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# FDI Spillovers and their Interrelationships with Trade

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# FDI SPILLOVERS AND THEIR INTERRELATIONSHIPS WITH TRADE

**OECD Trade Policy Working Paper No. 80**

**by Molly Lesher and Sébastien Miroudot**

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## ABSTRACT

Foreign direct investment (FDI) represents an increasingly important dimension of international economic integration with global FDI flows growing faster than output over the past two decades. FDI is a particular form of investment, as it transfers knowledge as well as finance that may otherwise be unavailable in the domestic economy. This paper uses firm-level data to identify FDI spillovers across countries, sectors and time. The analysis suggests that knowledge-related spillovers from FDI vary considerably across sectors. Services industries enjoy the strongest productivity-enhancing effects of FDI, particularly through backward linkages. There is no strong evidence of horizontal productivity spillovers at the aggregate level. The results also indicate a significant and positive correlation between the degree of trade openness and output when measuring the impact of foreign presence in the domestic economy. A positive interaction is found between trade liberalisation and productivity spillovers. Thus, trade liberalisation can be seen as an important component of any reform package designed to help countries maximise the benefits of FDI.


*Keywords*: investment, FDI, technology, spillovers, foreign participation, trade openness, trade liberalisation, horizontal linkages, backward linkages, forward linkages, services, firm-level, micro-data.


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## EXECUTIVE SUMMARY

Foreign direct investment (FDI) represents an increasingly important dimension of international economic integration with global FDI flows growing faster than output over the past two decades. FDI is a particular form of investment, as it transfers knowledge as well as finance that may otherwise be unavailable in the domestic economy. Knowledge effects originating from outside of the firm that boost productivity can come in many forms, such as technologies, working methods, and management skills. Spillovers can be unintended, such as when a domestic firm imitates a foreign product, or deliberate, such as when a foreign firm offers technical support to a domestic firm to meet certain quality criteria.

Recently, the debate about FDI spillovers has shifted from questioning their existence to studying the policies that encourage them. Trade policy has long been identified as a catalyst for FDI productivity spillovers, but the question remains open whether countries with relatively more open trade regimes are benefiting from higher productivity spillovers and whether these spillovers are consistently observed in certain sectors.

This paper uses firm-level data to identify FDI spillovers across countries, sectors and time. The analysis suggests that knowledge-related spillovers from FDI vary considerably across sectors. Among sectors, for example, computer and related activities, hotels and restaurants, construction, post and telecommunications and other business activities showed strong FDI spillovers via backward linkages (interactions with downstream customers). In addition, FDI-related spillovers via forward linkages (interactions with upstream suppliers) are found in agriculture, land transport, mining, as well as services sectors such as wholesale and retail trade or other business activities.

At the aggregate level, the results indicate that encouraging foreign presence in services sectors can generate strong positive direct and indirect effects in the economy. This study represents one of the first to study technology spillovers in services sectors, and it suggests that services industries enjoy the strongest productivity-enhancing effects of FDI, particularly through backward linkages. The fact that earlier studies tend to focus on manufacturing firms can explain why the literature has been somewhat sceptical about the existence of FDI spillovers and why it is important to include services in the analysis.

The results also indicate a significant and positive correlation between the degree of trade openness and output when measuring the impact of foreign presence in the domestic economy. One of the reasons why spillovers might be higher in more competitive markets is that stronger competition may induce greater knowledge transfer from MNE parent companies to their affiliates in order for the affiliate to compete effectively against its domestic rivals. In turn, local firms operating alongside more technologically advanced foreign affiliates will have greater opportunities for learning new technologies. This is likely to reduce the technology gap between domestic and foreign affiliated firms, thus increasing the opportunities for potential spillovers.

Moreover, an open trade regime implies that domestic companies tend to export more and that more domestic companies are in sectors in which the host economy has a comparative advantage. Exporting firms are generally more productive, and thus it is consistent to find a positive relationship between trade openness and higher firm productivity controlling for foreign presence in the sector. Many export-oriented firms, including export-oriented foreign affiliates, are relatively large because they produce for the world market, rather than exclusively for the local market. A consequence of this is that they likely offer more opportunities for local suppliers to benefit from economies of scale in production (which boosts productivity). Thus, trade liberalisation can be seen as an important component of any reform package designed to help countries maximise the benefits of FDI.

It is important to bear in mind that FDI-related spillovers are not automatic. The literature has identified various "prerequisite" host country characteristics needed for technology to flow from foreign companies to domestic firms, including absorptive capacity, which determines whether a particular firm can make use of the potential knowledge and knowhow made available by foreign investment. However, this study has shown that there is significant scope for firms (and countries) to benefit from FDI spillovers, and policymakers should promote policies that encourage an environment conducive to FDI-related spillovers.

## Introduction

1. Foreign direct investment (FDI) represents an increasingly important dimension of international economic integration with global FDI flows growing faster than output over the past two decades. FDI flows remain highly concentrated among OECD countries, and the potential benefits of inward FDI for the host economy are widely recognised (UNCTAD, 2006; OECD, 2002 and 2006). In addition to providing a source of external finance, FDI is associated with job creation and the introduction of new technologies by multinational corporations. FDI also provides a bridge between the host country of a foreign affiliate and the technological resources of foreign multinational corporations.

2. Importantly for the host economy, theory suggests that the presence of technologically advanced foreign affiliated firms can benefit local producers. Since the ideas embodied in new technologies can only be partially protected from other firms, the introduction of any new technology will often disperse to other firms through informal learning mechanisms commonly referred to as productivity "spillovers". Spillovers can be unintended, such as when a domestic firm imitates a foreign product, or deliberate, such as when a foreign firm offers technical support to a domestic firm to meet certain quality criteria.

3. A large body of empirical work has sought to identify and quantify the existence of FDI spillovers. A common methodology adopted in these studies is to infer the presence of spillovers by examining whether the presence of foreign affiliated firms increases domestic firm productivity[1]. While the results from many of these studies verify the existence of FDI spillovers, a recurring finding is that they are not automatic. The literature has identified a certain number of "prerequisite" host country characteristics needed for technology to flow from foreign companies to domestic firms, leading to the concept of absorptive capacity[2].

4. The debate about FDI spillovers has thus shifted from a discussion of their existence to the policies that encourage them. Early in the literature, trade policy was identified as a catalyst for FDI productivity spillovers in the "Bhagwati hypothesis", which states that productivity spillovers are higher in an open trade regime. At that time, Bhagwati was opposing import-substituting and export-promoting economies. While today most countries have opted for a generally open trade regime, openness still runs on a continuum among countries, and sectoral differences can be marked. The Bhagwati hypothesis can thus be reformulated in the following way: Are the most open countries benefiting from relatively higher productivity spillovers? And does the magnitude of FDI-related spillovers vary significantly by sector?

5. This report begins with a short literature review that sets the stage and includes recent empirical work on FDI spillovers. It then presents quantitative research that draws upon the literature as well as existing OECD resources to test the complementarity between trade openness and FDI spillovers in a sample of OECD economies. Policy implications that draw upon this research are then presented.

1 . In 1974, Richard Caves pioneered this approach, which has been refined by a number of scholars who over time have used improved data and empirical methods.

2 . A certain threshold of human capital, for instance, is needed to induce significant spillovers.

## I. FDI spillovers: Theory and evidence

### *Theory*

6. FDI is a particular form of investment. FDI reflects the establishment of a foreign affiliated firm under the management of a parent company. Compared to other types of investment, such as portfolio investment and aid, FDI often transfers knowledge – in the form of production expertise and managerial skills, among others – as well as finance (Balasubramanyam *et. al.*, 1996). These knowledge effects can be called externalities or spillovers. FDI, therefore, can mean more to a host country than building a new plant or subsidiary.

7. When we talk about spillovers, what exactly do we mean? Simply put, FDI spillovers are defined as an increase in the productivity of domestic firms as a consequence of the presence of foreign firms in the domestic economy. Spillovers can come in many forms, such as technologies, working methods, and management skills, but they have one thing in common – they boost productivity. While many researchers have studied the channels through which spillovers are possible, we review briefly these channels below.

**Table 1. FDI spillover channels**

| | |
|---|---|
| Skills via labour mobility | Workers gain new skills through explicit and implicit training. In particular, training in foreign firms may be of a higher quality given that only the most productive firms trade. Workers take these skills with them when they re-enter the domestic labour market. |
| Exports & infrastructure improvements | Because multinationals by definition trade, they lay the groundwork for domestic firms to benefit from distribution networks, logistics services and infrastructure improvements. Domestic firms can also learn about the regulatory frameworks with which exporters must comply. |
| Imitation | This very obvious form of spillover often takes the form of reverse engineering, whereby a domestic firm creates a similar product based on the design of a good or service that a foreign affiliate produces. Imitation is only successful if the domestic firm has the technical capacity and ability to source the necessary inputs to produce a similar product. |
| Competition | If the foreign firm is not a monopoly provider and it sells in the domestic economy, then it competes directly with domestic firms in the market. Since multinationals are often more productive – they have to be to trade – this forces domestic providers to become more productive to successfully compete for business. |
| Vertical Linkages | Backward and forward linkages are another way in which spillovers are transmitted in an economy. As foreign firms set up vertical production networks, they include domestic firms in their production chain. Since these suppliers must meet certain quality standards, they benefit from the experience and knowledge of the foreign firm. |

Source: Compiled by the Authors drawing upon Görg and Greenaway, 2003.

8. Theory not only provides an indication of how spillovers are transmitted, but also of the factors that may affect the ability of firms to effectively use the knowledge generated by multinationals. Indeed, while multinationals bring with them the possibility of productivity spillovers for the domestic economy, positive externalities are not automatic. There are differences in the magnitude of spillovers according to the type of investment and the firm's motives for investing. For instance, differences have been found in the impact of wholly-owned subsidiaries or projects associating foreign and domestic investors. The degree of foreign ownership matters as well as the nationality of the investor (Javorcik and Spatareanu, 2003; Javorcik, 2004). Whether foreign investment is "resource-seeking", "market-seeking" or "efficiency-seeking" is also likely to influence the scope for productivity spillovers as the degree to which firms interact with the domestic economy depends in part on the motivation for investing.

9. Moreover, not all countries benefit from the presence of more productive foreign firms in their economy. In particular, the "technology gap" between foreign and domestic firms may play a large role because it directly affects a domestic firm's ability to use the knowledge from multinationals (Wang and Blomström, 1992). Technology must be internalised and adapted to local conditions, and adaptation requires workers with the skills appropriate to the product or service at hand. One could imagine that if Boeing or Airbus set up a factory in a least-developed country, there would be less scope for productivity spillovers than if it set up production in a country higher up the income ladder. While bridging the technology gap may be challenging, protection of intellectual rights can play a role[3].

10. An associated concern involves the particularities of a given sector, country, and region within a country. For instance, infrastructure – both tangible, such as roads, and intangible, such as regulations – probably influence the degree to which domestic firms can take advantage of the knowledge available in multinationals. And there is some evidence to suggest that knowledge spillovers in certain sectors, such as high-technology sectors, may be more easily transmittable than others.

