within and across sectors in the host country. Technology and best practices from foreign MNEs can spill over to local competitors within the same industry (horizontal spillovers), or within vertical relationships with domestic firms as suppliers (backward spillovers) or buyers (forward spillovers). Spillovers come in many forms, such as new technologies, working methods, and management skills, and can result in improved productivity.

The results of studies analyzing spillover effects due to inward FDI have been rather ambiguous though, ranging from negative to positive depending on the data and methods used and the country that has been considered (Havranek and Irsova, 2011; Irsova and Havranek, 2013, Demena and van Bergeijk, 2017; Rojec and Knell, 2018).[2] The earliest empirical studies focused on horizontal spillovers at the industry-level and found positive associations between industry productivity and FDI in Australia (Caves, 1974) and Canada (Globerman, 1975). Other studies discussed the effects of FDI using well-elaborated case studies (Rhee and Belot, 1990; Larrain et al., 2001), but the results of these studies lacked the potential to be generalized. Cross-sectional studies at the firm level have confirmed a positive role of horizontal spillovers in the UK and Greece, respectively (Driffield, 2001, Dimelis and Louri, 2002).

As highlighted by Görg and Strobl (2001), technology diffusion is a dynamic phenomenon, making panel data analysis the most appropriate method to estimate improvements in host-country

[2] Görg and Greenaway (2004) survey the existing literature on the externalities due to inward foreign direct investment.

firms' productivity. Using a panel of US manufacturing firms, Keller and Yeaple (2009) found a substantial influence of FDI spillovers on productivity growth. Haskel et al. (2007) similarly confirmed that the foreign-affiliate presence had a positive impact on domestic firms' total factor productivity (TFP) in UK industries. On the other hand, several other studies have reported inconclusive or even negative effects of inward FDI on local firm productivity (Girma et al., 2001; Barrios and Strobl, 2002). The failure to find robust evidence for horizontal spillovers may be related to the fact that foreign multinationals have strong incentives to protect their superior technology in order to prevent leakages to local competitors (Veugelers and Cassiman, 2004). Moreover, at least in the short run, the entrance of foreign multinationals may also be harmful to local firms if competition by foreign affiliates reduces growth opportunities and the potential to reap scale economies, or if foreign affiliates succeed in attracting the most qualified employees (De Backer and Sleuwaegen, 2003; Kosova, 2010).

The effect of backward and forward spillovers on host-country firms' productivity have also been investigated (e.g. Havranek and Irsova, 2011). Most studies have focused on developing countries (e.g. Blalock, 2001; Javorcik, 2004; Kugler, 2006; Anwar and Nguyen, 2014; Alfaro, 2017). In general, findings suggest (economically) significant productivity-enhancing effects of backward spillovers to local upstream firms, while there is less evidence for the existence of substantive forward spillover effects.

A number of studies have suggested that the gains from spillovers due to FDI depend on the absorptive capacity and catching-up capabilities of local firms (Görg and Greenaway, 2004). According to the absorptive capacity argument of Cohen and Levinthal (1990) domestic firms need to possess a certain level of human capital and technological knowledge in order to understand, assimilate and exploit knowledge and technologies from foreign-affiliates. Domestic firms may be more able to catch-up technologically when the technology gap between both parties is not too large (Findlay, 1978). In a panel of 4000 UK manufacturing firms covering the period 1991-1996, Girma et al. (2001) showed that FDI spillovers benefit domestic firms with a relatively small technology gap relative to technology leaders. Similar evidence was found for Romanian (Lenaerts and Merlevede, 2015) and Hungarian firms (Békés et al., 2009).

International trade and productivity

There also is a growing literature examining the productivity effects of firms' participation in international markets as exporters or importers. One of the main challenges has been to determine the direction of causality between international trade and firm productivity. Most of the empirical studies have been focused on exporting.

Since the seminal papers of Bernard and Jensen (1999; 1995), and Bernard and Wagner (1997) two reasons are commonly advanced to explain why exporters tend to record superior productivity performance compared to their non-exporting counterparts. The first reason relates to self-selection of the more productive firms into export markets. The argument in favor of self-selection relates to the additional costs of exporting. Entering export markets involves sunk costs linked to obtaining knowledge of foreign markets, the screening of potential customers, the set-up of foreign distribution channels and the adoption of products and services to the local needs and tastes (Kneller and Pisu, 2007; Maurseth and Medin, 2016). These costs act as an entry barrier, preventing less productive firms from exporting. Firms may also anticipate competition in foreign markets, introduce new technologies to obtain higher quality products and services, and hence become more productive prior to export (López, 2005, 2009). The second reason relates to learning-by-exporting. Exporting firms may gain in efficiency and improve their productivity (Crespi et al., 2008; De Loecker, 2013) or innovation performance (Salomon and Jin, 2008; Almodóvar, 2014; Belderbos and Grimpe, 2020) through interactions with foreign customers and increased international competition.

Literature reviews (e.g. Wagner, 2012; López, 2015) conclude that the empirical evidence in favor of the selection effect is relatively clear-cut and consistent over a wide range of countries, including industrialized countries (Damijan et al., 2007; Pisu, 2008; Serti and Tomasi, 2008; Verardi and Wagner, 2012), and transition and developing economies (Alvarez and Lopez, 2005; Wilhelmsson and Kozlov, 2007; Ranjan and Raychaudhuri, 2011). Empirical evidence for the learning-by-exporting hypothesis is less conclusive. While several studies found beneficial effects of exporting (Girma et al., 2004; Crespi et al., 2008; Keller, 2010; De Loecker, 2013), other studies could not confirm positive learning-by-exporting effects (Bernard and Jensen, 2004; Ruane and Sutherland, 2005). Studies have also suggested that export learning may depend on firm characteristics and the pattern of exports. Baldwin and Gu (2003) and Delgado et al. (2002) found most learning to occur in younger firms. Andersson and Lööf (2009) and Castellani (2002) found learning effects most robust for firms with the highest export intensity. Learning by exporting also depends on the sophistication of exports markets and the degree of competition that firms face in these markets (Greenaway and Kneller, 2007; Wagner, 2012).