11. In addition, the characteristics of domestic firms themselves are also likely to affect how spillovers translate in the domestic economy. For instance, some researchers argue that domestic firms that export may not benefit from the presence of foreign firms since they are already productive enough to compete in foreign markets[4]. As a result, some economists hypothesise that spillovers from multinationals will be more pronounced in domestic firms that do not export or are less productive. Some have also suggested that firm size affects how spillovers are transmitted in the domestic economy. For example, larger firms may have more scope to efficiently internalise knowledge from multinationals.

12. Theory also suggests that vertical production networks can represent an important channel for spillovers. There are three types of vertical spillovers: the active transfer of knowledge from foreign firms and their parent companies (through a qualification process or training classes, for instance); technology leakages (*i.e.*, unintended transfers of knowledge) and incentives based on more intense competition (*i.e.*, an increase in domestic firm productivity independent of the technology embodied in foreign affiliated firms[5]).

13. Vertical productivity spillovers can occur through backward and forward linkages. Backward linkages involve a transfer of knowledge to a given domestic firm from that firm's customers, while

3 . Some studies show that technology transfer via licensing is positively and significantly correlated with the strength of intellectual property right protection, particularly for patents (Park and Lippoldt, 2005).

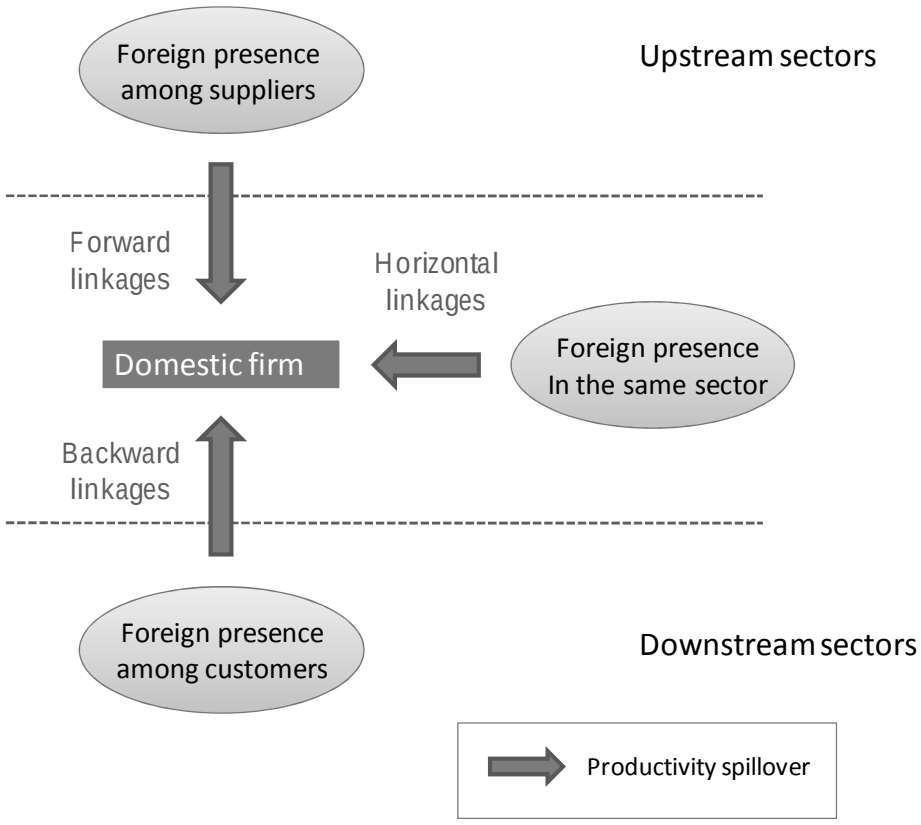
4 . See Crespo and Fontoura, 2006.

5 . Some studies have, for example, shown that U.S. parts suppliers in the automobile industry have improved their technology and productivity following the entry of Japanese car makers (Okamoto, 1999). Japanese car makers were neither more productive nor actively transferring technology to U.S. firms, but the competition effect led to an increase in productivity for U.S. car makers.

forward linkages imply knowledge transfer to a domestic firm from its suppliers. For example, Blalock (2002) finds evidence of backward linkages in the case of Indonesia, as does Javorcik (2004) in Lithuania.

14. Multinationals can help domestic firms increase their efficiency through an active transfer of knowledge to suppliers and customers (Görg and Greenaway, 2003; Blalock and Gertler, 2005). Transferring technology to suppliers can make inputs used by the MNE cheaper and of a better or more appropriate quality. Multinationals often require important quality and process improvements (Gage and Lesher, 2006). There are also incentives to transfer technology to the customer firms to improve their efficiency and sales so that in return they buy more inputs from the MNE.

**Box 1. Defining spillovers and linkages**




*FDI spillovers*: An increase in the productivity of domestic firms as a consequence of the presence of foreign firms in the domestic economy.

*FDI spillovers via horizontal linkages*: An increase in the productivity of domestic firms resulting from the presence of foreign firms in the same industry.

*FDI spillovers via forward linkages*: An increase in productivity resulting from the foreign presence among the suppliers of the industry in which the domestic firm operates (*i.e.*, upstream sectors).

*FDI spillovers via backward linkages*: An increase in productivity resulting from the foreign presence among the customers of the industry in which the domestic firm operates (*i.e.*, downstream sectors).

15. These spillovers may take place among domestic firms but are more likely to occur with foreign affiliated firms given their linkages with large foreign parent companies. In the case of horizontal spillovers, there are not such incentives and firms would rather protect their intellectual assets so that technology does not leak to competitors[6].

***Evidence***

16. While theory suggests that FDI tends to generate positive spillovers in the host economy, the evidence from both qualitative and quantitative research has been less clear cut (see Görg and Greenaway, 2003). Most quantitative studies follow the production function approach first used by Caves (1974), which has been refined by subsequent researchers. These studies often use data on goods (sometimes at the sector level) for one country, and seek to explain changes in productivity using the standard production variables (*i.e.*, capital, output, material inputs and labour). Moreover, these studies tend to focus on developing or upper middle-income economies.

17. The results from these types of studies are somewhat ambiguous. Some research on FDI spillovers shows that they exist, but only when domestic firms have enough technological capacity to imitate effectively[7]. Other research suggests that regional or country-level characteristics influence the diffusion of FDI spillovers[8], as does the export orientation and size of domestic firms[9]. Other research has focused on whether the degree of foreign ownership of multinational affiliates influences spillover effects, but again, the evidence is mixed[10]. While the approach used in these studies tests the effect of intra-industry productivity spillovers in a single country framework for goods, it says nothing about inter-industry spillovers[11], spillovers in services, and cross-country patterns.

18. Qualitative studies usually follow a case study format, and often focus on North-South FDI projects. The conclusions drawn from these studies also present a mixed bag. Theodore Moran is perhaps the most prolific producer of case studies on FDI spillovers, and his research generally points to the existence of positive spillovers in the domestic economy (see Moran, 2001). In contrast, other case study

6 . There are sometimes incentives to transfer technology to competitors when, for example, there is a need to create a new market (with a variety of products attracting consumers) or when a firm does not want to appear as having a dominant position in the market. But these cases are exceptions.

7 . Using R&D as a proxy for the level of technological capacity, Keller and Yeaple (2003) find evidence of positive FDI spillovers in high technology sectors in the United States. Similarly, Kinoshita (2001) finds evidence of positive spillovers for the Czech Republic in the presence of a given level of R&D spending within the domestic firm.

8 . See, for example, Imbriani and Reganati (1999), who find that regional characteristics within Italy influence whether domestic firms benefitted from foreign presence.

9 . Using data for Indonesia, Blomström and Sjöholm (1999) find that export-oriented domestic firms do not benefit from FDI spillovers, whereas firms that service only the domestic market do benefit from foreign presence. In contrast, Sinani and Meyer (2003) do not find any evidence to this effect. Other research focuses on firm size, and also produces contradictory evidence (see, for example, Girma and Wakelin (2001) and Aitken and Harrison (1999)).

10 . See Blomström and Sjöholm (1999) on Indonesia, Dimelis and Louri (2002) on Greece, and Javorcik (2004) on Lithuania.

11 . An important exception can be found in Javorcik (2004), who provides a thoughtful analysis of inter-industry spillovers using firm-level data for Lithuania.

research fails to find productivity spillovers from FDI (for example, see Hanson, 2000). And scholars have even come to different conclusions about the same investment project[12].

19. A small number of recent empirical studies have examined the impact of various host country factors on FDI spillovers. However, surprisingly few studies have investigated the role of trade policies[13], and of those that do, the evidence on the role of trade policies appears to be mixed (Kokko *et. al*., 2001; Kohpaiboon, 2006). Moreover, existing studies tend to focus on manufacturing sectors, despite the importance of the services sector in all OECD countries and the growth of services FDI. One of the purposes of this study is to explore the relationship between FDI spillovers and trade policy beyond the "Bhagwati Hypothesis" (Box 2).

20. The empirical analysis that follows tests the hypothesis that spillovers are higher in an open trade regime. It features three novelties. First, it analyses spillovers in services sectors, which traditionally have not been included in studies of spillovers, despite the increasing shift towards services FDI (UNCTAD, 2004). Second, trade indicators that have not been tested in previous papers are incorporated into the quantitative analysis. Third, the study utilises cross-country firm-level data.

**Box 2. The Bhagwati Hypothesis**

In the 1970s, Jagdish Bhagwati argued that trade policies could affect the benefits of inward FDI, with trade barriers encouraging investment in less productive import-substituting industries. This so-called "Bhagwati Hypothesis", can be split into two distinct parts. First, that countries with a relatively more open trade regime attract more FDI (the volume effect) and second, that those countries see increases in efficiency (*i.e.* productivity spillovers) resulting directly from FDI (the efficiency effect) (Balasubramanyam *et. al*., 1996).

The analysis in this paper focuses on the efficiency effect (that is, how trade liberalisation can enhance FDI spillovers). The intuition behind the efficiency effect has its roots in comparative advantage theory. Simply put, countries with an unrestrictive trade policy can allocate factors of production more efficiently based on comparative advantage, allowing firms to specialise and achieve economies of scale. In contrast, countries with a restrictive trade regime can expect important distortions in factor and product markets. As a result, one expects more pronounced FDI spillover effects in countries with more open trade regimes.

More recently, authors have focused on learning effects and the diffusion of technology through FDI, where trade can also play a role by encouraging forms of FDI leading to a higher level of technology transfer (efficiency-seeking FDI, vertical FDI).

12 . As noted in Görg and Greenaway (2003), Hanson (2000) does not find significant evidence for spillovers in the case of Intel's investment in Costa Rica, whereas research conducted around the same time by Larraín, Lopez-Calva and Rodríguez-Clare (2000) argues that Intel's investment in Costa Rica has indeed generated positive spillovers in the Costa Rican economy.

13 . An overview of the interrelationships between trade policy, domestic investment and FDI can be found in OECD (2005).

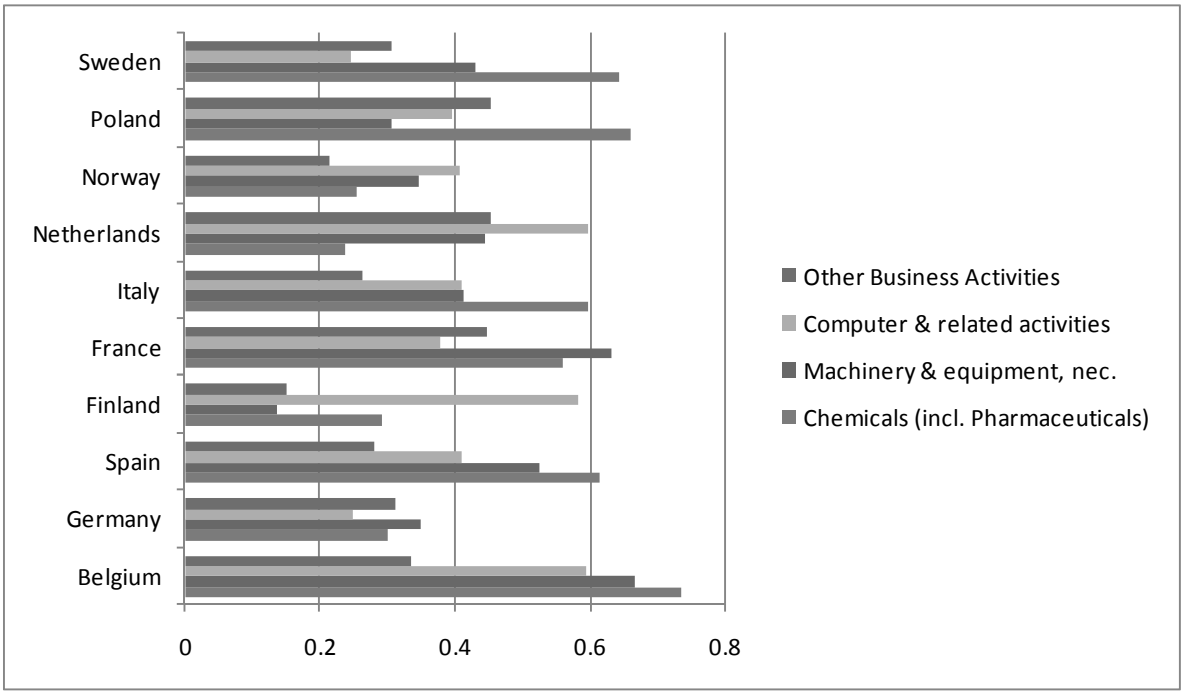
## II. Linkage analysis

21. Before studying spillovers, this section focuses on linkages. As illustrated in Box 1, these linkages measure how domestic firms are exposed to competition from and technologies of foreign companies established in their sector and in upstream and downstream sectors. Their strength is assessed through the share of foreign ownership in these sectors and how they relate one another. Spillovers are transfers of knowledge that can take place through these linkages.

22. Three types of linkages are studied in this section, following the methodology outlined by Javorcik (2004). First, we analyse horizontal linkages, which occur between multinationals and domestic producers within the same sector. Vertical specialisation can generate two other types of relationships; "backward linkages", or connections between domestic firms and their customers, and "forward linkages", or connections between a domestic firm and its suppliers.

23. Data from input-output tables are used to calculate these linkages, which measure the extent to which firms in a given sector buy inputs from upstream sectors and sell products to downstream sectors. The horizontal linkages measure the foreign presence in each sector, and they are calculated as the average percentage of foreign ownership in the sector weighted by each firm's contribution to sector output[14]. Backward linkages are calculated as a weighted share of the output produced by firms with foreign capital participation in downstream sectors, and forward linkages are calculated as a weighted share of the output produced by firms with foreign capital participation in upstream sectors. Annex 4 details the methodology followed to calculate these linkages and more detail on the sectoral classification can be found in Annex 1.

**Figure 1. Horizontal linkages across select countries and sectors**

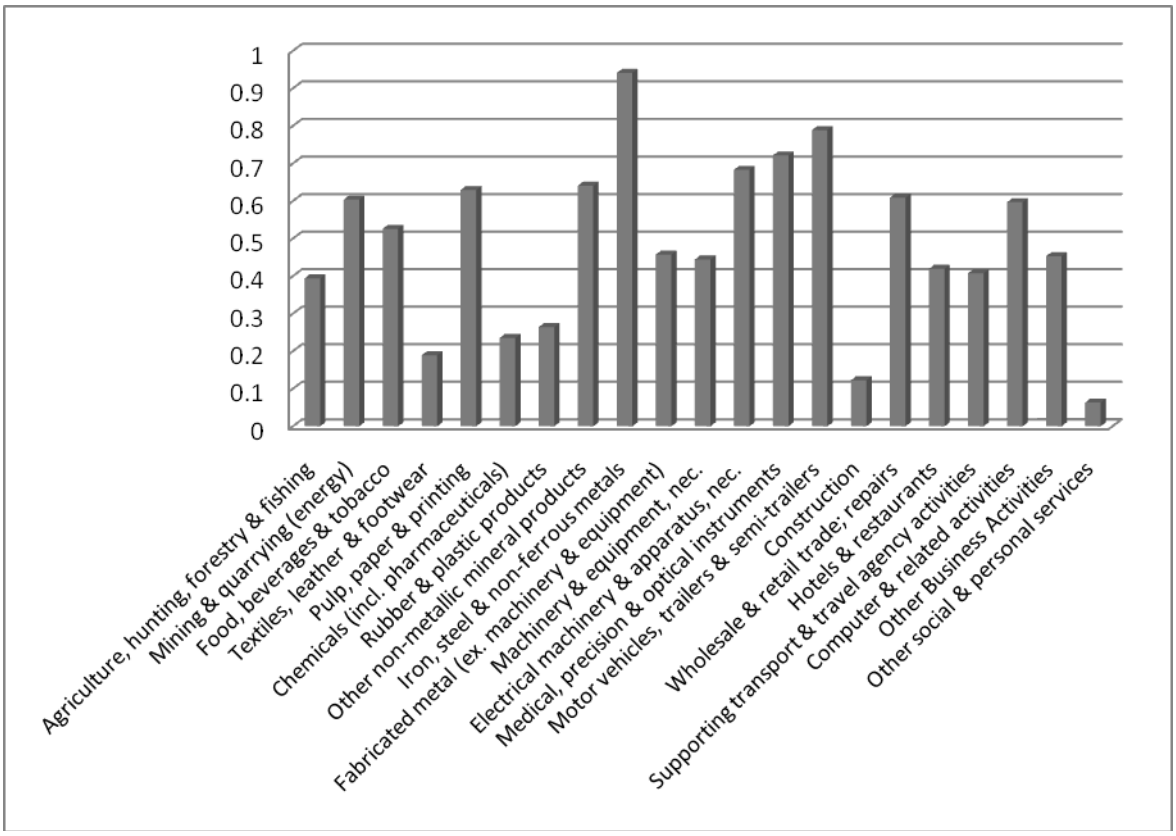



14 . As the horizontal linkage represents the average value of the foreign share in the firms of the sector, it takes a value between 0 and 1. Thus, a sector with a score of 1 includes only firms that are wholly-owned subsidiaries of foreign companies, and a score of 0 indicates a sector which includes only domestic firms.

24. This section presents a brief analysis of the linkages across sectors. To begin, Figure 1 displays horizontal linkages in 10 countries in 2 manufacturing sectors (chemicals and pharmaceuticals and machinery and equipment) and 2 services sectors (other business services and computer and related services) for 2000[15].

25. Six of the countries analysed show the strongest horizontal linkages in chemicals and pharmaceuticals, whereas on average, other business services show the smallest horizontal linkages. While variations across countries remain, it appears that the two manufacturing sectors analysed have higher horizontal linkages than the services sectors, thus suggesting that foreign presence is higher in the manufacturing sectors than in the services sectors analysed.

**Figure 2. Netherlands: Horizontal linkages**




26. A more detailed look at sectoral data within countries shows that the intensity of horizontal linkages differs considerably across sectors. Data from the Netherlands in 2000 is presented as an example (Figure 2).

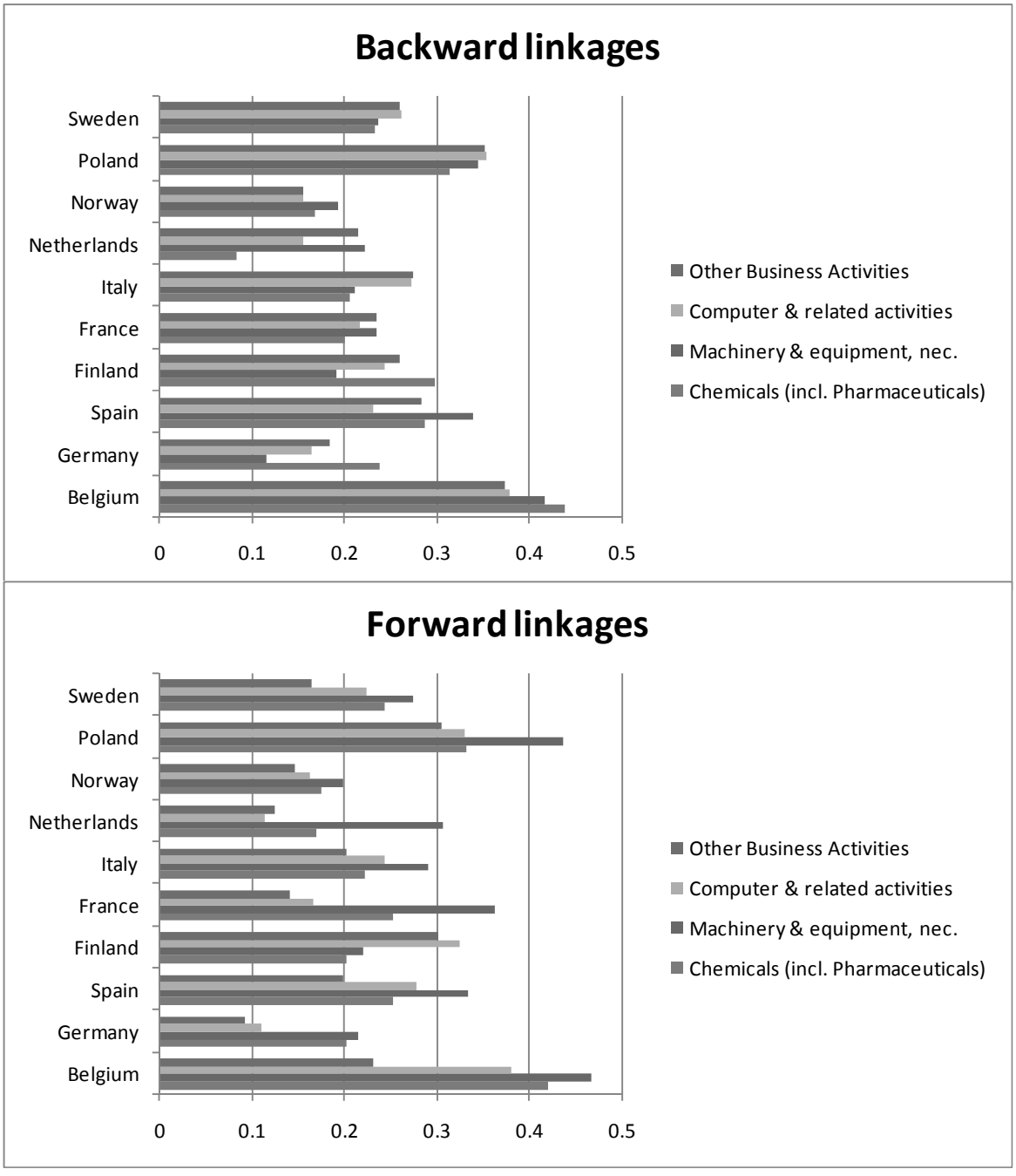
27. In some sectors like construction or textiles, leather and footwear, foreign presence is quite low and hence horizontal linkages are limited. It is also the case, albeit to a lesser extent, for chemicals and rubber and plastic products. On the other hand, data for sectors like iron and steel and motor vehicles indicate significant foreign participation, and therefore more scope for horizontal spillovers exists in these sectors. The intensity of horizontal linkages across countries varies because it depends on the degree to

15 . Figure 1 provides an indication of the foreign presence in each sector; an analysis of the productivity spillovers that can be derived from these linkages is presented in Section III.

which large foreign firms are present in the domestic economy, which is in turn partly explained by a variety of FDI determinants and partly explained by certain means of protection (such as trade barriers).