Similar arguments on selection and learning have been put forward to explain a positive association between import and productivity. Firms may self-select into import markets due to the fixed costs of importing, as information asymmetries associated with imperfect monitoring of the quality of purchased goods make the search for potential foreign suppliers costly (Altomonte and Békés, 2010). In addition, importing involves costs related to the transfer and the use of technologies that are embedded in imported intermediates. The costs related to importing make it more likely that the more productive firms self-select into importing. At the same time, importing intermediate inputs may allow firms to improve their production efficiency through access to a larger variety of intermediates of higher quality and at the forefront of technology (Ethier, 1982; Amiti and Konings, 2007; Bas and Strauss-Kahn, 2014). Advanced imports may then serve as an important channel for knowledge and technology transfers (Aristei et al., 2013).

Empirical studies examining the relationship between imports and productivity obtained robust evidence in favor of self-selection (Altomonte and Békés, 2010; Vogel and Wagner, 2010), while the evidence for learning-by-importing has been less conclusive. While most studies pointed at productivity gains through importing (Lööf and Andersson, 2010; McCann, 2011; Augier et al., 2013; Silva et al., 2013; Forlani, 2017), several studies found weak effects or effects that were only observed in the long run (Dovis and Milgram-Baleix, 2009; Smeets and Warzynski, 2013). Productivity gains from imports were found to be larger for firms with a stronger absorptive capacity (Okafor et al., 2017). Finally, the productivity-enhancing effects of imports may in turn increase the probability of exporting (Lo Turco and Maggioni, 2013). This may explain why two-way traders are often found to be the most productive firms compared to firms that only import, only export or do not trade at all (Andersson et al., 2008; Muûls and Pisu, 2009; Castellani et al., 2010; Aristei et al., 2013; Halpern et al., 2015). Two-way traders are also often integrated in global value chains, in particular in small open economies such as Belgium where exports consists for the largest part of intermediate goods (Duprez and Dresse, 2013). Some studies have also looked at the moderating effect of trade policies on the magnitude of FDI spillovers and found the latter to be stronger in countries with open trade regimes (cf. Lesher and Miroudot, 2008).

Our study

Our research builds on previous studies and provides several original contributions to the literature on heterogeneity in the spillover effects due to inward foreign investment. We contribute to the stream of literature that has examined how structural characteristics of MNEs and domestic firms moderate spillovers from FDI (Havranek and Irsova, 2011; Irsova and Havranek, 2013). We refine this analysis by considering the moderating role of engagement of local firms in international markets at the micro level, i.e. the level of individual firms. Previous studies have typically assumed that export, import and FDI are channels of spillovers that add up in contributing to productivity. Most of these studies have however taken the country as unit of analysis, while they rarely considered the different channels simultaneously.[3] At the level of firm, such complementarity between trade and FDI spillovers is less obvious. On the contrary, there are good reasons to expect that the different spillover channels may substitute for each other at the level of individual firms. FDI spillover effects found at the country level may not carry over to the firm level and may provide an incomplete view by aggregating over different types of firms with heterogeneous trade involvement.

Horizontal, backward and forward vertical spillovers occur with different intensities through the various technology and knowledge diffusion channels. Four channels are commonly distinguished: demonstration and imitation, competition, supplier and client linkages effect, and training (Blomström and Kokko, 1998; Rojec and Knell, 2018). Demonstration and imitation effects can occur in the context of various types of relationships between MNEs and domestic firms through the access to information on production technologies and managerial or organizational knowledge stemming from collocation with MNEs in the local market. Competition effects derive from rivalry with MNEs that puts pressure on domestic firms to improve production technologies and techniques. The foreign buyer and supplier linkage effect relates to knowledge spillovers gained by domestic firms

[3] One exception is a study of Pietrucha and Zelazny (2019) that explores trade (import and export) and foreign direct investment (FDI) as channels of international total factor productivity (TFP) spillovers in a cross-country analysis.

that export to sophisticated buyers MNE (Görg and Greenaway, 2004), or by domestic firms purchasing sophisticated inputs from supplier MNEs. Training effects typically derive from movements of highly skilled personnel from MNEs to domestic firms (Görg and Strobl, 2001).

These different mechanisms of FDI spillovers have different levels of relevance for the three types of FDI spillovers. Horizontal FDI spillovers will rely on imitation effects, hiring workers trained by MNEs subsidiaries, and competitive pressure to perform. For forward vertical spillovers, access to specialized intermediate inputs appears produced locally by MNEs is the most relevant channel (Rodriguez-Clare, 1996). The most important channels of spillover effects due to backward linkages are the direct knowledge transfer, higher requirements for product quality and on-time delivery imposed by MNE clients locally (Javorcik, 2004; Lall, 1980: Rojec and Knell, 2018).

We argue that local firms that are engaged in international trade are less exposed to interactions with MNE in the domestic market and hence are likely to benefit less from the various mechanisms through which MNEs with a local presence generate FDI spillovers. The spillover learning and productivity benefits of local firms engaging in trade are more likely to derive from their interactions with foreign-based clients, suppliers, and rival firms rather than local subsidiaries of MNEs. Horizontal FDI spillovers can be expected to be less important for internationally trading firms, since they are exposed to competition on foreign markets and have more options to learn and imitate best practices from foreign firms than only from local MNE affiliates (Aristei et al, 2013). Domestic firms importing intermediate goods benefit through their relationship with foreign suppliers and will benefit relatively less from relationships with local MNE suppliers, on which they are less likely to rely. Exporting firms exposed to sophisticated and demanding clients in foreign markets can be expected to benefit less from client relationships with local MNEs and backward FDI spillovers (Blomström & Sjoholm, 1999). A fortiori, firms that both import and export, especially those that are more integrated in global value chains will benefit most from their foreign trade integration, and hence can be expected to benefit least from horizontal and vertical FDI spillovers in the country, compared to purely domestic firms without such trade activities. We formulate these expectations as testable hypotheses as follows:

Horizontal FDI spillovers will be most important for domestic firms that do not import or export and will be least important for two-way traders.

Domestic firms that import will benefit less from forward FDI spillover, and domestic firms that export will benefit less from backward FDI spillovers.

3. Data, Variables and Empirical Methods

The data for our study are drawn from the BELFIRST[4] database containing financial reports of all active firms in Belgium if they employ personnel. We only take into account firms with at least five employees, as the calculation of total factor productivity is less accurate for smaller firms due to less reliable reporting. We estimate our models on a balanced sample of manufacturing firms, focusing on firms that were active throughout the period 2000-2007.[5] We only include domestic firms in the analysis, i.e. firms with headquarters located in Belgium. These selection screens led to a sample of 4594 domestic firms. The distribution of the sample firms over industries is roughly similar as the industry distribution of all firms in the population, and is presented in Table 1.

- INSERT TABLE 1 -

The *dependent variable* in our analysis is total factor productivity. We follow the index number method (Aw et al., 2001) to calculate total factor productivity.[6] One of the advantages of the index number method is that it allows for heterogeneity in the production technology of individual firms, whilst other methods assume an identical production technology among firms within a sector. The index number method does not produce productivity levels in absolute terms but constructs an index of productivity for each firm within its sector. It quantifies the relative TFP level of a firm in a year compared to the sectoral TFP mean in a reference period. We use the first year of the sample period (2000) as reference year. We obtain producer price deflators from Eurostat and deflators for investments in fixed assets from Belgostat.

[4] BELFIRST is the database on Belgian firms that is integrated in AMADEUS and ORBIS.

[5] Analysis of selection effects did not suggest that focusing the analysis on a balanced sample leads to selection bias (see Appendix D).

[6] For more information concerning the alternatives to calculate total factor productivity levels, see Van Biesebroeck (2007). Details on the calculation of the TFP index are provided in Appendix A. We also attempted semi-parametric methods of Olley and Pakes and Levinshon-Petrin as alternative ways to calculate total factor productivity. Regression estimation with Olley-Pakes method proved non-robust and led to a negative estimated coefficient for fixed assets. The Levinshon-Petrin method could not be performed due to a lack of data on materials input.

Independent variables. Consistent with earlier studies, (potential) FDI spillovers are measured as the relative presence of foreign owned affiliates. The horizontal spillover measure (HS_{jt}) is defined as the share of the output (Y) of foreign owned affiliates in the total output of industry *j* in period *t*:

$$HS_{jt} = \sum Y^{FMNE}{}_{jt} / \sum Y_{jt}$$

We capture the extent of potential spillovers from foreign-owned affiliates to local suppliers (backward spillovers) by the presence of foreign affiliates in relevant downstream industries. Backward spillovers (BS_{jt}) to sector *j* in period *t* are measured as the sum of the presence of foreign-owned firms in downstream industries *k* weighted by the share of industry *j*'s output destined for industry *k*:

$$BS_{jt} = \sum_k \alpha_{jk} HS_{kt}$$

The parameter α_{jk} denotes the proportion of sector *j*'s output supplied to sector *k*. We derive this proportion from an available input-output matrix for 2000.[7] The backward spillover measure excludes sales within the industry, as same-sector spillovers are captured by the horizontal spillovers variable.

Finally, we measure (potential) forward FDI spillovers as the sum of presence of foreign affiliates in upstream industries, weighted by the shares of intermediate inputs that sector *j* procures from these industries:

$$FS_{jt} = \sum_k \beta_{jk} HS_{kt}$$

where the parameter β_{jk} is the share of intermediary goods purchased by sector *j* from sector *k*.

[7] Since more recent input-output matrices are not available, we cannot take into account the changes in industry proportions over time, but it is quite unlikely that the input-output relationships between sectors have fluctuated substantially.

We control for a firm's absorptive capacity by including a firm-level indicator of human capital. We follow the approach of prior studies in measuring human capital by developing a composite indicator (Bouquet, 2004; Onkelinx et al., 2016). This indicator aims to capture the aggregate knowledge, skills, abilities and other competences of a firm's workforce (Ployhart et al., 2006). It comprises the average wage level of employees, and the percentages of white-collar employees and directors in the workforce. The wage level is an indicator of the experience and skills and is calculated by dividing the total wages by the number of employees in full-time equivalents. The percentages of white-collar employees and directors proxy for the knowledge stock of employees.[8] The average wage levels and the percentages of white-collar employees and directors are divided by the respective sector averages. These three indicators are then standardized and summed up to arrive at a normalized indicator for human capital. We employ weights of 50% for average wage levels, 35% for white-collar employees and 15% for director.[9]

Other variables included in the models are firm age, firm size, and a set of year dummies to control for macro-economic trends. The spillover variables are lagged by one year, as spillovers may take some time to affect productivity (Görg and Strobl, 2001).[10] A table with correlations of the variables is relegated to appendix B.

Model and Methods. We estimate fixed effects models to relate potential spillovers arising from FDI to total factor productivity:

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[8] Prior studies (e.g. Hitt et al., 2006, Onkelinx et al., 2016) have added the education level of the workforce to capture human capital. The education level could not be included in the composite indicator as this information was not sufficiently available in Belfirst for our sample of Belgian firms.

[9] Different weighting thresholds (with variations up to 15%) have been used to test for the sensitivity of the empirical results to the composite indicator. Results remain virtually unchanged.