28. Turning to backward and forward linkages, we present data for select countries and sectors (Figure 3). On average, the values calculated are lower than the horizontal linkage measure, in part because upstream and downstream sectors are weighted according to their contribution to sectoral output, and on average, sectors with relatively lower foreign participation weigh more in the calculation. There are, however, important variations in the backward and forward linkages illustrated in Figure 3.

**Figure 3. Backward and forward linkages across select countries and sectors**



29. Forward linkages (from suppliers to the domestic firm) show more variation across countries and sectors. With the exception of Finland, all countries analysed show the strongest forward linkage in the machinery and equipment sector. In contrast, the other business services sector has the lowest forward linkage across all of the countries presented. These results simply indicate that in the machinery and equipment sector, countries tend to source inputs from sectors in which foreign presence is high; firms in the other business services sector tend to source inputs from sectors with relatively low foreign presence. Backward linkages (from customers to the domestic firm of interest) are more similar across sectors within countries (that is, the linkages tend to cluster together), and the pattern across countries is less clear.

30. The linkages presented in this section assess foreign presence across sectors and how exposed firms in a given sector are to foreign competition and foreign technology in their own sector and in upstream and downstream sectors. The analysis suggests that there is large potential for knowledge transfer via these linkages, but this potential varies across sectors and countries. We extend the analysis in the next section, where we use these measures in a production function to assess how they translate into productivity gains.

## III. Quantitative analysis of spillovers

31. It is important to bear in mind that the concept of productivity spillovers is abstract and cannot be directly measured. As a proxy, a production function approach is used to model the effects of FDI spillovers and their relationship with trade policies. In this framework, domestic output[16] is regressed on the standard variables explaining the production of a firm (capital, labour and material inputs). Because we analyse the determinants of output controlling for inputs, the other variables introduced in the empirical model deal specifically with productivity. We include the foreign share of each firm to test the effects of productivity spillovers only on domestic firms; horizontal, backward and forward linkages; and trade variables to test the Bhagwati hypothesis that a more open trade regime leads to higher productivity spillovers. A fixed effects estimation method is used to control for unobservable factors[17]. A mathematical expression for the model can be found in Annex 3.

32. The trade variables that are included to provide an indication of openness to potential spillovers include general indicators of a country's overall trade policy regime, tariffs and sectoral measures, such as measures of restrictiveness in particular manufacturing and services sectors represent the trade-related variables added to the model[18].

16 . The dependent variable in our model is operating revenue at constant prices, a close but not perfect measure of firm output.

17 . Fixed effects, also called "unobserved effects", control for variables that are specific to the variable of interest (in our case, firm output, measured by operating revenue). In the model presented in this paper, for example, fixed effects allow us to create one variable specific to each year in the dataset. Thus, we include one fixed effect for the year 1997 that controls for any variables particular to that year, such as the Asian Financial Crisis. Similarly, fixed effects are included to represent each firm's country of origin.

18 . The trade measures include the applied weighted average tariff rate from the TRAINS database, the trade indicator from the Heritage Foundation's Index of Economic Freedom (this measure takes into account both tariff and certain non-tariff barriers). To cover trade in services in Mode 3, we look also at restrictiveness on inward FDI using OECD indicators (see Golub, 2003 and Koyama and Golub, 2006). These indicators quantify FDI restrictions on foreign equity limits, screening and approval requirements, input and operational measures, the movement of people, and rules governing management and Boards of Directors.

33. Moreover, the analysis benefits from the new 2007 edition of the OECD Input-Output Database to include measures of horizontal, backward and forward linkages in the models. Importantly, these linkages provide an indication as to whether spillovers occur within or across sectors[19].

34. In addition to the sectoral data, the quantitative analysis relies on a sample of firm-level panel data from the AMADEUS dataset[20] (see Annex 2) covering 207,439 companies from 15 OECD countries. AMADEUS includes an ownership database that lists the main shareholders for each company and indicates the global ultimate owner. The Authors calculate the foreign share variable based on this ownership information. The AMADEUS dataset does not include developing countries and, as such, they could not be incorporated into this analysis.

**Box 3. The interaction between trade openness and FDI spillovers**

While a positive correlation is generally found between trade openness and FDI flows, explaining why lower trade barriers are associated with higher firm productivity (both domestic and foreign) is a question of a different nature. The first explanation that can be advanced is that trade openness affects a firm's motive for investing.

Efficiency-seeking FDI requires access to imports of intermediate goods and services and is thus dependent on an open trade regime, whereas resource-seeking FDI is likely to ignore high trade barriers as long as they do not prevent the firm from acquiring or using needed domestic resources. In the case of tariff-jumping FDI, trade protection can even represent the motivation for the firm to invest as a way to circumvent border barriers. As a consequence, one can expect an ambiguous impact of trade protection on FDI flows (with the two competing and opposing effects of discouraging efficiency-seeking FDI and attracting market-seeking FDI).

In the case of FDI spillovers, the impact is likely to be less ambiguous if one accepts the idea that efficiency-seeking FDI is more conducive to spillovers than resource-seeking or market-seeking FDI. The existence of backward linkages and the positive impact of trade openness on productivity spillovers that we have found are consistent with such an assumption. There is anecdotal and case study evidence indicating that interactions between domestic and foreign firms are strong and that MNEs can be involved in improving the productivity of their suppliers. This is more likely to happen in a vertical specialisation network in the context of efficiency-seeking FDI and this type of FDI is assumed to respond positively to trade liberalisation.

Also related to the firm's motive for investing, open markets are more likely to attract competitive companies. As the competitive pressure is one channel through which firms have incentives to increase their productivity, trade liberalisation also plays a positive role in the competition effect from FDI. Barriers to entry make markets less competitive, generating inefficiencies in the market. With trade and FDI liberalisation, markets are contestable and incumbent firms have to rely on innovation and efficiency gains to maximize profits.

One of the reasons why spillovers might be higher in more competitive markets is that competition may induce greater technology transfer from MNE parent companies to their affiliates in order for the affiliate to compete effectively against its domestic competition. In turn, local firms operating alongside more technologically advanced affiliates will have greater opportunities for learning new technologies. This is likely to reduce the technology gap between domestic and foreign affiliated firms, thus increasing the opportunities for potential spillovers.

Lastly, an open trade regime means that domestic companies export more and that more domestic companies are in sectors in which the host economy has a comparative advantage. Exporting firms are generally found to be more productive, and thus it is consistent to find a positive relationship between trade openness and higher firm productivity controlling for foreign presence in the sector. Export-oriented firms, including export-oriented foreign affiliates, tend to be larger because they produce for the world market, rather than exclusively for the local market. A consequence of this is that they likely offer more opportunities for local suppliers to benefit from economies of scale in production (which boosts productivity).

19 . See Annex 4 and Section II for more information on the calculation and use of horizontal, forward and backward linkages.

20 . Several empirical studies on FDI spillovers are based on this firm-level dataset. Most of these studies are, however, country specific (*e.g.*, Javorcik and Spatareanu (2003) on Romanian firms). A cross-country approach is followed here.

35. Using firm-level data abstracts from the biases[21] associated with cross-section sectoral data (Görg and Greenaway, 2003), and lessens the probability of a selection effect bias. As some of the first studies on FDI spillovers were conducted at the sector level for a given year, some researchers have contested the existence of FDI spillovers when sector productivity and foreign presence positively correlate. They argue that the positive result obtained for the FDI spillover variable results from a selection effect in which investors pick the most productive sectors and where the overall productivity of the sector is influenced by foreign firms without spillovers to domestic firms. The use of firm-level data with a panel dimension makes this selection effect less likely because the productivity change is captured for each firm over a number of years controlling for its own foreign share.

36. We use two different estimation techniques to deal with specific issues highlighted in the literature on the estimation of production functions at the firm-level. First, equations are estimated using ordinary least squares (OLS) with fixed effects. We use robust standard errors and clustered standard errors (industry, year) to abstract from the fact that regressions including both firm- and sector-level data (*i.e.*, micro and aggregate data) are subject to an underestimation of the standard errors, which can generate statistical significance for the variable at the aggregate level when it does not exist (see Moulton, 1990). Second, to control for endogeneity of input selection (the 'simultaneity bias'), we estimate additional regressions using a dynamic system panel estimation. Annex 5 contains additional information on model selection and estimation results.

37. It should also be emphasised that this dataset primarily includes data on European firms. One might expect to see stronger evidence for productivity spillovers in this sample because developed countries make up the dataset and they have a high level of absorptive capacity. As developing countries generally have a lower stock of human capital than developed countries, they often are less able to make use of the knowledge spillovers embodied in FDI (for instance, in high technology sectors). But in developed countries, it may be precisely in these sectors in which the most significant knowledge spillovers exist.

38. Alternatively, one could argue that firms in developed countries are already very close to the global technology/productivity frontier, in which case they may be expected to benefit less than a firm in a developing country. However, as highlighted by Blonigen and Wang (2004), it might be inappropriate to pool wealthy and poor countries in empirical FDI studies as determinants of FDI are often very different in the two group of countries. Flows of FDI to developing countries also tend to be concentrated in a few emerging economies (UNCTAD, 2006). For poor countries, the question may not be how to benefit from FDI, but rather how to attract FDI in the first place, a question that certainly merits further research.

***Results***

39. Turning to the results generated for the sample of developed countries used in this paper, coefficients for the core variables (capital, labour, and material inputs) are within the bounds of the literature and significant at the 1% level. Consistent with the literature, we also observe a fairly high "goodness of fit" for the models, with $R^2$ values in the range of 0.85-0.96.

40. The results for all of the models are presented in Annex 5. We find a positive and significant coefficient for horizontal linkages indicating positive productivity spillovers. However, this result is not entirely robust as the sign of the horizontal linkage coefficient sometimes takes a negative value in certain specifications.