[10] As spillover effects on domestic firms' productivity may take more time to emerge, analyses have also been conducted with two-year lags, yielding similar results. Although we estimated the FDI spillover effects with lags, we cannot fully exclude the possibility that FDI is attracted to industries with high productivity. We note that, while this would be a potential source of bias for the estimates of horizontal spillovers, this would be unlikely to extend to backward and forward spillovers due to FDI in other than the focal industry.

$$tfp_{i,t} = \alpha + \beta_1 HS_{j,t-1} + \beta_2 BS_{j,t-1} + \beta_3 FS_{j,t-1} + \beta_4 age_{i,t} + \beta_5 empl_{i,t} + \beta_6 HC_{i,t} + y_t + \varepsilon_i + v_{i,t} \quad (1)$$

with small letters denote natural logarithms. The dependent variable $tfp_{i,t}$ refers to the natural logarithm of total factor productivity index of firm *i* in year *t*. Variables $HS_{j,t-1}$, $BS_{j,t-1}$ and $FS_{j,t-1}$ are one-year lagged horizontal, backward and forward spillovers calculated at the NACE two-digit level. Control variables $age_{i,t}$, $empl_{i,t}$ and $HC_{i,t}$ account for firm age, firm size and the firm's human capital, y_t refers to year dummies to control for year-specific effects on firm productivity, $v_{i,t}$ is the usual error term, and ε_i are firm fixed effects controlling for firm heterogeneity in productivity levels.

Our empirical strategy to test for differences in FDI spillovers between firms with and without trade engagement is to estimate equation (1) separately on different subsamples of firms: firms with no trade (i.e. no import or export activities), firms with only exports, firms with only imports, and two-way trade firms (i.e. engaged in both imports and exports).[11] Subsample analysis is widely used for comparing coefficients between groups due to the advantages it offers (Greene, 2008): it does not require that unexplained variance is identical between the groups of firms, and it allows the effects of the independent variables to differ between the groups, leading to consistent within-group estimates. We employ Wald tests to compare coefficients across subsamples.

-INSERT TABLE 2 -

Descriptives. Average total factor productivity indices by type of trade engagement, and the horizontal, backward and forward spillover measures are presented by industry (for the year 2007) in Table 2. In most sectors – exceptions are paper and printing, rubber and plastics and cars and transport equipment, the mean TFP index (in 2007) of firms engaged in export and import is significantly higher than the mean TFP of firms not engaged in trade. Industries with a strong foreign multinational firm presence are the chemicals and car and transport equipment industries, followed by the electrical equipment, metal, and machinery industries. Backward spillovers are relatively low in the food and car and transport equipment industries, as these industries generally

[11] In case a firm starts or ends a specific type of trade engagement, it is re-allocated to the relevant subsample.

have few industrial clients. Forward spillovers are relatively high in the rubber and plastic industry and machinery industries.

4. Empirical Results

The results of the fixed effects models are reported in Table 3. The first model is estimated for the full sample and serves as a comparison for the subsample analyses. The results suggest positive productivity effects for both horizontal and backward spillovers, but no productivity enhancing effect of forward spillovers (the coefficient is negative but insignificant). The results for the control variables show that more experienced, larger and skill-intensive firms have significantly higher productivity levels, as may be expected. The year dummies indicate a rising trend in total factor productivity during the period.

- INSERT TABLE 3 -

Columns 2-5 report results for specific sub-samples of firms depending on their international trade engagement, distinguishing firms that have no international transactions from those that only export, only import, or both export and import. The findings demonstrate important differences in the effects of FDI spillovers across these different types of firms. For domestic firms that are not engaged in trade, all channels of FDI spillovers exert a significantly positive effect on productivity, with forward spillovers showing the largest coefficient. In contrast, for two-way traders, there is a significantly negative coefficient for forward spillovers[12], while the coefficients for horizontal and vertical spillovers are smaller than those in the subsample of firms without trade.

For forward spillovers, a significant influence is notable for firms that do not import and hence are reliant on the domestic market for their intermediate inputs. In contrast, for firms importing from abroad, forward spillovers from foreign affiliates in the local economy have no significant productivity improving effect (column 3), while for firms engaging in both import and export the estimated coefficient on forward spillovers is even negative and significant, as noted

[12] We note that the observed negative effect does not imply an absolute decline in productivity due to MNE presence, since our measure of TFP is a firm level index relative to the industry level.

above. Wald tests (reported in Appendix C) confirm that the differences in the coefficient of forward spillovers for non-trading firms on the one hand, and the coefficients for importing or importing and exporting firms on the other hand, are significant ($p<0.001$). These results suggest a substitution effect between trade engagement and FDI spillovers where it concerns forward spillovers. These results are consistent with our expectations.

The effects of backward FDI spillovers are positive and significant across all firm types. While also in this case heterogeneity is observed, with the coefficients smaller for firms with export activities as expected, Wald tests indicate that these differences are not significant, such that the results only provide qualified evidence on the moderating role of trade engagement for backward spillovers.

With respect to horizontal spillovers, we observe clear (and significant, $p<0.001$) differences in coefficients between firms with no trade engagement on the one hand and importing firms and firms with full trade engagement on the other. The coefficient on horizontal spillovers for non-trading firms is also higher than the comparable coefficient for exporting firms, but this difference is not significant. Overall, the results also provide qualified evidence for substitution between trade engagement and horizontal FDI spillovers, as conjectured in section 2.

- INSERT TABLE 4 –

The magnitudes of the FDI spillover effects and the substitution effects between trade participation and domestic FDI spillovers are illustrated in Table 4. The numbers represent the percentage increase in TFP due to changes in FDI spillovers, and how these differ across firms with and without trade involvement. The predicted effects are calculated based on the actual observed range of FDI spillovers per industry (the difference between the industry's maximum and minimum values) during the observation period and then averaged, keeping all other variables at their mean. For comparison, the table also shows the average TFP index for the different samples of firms based on their trade engagement, benchmarked at the TFP level of firms without trade engagement. Table 4 shows that average TFP index levels are higher for exporting and importing firms compared to firms without trade engagement (106.7 and 107.3 respectively, against a benchmark of 100) and substantially higher for firms engaged in both imports and exports (121.6), illustrating the productivity advantages related to trade involvement documented in prior literature.