21 . For example, one advantage of using panel data rather than cross-sectional data is that the estimates are much less sensitive to omitted variable bias because they do not assume that one year of data is representative of the long-run equilibrium

41. Regressions run at the sector level indicate that this result appears to be driven by strong differences across sectors. Among the services sectors, for example, one observes that the horizontal linkage coefficient for the health and social work sector is strongly significant and negative, whereas the coefficient in the other business services sector has a similar magnitude, but takes a positive sign. We observe a similar back-and-forth among the manufacturing sectors, although deviations from the aggregate measure are partly explained by sectors with a relatively small number of observations. These competing forces probably contribute to the ambiguous result we see on the aggregated horizontal measure.

**Box 4. How can we explain backward linkages?**

The quantitative analysis suggests that in our sample of countries, FDI spillovers exist via vertical backward linkages (but not to a significant extent through vertical forward linkages). What exactly are backward linkages?

Anecdotal evidence and case studies highlight different mechanisms through which foreign firms transfer knowledge or provide incentives to domestic suppliers to increase their productivity. A first mechanism relies on quality control and testing. Multinationals often send engineers or consultants to their suppliers to control the quality of the inputs they provide and to inspect their facilities. These visits are generally an opportunity to provide suggestions on how to improve the production process. Domestic suppliers can also be asked to send samples for testing and some feedback is given with suggestions for quality improvement. Such mechanisms illustrate the dual nature of FDI spillovers that are derived on the one hand by a transfer of knowledge and on the other hand on competitive pressures or incentives to improve productivity. If the buyer is not satisfied by the quality control or testing, this can lead to the termination of the contract between the domestic and foreign firm.

Foreign firms can be more directly involved in increasing the productivity of their suppliers when they offer training to the workers of the domestic firm. For example, employees can be trained in the parent company of the subsidiary that buys inputs from local suppliers. While this represents a cost for the buyer, it can be in its interest to increase the productivity of its suppliers. There is lastly a potential scale effect when domestic companies start to sell to affiliates of foreign companies. By becoming part of a larger production network, the domestic company is likely to export to the parent company or other affiliates in third countries, thus increasing the size of its production with economies of scale that lead to higher productivity. Managers from U.S. and Japanese companies report that they often recommend a good supplier to other affiliates.

One cannot completely rule out the possibility of a "self-selection" effect in the correlation between backward linkages and higher productivity in the sense that MNEs can cherry pick the most productive suppliers. However, this does not necessarily contradict the existence of FDI spillovers. Foreign presence can still help to increase efficiency in the domestic economy as the least productive firms are forced to exit the market.

*Source*: Blalock and Gertler (2005), Javorcik and Spatareanu (2005).

42. The results for the aggregate measure of backward linkages consistently shows a strongly positive and significant effect, suggesting that foreign presence in firms to which a given firm sells outputs generally positively correlates with higher productivity. In contrast, the aggregate measure of forward linkages often displays a negative and significant effect, which indicates that foreign presence in upstream firms (*i.e.*, those sectors that supply inputs to a given firm) negatively correlate with production. Similar to the horizontal measure, significant variation exists across sectors at the disaggregated level (see Table 7).

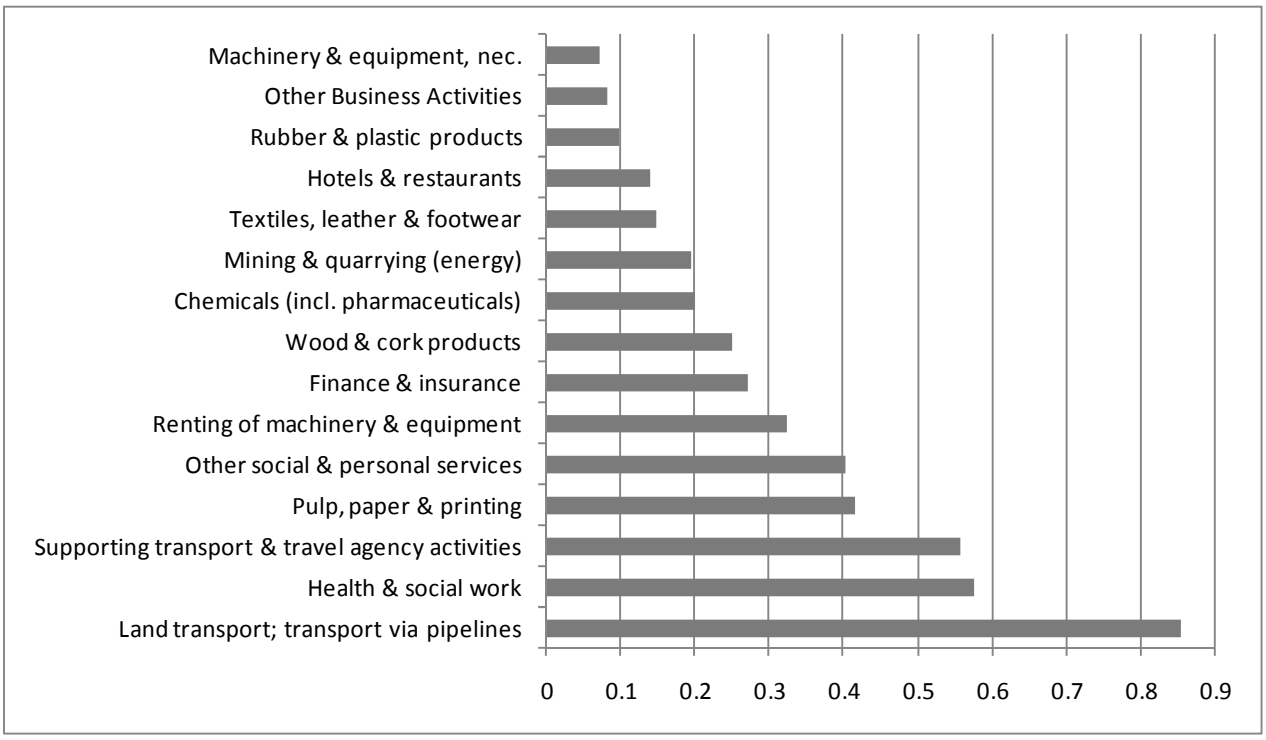
43. This initial result, which takes into account spillovers across all sectors in the economy, suggests that in general, firms benefit from FDI-related spillovers originating from their customers rather than their suppliers. This result is consistent with the findings in the literature on FDI spillovers (Box 4). This has also been documented in some case study analysis on the retail giant IKEA, who has invested much time and resources into ensuring that the firms from which they source components adhere to various quality and cost guidelines.

44. Moreover, the results of the linkage variables that have been disaggregated into three sectors – primary, manufacturing, and services – suggest that the spillovers from backward linkages (*i.e.*, foreign presence in downstream firms) occur in primary and services sectors. In fact, it appears that the effect of spillovers from downstream services firms is so large that it overrides the negative effect from the manufacturing sectors to influence the overall backward linkage variable discussed above.

45. These results suggest that encouraging foreign presence in the services sectors can have strongly positive direct and indirect effects in the economy. At the sector level, we also observe a certain number of positive spillovers through forward linkages in sectors such as finance and insurance or post and telecommunications, and to a lesser extent construction and certain transport services. On average, spillovers effects are stronger in services sectors, a result not highlighted so far in the literature. Figure 4 presents the sectors in which the highest horizontal spillovers emerged, while Figure 5 illustrates the sectors with significant positive spillovers through backward and forward linkages.

46. Turning to the trade policy variables, the results suggest that both trade policy measures – tariffs (manufacturing only), the index of trade openness (including both tariff and certain non-tariff barriers) and trade restrictiveness indices – are significantly negatively correlated to productivity. In other words, trade protection correlates with lower productivity, all else equal. Using interaction terms for the trade policy variables and the horizontal, backward and forward linkages, the coefficients found highlight the complimentary relationship between FDI spillovers and trade liberalisation[22]. Box 3 points out how concretely this interrelationship happens.

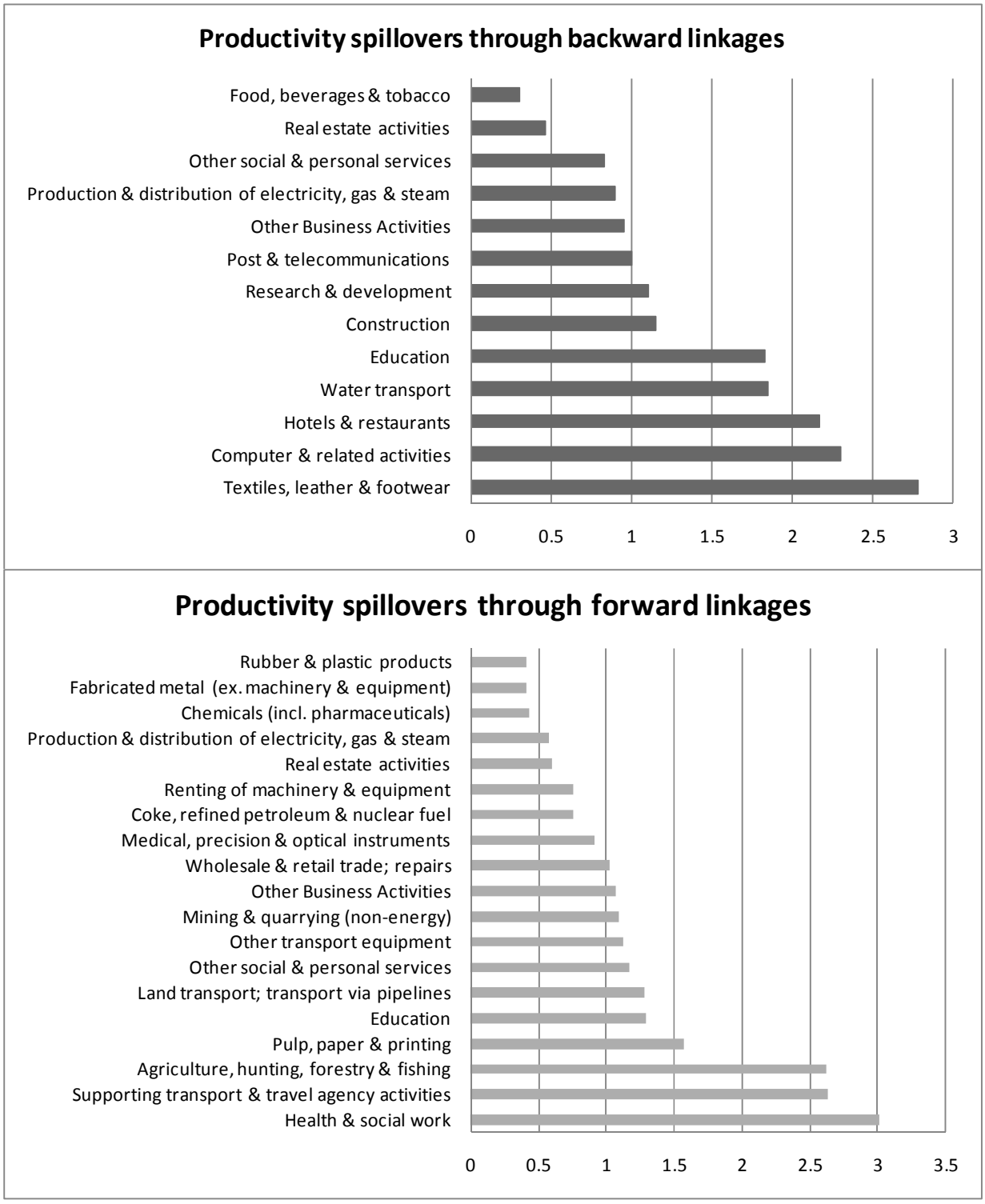
**Figure 4. Spillovers through horizontal linkages (regression coefficients)**




*Source* : Based on results in Table 7. Only positive and significant coefficients are reported.

22 . See Annex 5 for results.

**Figure 5. Spillovers through backward and forward linkages (regression coefficients)**




*Source* : Based on results in Table 7. Only positive and significant coefficients are reported.

## IV. Policy implications and concluding remarks

47. The quantitative analysis presented in the previous section leads to several important policy conclusions.

1. ***Trade liberalisation is associated with stronger FDI-related spillovers and higher productivity***. There is a significant and positive correlation between the degree of trade openness and output when measuring the impact of foreign presence in the domestic economy. A policy of openness to trade tends to attract relatively more productive foreign firms whose efficiency stimulates domestic firms to improve their productivity to compete effectively. Thus, trade liberalisation can be seen as an important component of any reform package designed to help countries maximise the benefits of FDI.
2. ***Encouraging foreign presence in the services sectors can generate strong positive productivity effects in the economy***. The analysis presented in this study suggests that it is in services industries that the productivity-enhancing effects of FDI are the strongest. In our sample of firms, spillovers from backward linkages occur mainly in services sectors. The fact that earlier studies tended to focus on manufacturing firms can explain why the literature has been somewhat sceptical about the existence of FDI spillovers and why it is important to include services in the analysis.
3. ***The potential for knowledge-related spillovers from FDI varies considerably across sectors.*** Results obtained at a relatively detailed sector level indicate that the potential for FDI-related spillovers varies considerably. Among sectors, for example, computer and related activities, hotels and restaurants, construction, post and telecommunications and other business activities showed strong FDI spillovers via backward linkages. In addition, FDI-related spillovers via forward linkages are found in agriculture, land transport, mining, but also services sectors such as wholesale and retail trade or other business activities.

48. While the quantitative analysis could not cover developing economies for which firm-level data and input-output tables are not easily available, some of the policy implications derived from this study may be extended to emerging economies. It is in the context of trade and investment liberalisation that FDI spillovers can contribute to productivity growth. Country case studies generally show that knowledge spillovers are significant contributors to productivity growth in the post- rather than pre-liberalisation phase (see Jacob and Szirmai (2007) on Indonesia). The ambiguous results of some empirical studies on FDI spillovers in developing countries may fail to capture productivity effects because they do not take into account trade reforms or other reforms that are part of the complementary policies required for a positive impact of foreign investment; this issue merits further research.

49. The role of multinationals in the diffusion of technology is increasingly recognised. In the past, MNEs were often regarded as a threat to the domestic economy, as policymakers feared that they would extract rents from local customers and suppliers or abuse key resources. This view has changed in part because MNEs face a more competitive business environment, and they increasingly rely upon vertically integrated production networks in an effort to improve efficiency. Consequently, it is increasingly in their interest to cultivate reliable, long-term relationships with suppliers and responsibly use host country resources. Open trade policies are part of this competitive environment that can prevent MNEs from adopting predatory or rent-seeking practices, while at the same time encouraging them to produce partly abroad and to share some of their knowledge with local partners.

50. While trade theory suggests that an open trade regime increases efficiency and productivity, investment is one channel through which this happens as it flows to the sectors in which a country has a comparative advantage. By definition, a multinational must have some advantage that allows it to

successfully compete with domestic producers. This advantage could be a proprietary technology, but it could also take the form of specialised management skills, marketing, and branding, among others (Kokko, *et. al*., 2001). This is important when one considers the spillover effects of these advantages on the domestic economy, since an open trade regime can allow investment to flow into productive sectors, and the spillover benefits from FDI will occur precisely in those sectors that policymakers would want to encourage.

51. One of the reasons why spillovers might be higher in more competitive markets is that stronger competition may induce greater knowledge transfer from MNE parent companies to their affiliates in order for the affiliate to compete effectively against its domestic rivals. In turn, local firms operating alongside more technologically advanced foreign affiliates will have greater opportunities for learning new technologies. This is likely to reduce the technology gap between domestic and foreign affiliated firms, thus increasing the opportunities for potential spillovers.

52. Moreover, an open trade regime implies that domestic companies tend to export more and that more domestic companies are in sectors in which the host economy has a comparative advantage. Exporting firms are generally more productive, and thus it is consistent to find a positive relationship between trade openness and higher firm productivity controlling for foreign presence in the sector. Export-oriented firms, including export-oriented foreign affiliates, tend to be larger because they produce for the world market, rather than exclusively for the local market. A consequence of this is that they likely offer more opportunities for local suppliers to benefit from economies of scale in production (which boosts productivity). Thus, trade liberalisation can be seen as an important component of any reform package designed to help countries maximise the benefits of FDI.

53. Yet FDI-related spillovers are not automatic. There will be instances in which foreign firms will be reluctant to share their knowledge, or they may have very few interactions with domestic companies, thus limiting the FDI spillover effects. In addition, host country characteristics, such as absorptive capacity, determines whether a particular firm can make use of the potential knowledge transfer embodied in spillovers. And while openness to trade is positively associated with FDI spillovers, increased openness can create difficult adjustment challenges, as in cases where increased competition in the domestic market drives the least productive domestic companies out of business. Policymakers thus need a comprehensive approach, with policies to employ adjustment-related assistance complemented by policies that encourage an environment conducive to FDI-related spillovers.

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## ANNEX 1: THE DATASET

The dataset covers the following countries for the period 1993-2006, although the number of observations per year varies: Austria, Belgium, Finland, France, Germany, Hungary, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Spain, and Sweden. The sectoral classification used in the dataset can be found in Table 2 below.

**Table 2. The sectoral classification**

| | SECTORAL CLASSIFICATION (ISIC Rev. 3) |
|---|---|
| | **Primary** |
| 1+2+5 | Agriculture, hunting, forestry and fishing |
| 10+11+12 | Mining and quarrying (energy) |
| 13+14 | Mining and quarrying (non-energy) |
| | **Manufacturing** |
| 15+16 | Food products, beverages and tobacco |
| 17+18+19 | Textiles, textile products, leather and footwear |
| 20 | Wood and products of wood and cork |
| 21+22 | Pulp, paper, paper products, printing and publishing |
| 23 | Coke, refined petroleum products and nuclear fuel |
| 24 | Chemicals (including pharmaceuticals) |
| 25 | Rubber and plastics products |
| 26 | Other non-metallic mineral products |
| 27 | Iron & steel / Non-ferrous metals |
| 28 | Fabricated metal products, except machinery and equipment |
| 29 | Machinery and equipment, nec |
| 30 | Office, accounting and computing machinery |
| 31 | Electrical machinery and apparatus, nec |
| 32 | Radio, television and communication equipment |
| 33 | Medical, precision and optical instruments |
| 34 | Motor vehicles, trailers and semi-trailers |
| 35 | Building & repairing of ships and boats / Aircraft & spacecraft / Railroad and transport equipment n.e.c. |
| 36+37 | Manufacturing nec; recycling (include Furniture) |
| | **Services** |
| 40 | Production, collection and distribution of electricity, gas and steam |
| 41 | Collection, purification and distribution of water |
| 45 | Construction |
| 50+51+52 | Wholesale and retail trade; repairs |
| 55 | Hotels and restaurants |
| 60 | Land transport; transport via pipelines |
| 61 | Water transport |
| 62 | Air transport |
| 63 | Supporting & auxiliary transport activities; activities of travel agencies |
| 64 | Post and telecommunications |
| 65+66+67 | Finance and insurance |
| 70 | Real estate activities |
| 71 | Renting of machinery and equipment |
| 72 | Computer and related activities |
| 73 | Research and development |
| 74 | Other Business Activities |
| 75 | Public administration and defence; compulsory social security |
| 80 | Education |
| 85 | Health and social work |
| 90+91+92+93 | Other community, social and personal services |
| 95+99 | Private households with employed persons & extra-territorial organisations & bodies |

Input-output data come from the 2007 edition of the OECD Input-Output Database for the years indicated in Table 3 below.

**Table 3. Input-output data**

| Country | Input-Output Data |
|---|---|
| Austria | 1995 / 2000 |
| Belgium | 1995 / 2000 |
| Finland | 1995 / 2000 |
| France | 1995 / 2000 |
| Germany | 1995 / 2000 |
| Hungary | 1998 / 2000 |
| Italy | 1995 / 2000 |
| Luxembourg | 1995 / 2000 |
| Netherlands | 1995 / 2000 |
| Norway | 1995 / 2000 |
| Poland | 1995 / 2000 |
| Portugal | 1995 / 2000 |
| Slovak Republic | 1995 / 2000 |
| Spain | 1995 / 2000 |
| Sweden | 1995 / 2000 |

**Table 4. Variable descriptions**

| Variable | Description | Source |
|---|---|---|
| Output (lnoprev) | The log of operating revenue[A] | AMADEUS |
| Labour (lnlabour) | The log of the number of employees | AMADEUS |
| Capital (lncap) | The log of fixed assets[A] | AMADEUS |
| Materials (lnmat) | The log the cost of materials[A] | AMADEUS |
| Foreign share (forshare) | The percentage of shares held by foreign shareholders | Calculated by the Authors using AMADEUS |
| Horizontal linkage (spill) | The average level of foreign ownership across each sector weighted by the firm's share in total sectoral output | Calculated by the Authors using AMADEUS |
| Backward linkage (spill) | A measure of the spillover effects on a producer industry from foreign presence in downstream sectors | Calculated by the Authors using AMADEUS and the 2007 OECD Input-Output Database |
| Forward linkage (spill) | A measure of the spillover effects from foreign presence in a producer industry's suppliers | Calculated by the Authors using AMADEUS and the 2007 OECD Input-Output Database |
| Backward linkage primary (spill) | A measure of the spillover effects on a producer industry from foreign presence in downstream primary product sectors | Calculated by the Authors using AMADEUS and the 2007 OECD Input-Output Database |
| Backward linkage manufacturing (spill) | A measure of the spillover effects on a producer industry from foreign presence in downstream manufacturing sectors | Calculated by the Authors using AMADEUS and the 2007 OECD Input-Output Database |
| Backward linkage services (spill) | A measure of the spillover effects on a producer industry from foreign presence in downstream services sectors | Calculated by the Authors using AMADEUS and the 2007 OECD Input-Output Database |
| Forward linkage primary (spill) | A measure of the spillover effects from foreign presence in the primary product suppliers of a producer industry | Calculated by the Authors using AMADEUS and the 2007 OECD Input-Output Database |

| | | |
|---|---|---|
| Forward linkage manufacturing (spill) | A measure of the spillover effects from foreign presence in the manufacturing suppliers of a producer industry | Calculated by the Authors using AMADEUS and the 2007 OECD Input-Output Database |
| Forward linkage services (spill) | A measure of the spillover effects from foreign presence in the services suppliers of a producer industry | Calculated by the Authors using AMADEUS and the 2007 OECD Input-Output Database |
| Tariff (policy) | The natural log of the weighted average applied tariff rate in sector *j* | UNCTAD Trains Database |
| Index of Economic Freedom (IEF) (policy) | The trade indicator in the Index of Economic Freedom | Heritage Foundation |
| FDI Restrictiveness Index (policy) | The value of the OECD FDI regulatory restrictiveness index in sector *j*. | OECD (Koyama and Golub, 2006) |

[A] Deflated using economy-wide producer prices from the OECD Main Economic Indicators.