At the same time, the table shows that the predicted productivity gains from increases in FDI are highest for domestic firms without trade involvement: for horizontal spillovers (15.5%), forward spillovers (7.9%), and backward spillovers (5.8%). The TFP increase due to horizontal spillovers are substantially smaller for firms engaged in import and export (6.6%) but the difference is less strong with exporting firms (13.5%). While the effects of backward spillovers do not differ much across types of firms, important differences in predicted effects of forward spillovers are observed: compared to the 7.9% for firms without trade engagement and 6.8% for exporters, there is no significant effect for importers and a 3.3% decline for firms with full trade involvement. Hence, the lower productivity levels for firms without or with less trade engagement are at least partially compensated by higher levels of domestic FDI spillovers, illustrating the substitution effect between spillovers from trade and FDI. The high relative TFP level for firms engaged in both import and export suggest that the FDI spillovers effects for domestic firms are not such that they can fully compensate for the productivity effects of trade.

We examined the potential role of heterogeneity in the effects of spillovers due to differences in absorptive capacity. While the majority of prior studies assumed that the spillovers from FDI affected the productivity of all domestic firms equally, a growing number of empirical researches examine the potential role of absorptive capacity. One strand of the literature uses (indices of) R&D information, proportion of skilled labour and training activities as a proxy for a firms' absorptive capacity (e.g. Marcin, 2007; Chudnovsky et al., 2008; Augier et al., 2013; Kim, 2015; Liang, 2017), while another stream of studies measures absorptive capacity through the firm's technology gap with industry leaders (e.g. Girma and Görg, 2005; Zhang et al., 2010). These studies argue that spillover effects may be higher for firms that have more absorptive capabilities to reap the benefits of knowledge leakages that could eventually spill over from foreign firms (Augier et al., 2013; Smith, 2014; Crescenzi et al., 2015; Liang, 2017). Other studies suggest, however, that the productivity impact of technology spillovers and transfers may benefit lagging firms most, as they have more opportunities to learn and to catch up with the leaders (Griffith et al., 2009).

To examine the potential role of absorptive capacity in affecting FDI spillovers, we introduce interaction terms between the human capital index and the FDI spillover measures and present the results of this extended model in Table 5. Overall, while the results suggest differences in the magnitude of the spillover effects in accordance with a firm's human capital, the core results regarding substitution between trade and FDI spillovers remain unchanged. Our findings generally support the relevance of absorptive capacity for the effect of vertical FDI spillovers. Similar to Marcin (2007) and Liang (2017), we find that the effect of backward spillovers is more pronounced for firms with stronger absorptive capacity due to greater human capital. The interaction terms are significant in all models. For forward spillovers a similar pattern is observed, with the exception of the exporter subsample, in which the positive interaction coefficient does not reach conventional significance levels. The analysis confirms prior findings that potential negative effects of forward spillovers (in the two-way trade subsample) are significantly reduced for high absorptive capacity firms (e.g. Kim, 2015). In the case of horizontal spillovers, on the other hand, we observe a very different pattern. Positive effects of FDI spillovers are reduced, rather than increased, for firms with greater human capital, although the effect sizes are rather small. This could indicate potentially more accentuated negative effects of the downside of MNE presence due the direct competition of domestic firms with MNEs: local firms with more skills and similar capabilities as MNEs may find stronger negative effects of competition on productivity by constraining growth potential as they compete for similar sophisticated parts of the markets, while they will also compete more intensively with MNE for skilled employees. (De Backer and Sleuwaegen, 2003; Kosova, 2010).

We performed a number of supplementary analyses to examine the robustness of our finding. First, we estimated two-step models due to Heckman (1979) to test whether estimations are biased due to a non-random exit of firms from the sample during the observation period. The results are presented in Appendix D and remained unchanged in this specification, with the selection parameter insignificant in the productivity equation.

- INSERT TABLE 5 –

5. Conclusion

Although an extensive body of literature has examined the importance of spillovers from inward foreign direct investment (FDI) in industrialized countries (Doms and Jensen, 1998; Girma et al., 2001; Görg and Strobl, 2001; Görg and Greenaway, 2004), prior studies have not examined to what extent the spillover effects may be affected by the simultaneous involvement of domestic firms in international trade. Firms with a strong international involvement through sourcing goods and services from abroad and/or by exporting goods to foreign buyers are less dependent on the domestic economy and interactions with local affiliates of MNEs, and may be relatively less likely to benefit less from spillovers due to the presence of foreign affiliates in their home country. The involvement of firms in international markets and value chains can be considered alternative channels for productivity gains and international knowledge spillovers (Bernard and Jensen, 2004; Muûls and Pisu, 2009; McCann, 2011; De Loecker, 2013; Belderbos and Grimpe, 2020). Prior - aggregate level - studies could not give this detailed attention, since the relationship between trade and FDI spillovers is heterogeneous across firms and requires a micro level analysis.

Our analysis of total factor productivity, FDI spillovers, and trade engagement of Belgian firms shows that the importance of FDI spillovers indeed depends on the trade engagement of the domestic firm. On average, domestic firms benefit from horizontal and backward spillovers but effects of forward spillovers are absent (Blalock, 2001; Javorcik, 2004; Kugler, 2006). However, forward spillovers do significantly benefit productivity of domestic firms as long as they are not engaged in import activity. Differences in the effects of FDI on productivity are also found for horizontal spillovers, with spillovers significantly smaller for firms engaged in imports and exports. Backward spillovers, in contrast, appear relatively robust across types of firms. The latter appears consistent with prior studies suggesting relatively strong effects of backward spillovers related to the active engagement of multinational affiliates in local supplier development (e.g. Javorcik, 2004; Javorcik and Spatareanu, 2008). Absorptive capacity as indicated by the presence of human capital positively moderates the relationship between productivity and forward as well as backward FDI spillovers, whereas a negative moderating relationship is observed for horizontal spillovers. Higher human capital may accentuate the potential downside of MNE presence due the direct competition of domestic firms with MNEs: local firms with more skills and similar capabilities as MNEs may find stronger negative effects of competition on productivity by constraining growth potential as they compete for similar sophisticated parts of the markets, while they will also compete more intensively with MNE for skilled employees. (De Backer and Sleuwaegen, 2003; Kosova, 2010).