## ANNEX 2: THE AMADEUS DATABASE AND THE FOREIGN SHARE CALCULATIONS

We use a subset of Bureau Van Dijk's AMADEUS dataset that includes the top 1.5 million companies out of 9 million available. Companies are selected on the basis of their size as well as certain additional criteria to generate a representative sample in terms of sectors and countries. The sample includes some small and medium-sized enterprises (SMEs), with about half of the companies in the sample having less than 20 employees. Among the firms in the sample, 207,439 firms contained the data required for this study, including ownership information. The final sample thus includes 15 countries for a total of 1,188,210 observations. While the sample is an unbalanced panel, on average there are 5 years of observations for each company.

The foreign share variable calculated for each company is defined as the percentage of shares held by foreign shareholders. Both direct and indirect ownership is taken into account. A foreign shareholder is defined as a corporation from a foreign country. Private individuals are not regarded as foreign shareholders. First, there is no information on their nationality in the AMADEUS ownership database and it is impossible to distinguish between domestic and foreign individuals. Second, assuming they are from a different country, they are not expected to have any active role in the management of the company and therefore are not part of the "foreign presence" that we would like to measure in relation to potential productivity spillovers. Public shareholders are regarded as domestic as it is unclear whether foreign public shareholders are also classified as public shareholders in the AMADEUS ownership database (similar to the situation involving private individuals, there is no information reported on the country of origin of public shareholders). Likewise, when a corporation is listed as a shareholder but the information is missing on its nationality, it is not included in the calculation of the foreign share.

Not all shareholders are listed by Bureau Van Dijk, but the ownership database is quite extensive (it includes 21 million active links) and many of the shareholders listed have a negligible share so that generally all the main shareholders should be covered. However, the nationality of shareholders is not always easy to identify as a shareholder can be a subsidiary of another foreign or domestic company. We rely on the information on the "global ultimate owner" when available to identify the nationality of the investor. There are several possible definitions of the ultimate owner in AMADEUS. The one that is used here relies on a minimum percentage of 25% at each step of the path from a subject company to its ultimate owner. The ultimate owner (or the "end" of the path) is identified through the independence indicator reported by Bureau Van Dijk when the company is regarded as independent and has no owner.

The main limitation to the ownership information in AMADEUS is that only the most recent information is reported. It is therefore impossible to follow changes in ownership and events such as mergers or acquisitions. We thus assume that the ownership structure is unchanged over the years in the panel. To see the extent to which this may affect the results, the main regressions are also estimated over a shorter time period corresponding to the years for which the ownership information is likely to be more robust (2004-2006). The results are quite similar, at least regarding the sign and magnitude of the main variables, including the foreign shares.

Again, the foreign share is susceptible to change only when domestic owners become foreign or vice-versa. Ownership changes that are between domestic or foreign companies have no consequence for the foreign share calculated. In any case, the bias introduced in the analysis by the lack of information on past ownership is expected to be small as the dataset includes many more observations corresponding to recent years for which the ownership information is accurate.

## ANNEX 3: THE PRODUCTION FUNCTION AND ITS ESTIMATION

The firm-level production function is expressed mathematically as:

$$\ln oprev_{ikt} = \alpha + \beta_1 \ln cap_{ikt} + \beta_2 \ln labour_{ikt} + \beta_3 \ln mat_{ikt} + \beta_4 \sum spill_{ikt} + \beta_5 \sum policy_{it} + B_6 forshare_{ikt} + \gamma_i + \kappa_k + \lambda_t + \varepsilon_{ikt}$$

Where:

*oprev* = operating revenue in constant 2000 prices
*cap* = fixed assets in constant 2000 prices
*labour* = number of employees
*mat* = volume of materials in constant 2000 prices
*spill* = various spillover measures
*policy* = various trade policy measures
*forshare* = percentage of shares held by foreign shareholders
$\alpha$ = constant
$\gamma$ = country fixed effects
$\kappa$ = sector fixed effects
$\lambda$ = year fixed effects
*i* = country subscript
*k* = sector subscript
*t* = time subscript
$\varepsilon$ = error term

We start with an OLS estimation of this production function where fixed effects account for unobserved variables at the country, year and sector level. These fixed effects can in particular account for unobserved productivity shocks or variations among countries, sectors and years in the dataset. Robust standard errors are used to correct for heteroscedasticity.

The second series of estimations is based on clustered standard errors. As we use both firm- and sector-level data in the regressions, there is a potential bias that can lead to an underestimation of the standard errors, generating statistical significance for the variables at the sector level (including our horizontal, forward and backward linkages) when it does not exist. This is known in the literature as the "Moulton Correction" (Moulton, 1990).

The third series of estimations introduces a change in the fixed effects. Instead of country, sector and time fixed effects (as in the above equation), we use firm-level fixed effects. This specification is used as a robustness check to assess whether significant spillovers exist when the model controls for all firm-related specificities. The regressions are run on domestic firms only (with a foreign share lower than 10 percent) as the foreign share is most of the time constant over the years (and hence collinear with the fixed effects). As we have relatively few observations per firm and some of the firm-level variables do not vary significantly across the sample, the results of these estimations should be interpreted with caution. Also, from a theoretical point of view, one can question whether firm fixed effects are likely to capture at least some part of the spillovers effects we would like to measure.

Lastly, we propose a dynamic system panel estimation with the Arellano-Bover/Blundell-Bond GMM estimator (Arellano and Bover, 1995; Blundell and Bond, 1998). The potential bias for which we would

like to correct is the "simultaneity bias". It results from the endogeneity at the firm level between the level of productivity and the choice of inputs of labour, material and capital inputs.

Some authors have used the Olley-Pakes approach (Olley and Pakes, 1996) or the Levinsohn and Petrin approach (Levinsohn and Petrin, 2003) to correct for the simultaneity bias[23]. These methods rely on the use of a proxy for unobserved productivity shocks and to account for the endogeneity in the selection of inputs (the proxy is investment in the Olley-Pakes methodology and an intermediate input – such as energy – in the Levinsohn and Petrin methodology). As we do not have a good proxy in the dataset, we prefer to use a dynamic panel estimation technique whereby the lagged output is used as an instrument and lagged variables are introduced for the firm inputs. The "Arellano-Bond systems GMM estimator" is regarded as providing consistent estimators for a production function with firm-level data, especially in the case of many panels and few periods in the dataset. As with the firm fixed effects specifications, we remove the foreign share from these regressions and the dataset is limited to domestic firms to capture an impact on the productivity of local firms.

23 . See Arnold (2005) for an overview of the methods available for estimating productivity at the firm-level.

## ANNEX 4: LINKAGE CALCULATIONS

The linkages are calculated following the general methodology set out in Javorcik (2004), although some modifications, indicated below, have been made.

### *Horizontal linkage*

This linkage is calculated as the average level of foreign ownership across each sector weighted by the firm's share in total output in the sector.

$$\text{Horizontal}_{jt} = \sum_{i\ for all\ i \in j} \text{Foreign Share}_{it} * \frac{Y_{it}}{\sum_{i for all\ i \in j} Y_{it}}$$

### *Backward and forward linkages*

The backward and forward linkages are calculated using data from the 2007 OECD Input-Output Database, which shows the values of inputs and outputs used in the production of goods and services in 42 sectors (see Table 2). Since our dataset covers the period 1993-2006, we use a linear interpolation function to generate values for the years in-between our two data points. Then the value for the earliest data point is applied to all years prior, and the value for the latest data point is applied to all years afterwards.

The backward linkages represent a measure of the potential spillover effects on a producer industry from foreign presence in downstream sectors. The backward linkages are then calculated as:

$$\text{Backward}_{jt} = \sum_{k\ if\ k \neq j}^{n} \alpha_{jk}\ \text{Horizontal}_{kt}$$

Where $\alpha_{jk}$ represents the amount of sector *j*'s domestic output[24] supplied to sector *k*, taken from the 2007 OECD Input-output Database[25].

The forward linkages proxy the potential spillover effects from foreign presence in a producer industry's suppliers. The forward linkages are then calculated as:

24 . Using only the value of domestic outputs represents a departure from the methodology of Javorcik (2004). By only considering domestic inputs and output relationships, we have a better sense of how foreign presence affects the domestic economy.

25 . The inclusion of the horizontal linkage in the equation accounts for intra-industry inputs, so they are excluded in the aggregate.

$$\text{Forward}_{jt} = \sum_{m \; if \; m \neq j}^{m} \sigma_{jm} \; \text{Horizontal}_{mt}$$

Where $\sigma_{jm}$ represents the amount of sector *j*'s input derived from sector *m* (excluding imported inputs), taken from the 2007 OECD Input-Output Database.

## ANNEX 5: REGRESSION RESULTS

### *Aggregate level effects*

Table 5 presents the results of the regressions at the aggregate level, using an OLS estimation of the production function with year, country and sector fixed effects, as well as a dynamic panel estimation.

We start with estimations using robust standard errors to correct for heteroscedasticity. Across all of the regressions estimated, we find a positive and significant coefficient for the foreign share, indicating that foreign companies tend to be more productive than domestic firms. Importantly, the foreign share controls for the presence of foreign firms in the sample of companies and thus the coefficients found for other variables, including the spillover variables, reflects the effects of those variables on domestic firms only.

In Column (1), we test the existence of horizontal spillovers. We find a positive and significant coefficient indicating that domestic companies in sectors that include a larger number of foreign firms benefit from increased productivity. Such a result cannot be interpreted as a direct causal relationship between FDI and productivity. It could be the case that foreign firms have picked sectors that are more likely to have become more productive over the years. This is the limit of the analysis carried out on the basis of the methodology proposed here. Moreover, this result stands in contrast to other estimations which include other variables, such as backward and forward linkages.

In Column (2), we introduce backward and forward linkages in the equation. We note that the sign of the horizontal variable has changed and is now negative, suggesting a negative impact on productivity from horizontal linkages (that is, the foreign presence within the same industry). As previously indicated in Section III, we observe in some cases a change in the sign of horizontal spillovers across our regressions. Other studies have found the variable to be insignificant (*e.g.*, Javorcik, 2004). Further, collinearity does not appear to be an issue among the measures of backward, forward and horizontal linkages. The sectoral analysis provided in Table 7 highlights that there are marked differences across sectors in the sign of spillovers through horizontal linkages, which could in part help explain these seemingly contradictory results.

The results for backward linkages, however, appear more robust across the regressions and also exhibit higher economic significance. Again, the sectoral analysis reveals that positive spillovers through backward linkages are found only in specific sectors. It is unsurprising with regard to both the literature and the theoretical considerations reviewed in Section I. We also observe differences among sectors that contribute to forward linkages that are not robust at the aggregate level. But the general trend appears to show that these linkages are associated with lower productivity, suggesting that domestic firms do not learn as much from their suppliers as they do from their customers.