Our findings confirm that learning from direct trade engagement can substitute for learning and spillovers due to the presence of foreign multinationals in the local economy, in particular where it concerns the productivity benefits of sourcing intermediate goods from foreign affiliates, and the effects of local affiliates operating in domestic firms' output market. An implication is that the often ambiguous findings on the importance of FDI spillovers in prior studies may be due to the failure to take heterogeneity in spillover effects due to domestic firms' engagement in trade into account. Similarly, earlier mixed findings on the role of learning by exposure to international (export or import) markets may be partially due to the heterogeneous availability of alternative avenues for learning related to potential FDI spillovers in the host country. Our findings call for balanced and nuanced policies with respect to trade and FDI, in which foreign sourcing through imports, inward foreign direct investment and exports are seen as equally important instruments to upgrade activities and generate productivity growth in the local economy.

Our research has a number of limitations. First, lack of data limited our analysis to a distinction between import and export status, while we could not take into account differences in import and export intensities. Second, spillover effects are likely to differ depending on the domestic or foreign market orientation of the foreign affiliates of the MNEs. For instance, firms without trade engagement may benefit less from horizontal spillovers when foreign affiliates are mostly targeting international markets (e.g. Crescenzi et al., 2015), and there may be differences between minority owned and majority owned affiliates (Merlevede et al., 2014). Third, although we related productivity to lagged levels of FDI, we cannot fully exclude the possibility that FDI is also attracted to industries with high productivity. While this would be a source of bias for the estimates of horizontal spillover effects, perhaps this is less likely for the estimates of backward and forward spillovers, since these involve FDI in industries other than the focal industry.

We suggest that future studies explicitly differentiate the channels through which productivity gains and knowledge spillovers can be obtained accounts for different risks associated with the trade and FDI channels (see e.g. Gupta et al., 2019). Such studies would preferably make use of information on the actual intensities of import and export involvement of domestic firms, going beyond the categorization of import and/or export status in the current study.

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Table 1: Distribution of firms across industries

Industry	Firms: Numbers	Firms: %
Food, drink and tobacco	655	14.3
Textiles and leather	542	11.8
Paper, printing and publishing	741	16.1
Chemical industry	212	4.6
Rubber and plastic	155	3.4
Non-metal mineral products	287	6.2
Metals	889	19.4
Machinery	351	7.6
Electrical equipment	266	5.8
Cars and transport equipment	89	1.9
Other manufacturing industries	407	8.9
Total	4594	100

Table 2: Means of total factor productivity and potential spillovers from FDI per industry and trade participation status of domestic firms (2007)

Industry	*Total Factor Productivity*					*Spillovers*		
	Full Sample	Export only	Import only	Two-way trade	No trade	Horizontal	Backward	Forward
Food, drink and tobacco	1.28	**1.28**	*1.25*	**1.41**	1.08	0.51	0.03	0.09
Textiles and leather	0.83	0.56	0.70	**0.89**	0.66	0.29	0.14	0.18
Paper, printing and publishing	0.95	0.93	0.91	0.96	0.97	0.35	0.16	0.14
Chemical industry	1.82	1.58	1.63	1.88	1.45	0.92	0.14	0.08
Rubber and plastic	0.74	0.72	0.68	0.74	0.86	0.63	0.44	0.40
Non-metal mineral products	0.52	0.61	0.47	0.60	0.46	0.52	0.35	0.17
Metals	0.26	0.20	0.29	*0.31*	0.23	0.68	0.30	0.13
Machinery	0.84	0.68	0.82	**0.92**	0.70	0.65	0.13	0.34
Electrical equipment	1.35	1.32	*1.39*	**1.47**	1.12	0.75	0.28	0.15
Cars and transport equipment	1.03	1.05	1.02	1.12	0.88	0.88	0.09	0.23
Other manufacturing industries	0.50	0.44	0.58	0.51	0.47	0.24	0.25	0.28

Note: Sectoral TFP means are compared with those of the "No trade" sample, with significant differences in bold.

Table 3: FDI spillovers and total factor productivity of domestic firms depending on trade participation: Results of fixed effects models (2000-2007)

	(1) Full sample	(2) No trade	(3) Only export	(4) Only import	(5) Two-way trade
Horizontal spillovers	1.137***	1.634***	1.417***	1.151***	0.695***
	(0.034)	(0.064)	(0.146)	(0.100)	(0.052)
Backward spillovers	1.712***	1.662***	1.363***	1.916***	1.417***
	(0.108)	(0.170)	(0.431)	(0.262)	(0.193)
Forward spillovers	-0.267	2.935***	2.391**	-0.537	-1.137***
	(0.259)	(0.562)	(1.028)	(0.690)	(0.366)
Age of firm	0.035**	0.053**	0.168***	-0.022	0.038
	(0.014)	(0.023)	(0.061)	(0.051)	(0.024)
Employees	0.026***	-0.007	-0.009	0.058***	0.018
	(0.008)	(0.013)	(0.030)	(0.023)	(0.012)
Human capital index	0.030***	0.028***	0.045**	0.062***	0.018***
	(0.004)	(0.007)	(0.019)	(0.017)	(0.006)
Year 2001	0.105***	0.100***	0.095***	0.102***	0.112***
	(0.006)	(0.009)	(0.018)	(0.015)	(0.009)
Year 2002	0.227***	0.227***	0.236***	0.215***	0.236***
	(0.006)	(0.010)	(0.023)	(0.018)	(0.009)
Year 2003	0.354***	0.352***	0.358***	0.314***	0.375***
	(0.007)	(0.011)	(0.026)	(0.019)	(0.010)
Year 2004	0.546***	0.584***	0.583***	0.523***	0.547***
	(0.009)	(0.016)	(0.035)	(0.025)	(0.013)
Year 2005	0.659***	0.700***	0.679***	0.650***	0.663***
	(0.009)	(0.017)	(0.037)	(0.027)	(0.013)
Year 2006	0.777***	0.827***	0.804***	0.762***	0.797***
	(0.010)	(0.020)	(0.042)	(0.031)	(0.015)
Year 2007	0.913***	0.959***	0.936***	0.887***	0.941***
	(0.010)	(0.020)	(0.043)	(0.032)	(0.015)
Constant	-1.154***	-1.994***	-2.005***	-1.144***	-0.613***
	(0.072)	(0.129)	(0.296)	(0.226)	(0.115)
Observations	30,395	9,904	2,593	3,817	14,081
Number of groups	4,594	1,772	753	912	2,520
R-squared	0.606	0.589	0.590	0.575	0.620

Notes: Robust standard errors in brackets. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4. Average Predicted (Percentage) Increase in TFP due to FDI Spillovers - depending on Trade Participation

	No trade	Export only	Import only	Two-way trade
Horizontal FDI spillovers	15.5	13.5	10.8	6.6
Backward FDI spillovers	5.8	4.8	6.6	4.9
Forward FDI spillovers	7.9	6.8	[-1.7]	-3.2
Relative TFP level	100 (benchmark)	106.6	107.3	121.6

Notes: percentages are predicted increases in TPF if FDI is increased from the observed minimum to the observed maximum for the industry, while keeping all other variables at their mean. [ ] = not significant

Table 5: FDI spillovers, trade participation, and total factor productivity of domestic firms: results of Fixed Effects Models. Interaction with the human capital index

	(1) Full sample	(2) No trade	(3) Only Export	(4) Only Import	(5) Two-way trade
Horizontal spillover	1.103***	1.649***	1.413***	1.132***	0.657***
	(0.035)	(0.065)	(0.152)	(0.103)	(0.053)
HS x HC index	-0.070***	-0.210***	-0.202**	-0.191**	-0.063**
	(0.018)	(0.043)	(0.092)	(0.075)	(0.028)
Backward spillover	1.543***	1.581***	1.117**	1.680***	1.231***
	(0.109)	(0.171)	(0.436)	(0.267)	(0.195)
BS x HC index	0.592***	0.466***	0.771***	0.756***	0.626***
	(0.052)	(0.086)	(0.199)	(0.155)	(0.092)
Forward spillover	-0.239	2.897***	2.613**	-0.178	-1.132***
	(0.266)	(0.575)	(1.037)	(0.707)	(0.384)
FS x HC index	0.348***	0.396***	0.247	0.375**	0.497***
	(0.067)	(0.132)	(0.202)	(0.180)	(0.123)
Age of firm	0.038***	0.057**	0.153**	-0.007	0.052**
	(0.014)	(0.022)	(0.061)	(0.050)	(0.024)
Employees	0.027***	-0.008	-0.006	0.052**	0.023*
	(0.008)	(0.013)	(0.030)	(0.023)	(0.012)
Human capital index	0.148***	0.084***	0.108*	0.165***	0.150***
	(0.017)	(0.029)	(0.063)	(0.058)	(0.029)
Year 2001	0.105***	0.100***	0.097***	0.102***	0.112***
	(0.006)	(0.009)	(0.018)	(0.015)	(0.009)
Year 2002	0.228***	0.227***	0.243***	0.217***	0.235***
	(0.006)	(0.010)	(0.023)	(0.018)	(0.009)
Year 2003	0.356***	0.350***	0.364***	0.319***	0.377***
	(0.007)	(0.011)	(0.026)	(0.019)	(0.010)
Year 2004	0.545***	0.580***	0.589***	0.525***	0.545***
	(0.009)	(0.016)	(0.035)	(0.025)	(0.013)
Year 2005	0.659***	0.694***	0.688***	0.654***	0.664***
	(0.009)	(0.017)	(0.037)	(0.027)	(0.013)
Year 2006	0.778***	0.822***	0.816***	0.767***	0.798***
	(0.010)	(0.020)	(0.042)	(0.031)	(0.015)
Year 2007	0.916***	0.955***	0.952***	0.896***	0.944***
	(0.010)	(0.020)	(0.043)	(0.032)	(0.015)
Constant	-1.123***	-1.985***	-1.968***	-1.187***	-0.626***
	(0.072)	(0.131)	(0.298)	(0.226)	(0.115)
Observations	30,395	9,904	2,593	3,817	14,081
Number of groups	4,594	1,772	753	912	2,520
R-squared	0.611	0.592	0.596	0.581	0.625

Notes: Robust standard errors in brackets. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Appendix

Appendix A: Total factor productivity: index number method

To obtain comparable productivity levels across firms we use the index number method following Aw et al. (2001). Productivity levels are calculated as an index where the total factor productivity for each individual firm is compared with the mean TFP level in its industry in a reference period. Total factor productivity is calculated as the proportion of the value added (Y) that is not explained by the input factors (X). To obtain the TFP in an index number format, the deviation of the natural logarithm of respectively the output and input factors of firm *f* and the arithmetic means of these factors at the industry level are taken into account (respectively $(\ln Y_{ft} - \overline{\ln Y_t})$ and $(\ln X_{ift} - \overline{\ln X_{it}})$, with *i* indicating the input factor labor or capital). In order to arrive at an index that compares productivity performances with the industry mean at a certain point in time, deviations in the means over two consecutive years are chain-linked over time for both output and input factors ($\sum_{s=2}^{t}(\overline{\ln Y_s} - \overline{\ln Y_{s-1}})$ and $\sum_{s=2}^{t}\sum_{t=1}^{n}(\overline{\ln X_{is}} - \overline{\ln X_{is-1}})$). The model also controls for heterogeneity in the production technology of individual firms by incorporating the respective input cost shares into the formula (denoted by the S factors). The formula to calculate the TFP index in its natural logarithmic form, following Aw et al. (2001, p. 11) is:

$$\ln TFP_{ft} = (\ln Y_{ft} - \overline{\ln Y_t}) + \sum_{s=2}^{t}(\overline{\ln Y_s} - \overline{\ln Y_{s-1}}) - \left[\sum_{i=1}^{n}\frac{1}{2}(S_{ift} + \overline{S_{it}})(\ln X_{ift} - \overline{\ln X_{it}}) + \sum_{s=2}^{t}\sum_{t=1}^{n}\frac{1}{2}(\overline{S_{is}} + \overline{S_{is-1}})(\overline{\ln X_{is}} - \overline{\ln X_{is-1}})\right]$$

Appendix B: Correlation tables

Full sample (n=30395)

Variables	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)
(1) Total factor productivity	-3.860	4.925	1.000					
(2) Horizontal spillover	0.196	0.942	0.019	1.000				
(3) Backward spillover	0.029	0.455	-0.253	0.214	1.000			
(4) Forward spillover	0.069	0.408	-0.125	-0.142	0.325	1.000		
(5) Age of firm	0.000	107.000	0.125	-0.060	-0.075	-0.026	1.000	
(6) Number of employees	1.000	4220.000	0.120	-0.015	-0.040	0.021	0.166	1.000

Export only sample (n=2593)

Variables	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)
(1) Total factor productivity	-1.588	3.846	1.000					
(2) Horizontal spillover	0.196	0.942	-0.022	1.000				
(3) Backward spillover	0.029	0.455	-0.205	0.196	1.000			
(4) Forward spillover	0.069	0.408	-0.164	-0.095	0.316	1.000		
(5) Age of firm	0.000	103.000	0.069	-0.127	-0.030	-0.026	1.000	
(6) Number of employees	1.000	361.000	0.062	-0.086	0.013	-0.012	0.141	1.000

Import only sample (n=3817)

Variables	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)
(1) Total factor productivity	-1.234	3.805	1.000					
(2) Horizontal spillover	0.196	0.942	0.022	1.000				
(3) Backward spillover	0.029	0.455	-0.252	0.205	1.000			
(4) Forward spillover	0.069	0.408	-0.079	-0.072	0.225	1.000		
(5) Age of firm	0.000	106.000	0.118	-0.076	-0.128	-0.086	1.000	
(6) Number of employees	2.000	868.000	0.016	0.003	0.011	-0.065	0.109	1.000

Two-way trade sample (n=14081)

Variables	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)
(1) Total factor productivity	-1.219	4.925	1.000					
(2) Horizontal spillover	0.196	0.942	0.093	1.000				
(3) Backward spillover	0.029	0.455	-0.257	0.166	1.000			
(4) Forward spillover	0.069	0.408	-0.178	-0.137	0.412	1.000		
(5) Age of firm	0.000	107.000	0.096	-0.068	-0.080	-0.030	1.000	
(6) Number of employees	2.000	4220.000	0.015	-0.021	-0.017	-0.025	0.121	1.000

No trade sample (n=9904)

Variables	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)
(1) Total factor productivity	-3.860	4.799	1.000					
(2) Horizontal spillover	0.196	0.942	-0.119	1.000				
(3) Backward spillover	0.029	0.455	-0.238	0.307	1.000			
(4) Forward spillover	0.069	0.408	-0.099	-0.217	0.243	1.000		
(5) Age of firm	0.000	93.000	0.111	-0.037	-0.035	-0.053	1.000	
(6) Number of employees	1.000	900.000	0.125	-0.050	-0.023	-0.009	0.079	1.000

Appendix C. Wald Chi-squared tests of spillover effects: comparison with firms without trade engagement

Comparison sample	Spillovers		
	Horizontal	Backward	Forward
Export only	1.69	0.45	0.16
Import only	18.02***	0.65	18.34***
Two-way trade	144.22***	1.50	43.12***

Notes: *** significant at 1%.

Appendix D: potential selection bias

We employed a two-step estimation method developed by Heckman (1979) to examine whether estimations may suffer from a selection bias due to a non-random exit of firms from the sample. We can employ this method for the full sample estimation. In a first step, we estimated a probit model of the probability that a firm survives between 2000 and 2007. As excluding restriction we include age squared and the trade engagement dummies. From this probit model we derived the inverse Mill’s ratio as the ratio of the probability density function and the cumulative distribution function, and included it in the second step as an additional explanatory variable in the model. The results presented in Table 6 show that the coefficient of the inverse Mill’s ratio is insignificantly different from zero, while empirical results of the full-sample productivity model are largely unchanged.

Table 6: Results of the Heckman selection model

	Heckman	
	First stage	Second stage
Horizontal spillover	0.164*	1.139***
	(0.086)	(0.035)
Backward spillover	0.463***	1.738***
	(0.155)	(0.109)
Forward spillover	-0.238	-0.328
	(0.201)	(0.260)
Export only	0.103*	
	(0.060)	
Import only	0.065	
	(0.052)	
Two-way trade	0.197***	
	(0.042)	
Age of firm	0.462***	0.052***
	(0.087)	(0.018)
Age squared of firm	-0.070***	
	(0.017)	
Number of employees	-0.009	0.026***
	(0.019)	(0.008)
Year 2001		0.084***
		(0.015)
Year 2002	-0.603***	0.210***
	(0.060)	(0.014)
Year 2003	-0.568***	0.337***
	(0.062)	(0.014)
Year 2004	-0.550***	0.536***
	(0.062)	(0.013)
Year 2005	-0.413***	0.647***
	(0.066)	(0.015)
Year 2006	-0.478***	0.767***
	(0.065)	(0.015)
Year 2007	-0.436***	0.914***
	(0.067)	(0.011)
Inverse Mill's ratio		0.376
		(0.252)
Constant	1.546***	-1.211***
	(0.142)	(0.082)
Observations	33567	30395
Number of groups	4791	4594
R-squared	0.035	0.605

Notes: Robust standard errors in parentheses.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

MANAGEMENT, STRATEGY AND INNOVATION (MSI)
Naamsestraat 69 bus 3535
3000 LEUVEN, Belgium
tel. + 32 16 32 67 00
msi@econ.kuleuven.be
https://feb.kuleuven.be/research/MSI/