In Column (3), the spillover effects are decomposed in three broad sectors: primary, manufacturing and services sectors. This estimation reveals that the positive coefficient for backward linkages at the aggregate level is driven entirely by services industries. No such positive spillovers are found on average for primary and manufacturing industries. Regarding forward linkages, the three sectors show negative coefficients but we note that the severity of the decrease in productivity is lower for services. Hence the conclusion made in this report of the importance of productivity-related spillovers from services sectors.

The other columns in Table 5 present estimations used as robustness checks, focusing on the measures of horizontal, backward and forward spillovers. Columns (4) through (6) present regression estimates using

clustered standard errors (Moulton correction). While the results are not significantly altered, there are several notable differences. One can see in Column (5) that the coefficient for horizontal spillovers is not significant. In Column (6), it is positive but of a lower magnitude than in Column (3) for a similar specification. Spillovers through backward linkages and forward linkages have unchanged coefficients but backward linkages in the primary sector and forward linkages in services are no longer significant. In sum, estimates using the Moulton correction suggest that the results for the primary and manufacturing linkages are not strongly robust.

In Columns (7) through (9), additional regressions are included to show whether results are robust when including firm fixed effects. These effects are estimated on a low number of observations (on average there are 5 years of observations for each company) and can be somewhat collinear with some of the other variables, particularly when there is not a lot of variation over time. The regressions are run on domestic firms only (with a foreign share lower than 10 percent) to avoid such collinearity issues with the share of foreign ownership. Horizontal linkages have a negative coefficient in all these regressions. We note also a change in the sign of forward linkages in the manufacturing and services sectors (with now positive and significant coefficients). Backward linkages have a negative coefficient at the aggregate level but importantly, we still have a positive and significant coefficient for spillovers through backward linkages in the services sector.

The last part of Table 5 (Columns 10 through 12) presents results of a dynamic panel estimation where we check for the endogeneity in input selection. Regressions are also run on domestic companies because the foreign share would be collinear with some of the instruments in such an estimation. One lag has been used for the dependent variable (operating revenue), as well as labour, capital and material inputs (these choices have no major impact on the results, we tried also two lags). The coefficients obtained are generally smaller than in the other regressions, indicating that it is useful to correct for the potential endogeneity in input selection. For variables that were already noted as not particularly robust, such as the horizontal spillovers, there is a change in the sign. The sector decomposition in Column (12) confirms that there is a positive relationship between the foreign presence in downstream sectors (backward linkages) and the productivity of domestic firms in the services sectors. Interestingly, positive spillovers are also found in agriculture sectors.

***Trade policy effects***

Table 6 presents the results of regressions including three trade policy variables. Both the tariff variable and the trade component of the Index of Economic Freedom show a negative sign, which is expected as higher tariffs and a higher index mean more protection and trade openness is conducive to higher FDI spillovers (see Box 3). The FDI restrictiveness index also has a strong negative sign, indicating that barriers to FDI are not only likely to restrict capital flows but also negatively impact productivity. As a proxy for barriers to Mode 3 trade in services (commercial presence), the negative sign and strong significance of the coefficient of the index can also be interpreted as the negative impact of limiting the presence of foreign services suppliers in the domestic economy. When only the tariff, the Index of Economic Freedom or the FDI restrictiveness index is introduced in the regression, it is difficult to infer much about the interaction between trade policy and FDI spillovers. Taken together, however, these results suggest that an open trade regime is generally associated with higher productivity.

To further assess the relationship between trade policy and foreign presence, estimations are included using interaction terms (Columns (2), (4) and (6)). These interaction terms are calculated by simply multiplying the trade variables by the different linkages calculated. It is important to interpret the interaction terms together with the coefficients for each trade indicator and each type of spillover (horizontal, backward and forward). Tariffs are only for goods and so Column (5) reflects the results for the backward and forward variables found for the manufacturing sector (hence the insignificant coefficient

for backward spillovers). There is a positive interaction between the trade component of the Index of Economic Freedom and backward linkages. This can be understood by setting the index to zero (free trade). The positive coefficient found for backward linkages is not only stronger than in other regressions but the overall output of the firm is no longer affected by the negative coefficients estimated for the impact of the trade index variable and the interaction term between the index and the backward linkages. Spillovers are thus higher when the trade regime is liberal.

***Sectoral effects***

Table 7 presents results at a disaggregated sector level, using OLS with fixed effects and clustered standard errors. Among sectors, computer and related activities, hotels and restaurants, construction, post and telecommunications and other business activities showed strong FDI spillovers via backward linkages (interactions with downstream customers). In addition, FDI-related spillovers via forward linkages (interactions with upstream suppliers) are found in agriculture, land transport, mining, as well as services sectors such as wholesale and retail trade or other business activities. Overall, the analysis shows that there is stronger evidence in favour of spillovers via backward linkages than there is for spillovers via forward linkages, and that spillovers can be economically significant in services sector. There are potentially horizontal spillovers but differences among sectors lead to a coefficient at the aggregate level that is not always positive and not robust.

**Table 5. Regressions at the aggregate level**

| Dependent variable: operating revenue | OLS Fixed effects - Robust standard errors | | | OLS Fixed effects - Clustered standard errors | | | OLS Fixed effects (with firm fixed effects) | | | Dynamic panel estimation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Horizontal linkages | Backward and forward linkages | Decomposition by sector | Horizontal linkages | Backward and forward linkages | Decomposition by sector | Horizontal linkages | Backward and forward linkages | Decomposition by sector | Horizontal linkages | Backward and forward linkages | Decomposition by sector |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Labor input | 0.345*** | 0.340*** | 0.341*** | 0.345*** | 0.340*** | 0.341*** | 0.287*** | 0.291*** | 0.290*** | 0.123*** | 0.129*** | 0.132*** |
| | (0.000910) | (0.000848) | (0.000867) | (0.00521) | (0.00334) | (0.00349) | (0.00214) | (0.00216) | (0.00216) | (0.00448) | (0.00454) | (0.00448) |
| Capital input | 0.127*** | 0.132*** | 0.133*** | 0.127*** | 0.132*** | 0.133*** | 0.113*** | 0.110*** | 0.109*** | 0.0526*** | 0.0527*** | 0.0532*** |
| | (0.000550) | (0.000534) | (0.000543) | (0.00305) | (0.00258) | (0.00273) | (0.000876) | (0.000872) | (0.000870) | (0.00251) | (0.00249) | (0.00245) |
| Material input | 0.416*** | 0.400*** | 0.407*** | 0.416*** | 0.400*** | 0.407*** | 0.439*** | 0.440*** | 0.440*** | 0.359*** | 0.363*** | 0.364*** |
| | (0.000781) | (0.000683) | (0.000709) | (0.00448) | (0.00399) | (0.00368) | (0.00182) | (0.00185) | (0.00185) | (0.00450) | (0.00455) | (0.00452) |
| Foreign share | 0.201*** | 0.226*** | 0.211*** | 0.201*** | 0.226*** | 0.211*** | | | | | | |
| | (0.00168) | (0.00176) | (0.00176) | (0.00651) | (0.00586) | (0.00593) | | | | | | |
| Horizontal linkages | 0.198*** | -0.0340*** | 0.0375*** | 0.198*** | -0.0340 | 0.0375* | -0.197*** | -0.195*** | -0.177*** | -0.0857*** | -0.0742*** | -0.0291** |
| | (0.00604) | (0.00425) | (0.00426) | (0.0105) | (0.0229) | (0.0198) | (0.00853) | (0.00865) | (0.00869) | (0.0122) | (0.0121) | (0.0118) |
| Backward linkages | | 0.506*** | | | 0.506*** | | | -0.804*** | | | -0.640*** | |
| | | (0.00834) | | | (0.0503) | | | (0.0251) | | | (0.0397) | |
| Forward linkages | | -1.743*** | | | -1.743*** | | | 0.738*** | | | -0.0464** | |
| | | (0.0121) | | | (0.0558) | | | (0.0151) | | | (0.0204) | |
| Backward Primary | | | -0.236*** | | | -0.236 | | | -0.202*** | | | 0.646*** |
| | | | (0.0610) | | | (0.477) | | | (0.0653) | | | (0.0851) |
| Backward Manufacturing | | | -0.120*** | | | -0.120** | | | -1.951*** | | | -1.177*** |
| | | | (0.00937) | | | (0.0532) | | | (0.0400) | | | (0.0715) |
| Backward Services | | | 0.911*** | | | 0.911*** | | | 0.430*** | | | 0.248*** |
| | | | (0.0177) | | | (0.140) | | | (0.0337) | | | (0.0440) |
| Forward Primary | | | -3.602*** | | | -3.602*** | | | -0.995*** | | | -1.456*** |
| | | | (0.0409) | | | (0.220) | | | (0.0559) | | | (0.100) |
| Forward Manufacturing | | | -1.888*** | | | -1.888*** | | | 1.227*** | | | -0.485*** |
| | | | (0.0126) | | | (0.0625) | | | (0.0393) | | | (0.0677) |
| Forward Services | | | -0.197*** | | | -0.197 | | | 0.462*** | | | -0.0108 |
| | | | (0.0192) | | | (0.128) | | | (0.0182) | | | (0.0251) |
| Operating revenue (L1) | | | | | | | | | | 0.757*** | 0.751*** | 0.724*** |
| | | | | | | | | | | (0.0108) | (0.0110) | (0.0108) |
| Labor input (L1) | | | | | | | | | | -0.0742*** | -0.0764*** | -0.0695*** |
| | | | | | | | | | | (0.00351) | (0.00368) | (0.00361) |
| Material input (L1) | | | | | | | | | | -0.279*** | -0.279*** | -0.270*** |
| | | | | | | | | | | (0.00551) | (0.00556) | (0.00544) |
| Capital input (L1) | | | | | | | | | | -0.0283*** | -0.0259*** | -0.0235*** |
| | | | | | | | | | | (0.00234) | (0.00232) | (0.00229) |
| Observations | 1,159,345 | 1,139,400 | 1,139,400 | 1,159,345 | 1,139,400 | 1,139,400 | 955,641 | 942,004 | 942,004 | 733,192 | 722,943 | 722,943 |
| R-squared | 0.865 | 0.852 | 0.852 | 0.865 | 0.852 | 0.852 | 0.968 | 0.968 | 0.968 | n/a | n/a | n/a |

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

**Table 6. Regressions with the trade variables**

| Dependent variable: operating revenue | Average weighted tariff | | Index of Economic Freedom | | FDI restrictiveness index | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Labor input | 0.329*** | 0.329*** | 0.373*** | 0.374*** | 0.351*** | 0.348*** |
| | (0.00163) | (0.00162) | (0.000864) | (0.000864) | (0.00096) | (0.00097) |
| Capital input | 0.134*** | 0.134*** | 0.143*** | 0.143*** | 0.123*** | 0.123*** |
| | (0.00107) | (0.00107) | (0.000540) | (0.000540) | (0.00059) | (0.00059) |
| Material input | 0.462*** | 0.463*** | 0.397*** | 0.397*** | 0.412*** | 0.413*** |
| | (0.00162) | (0.00162) | (0.000718) | (0.000718) | (0.00085) | (0.00084) |
| Foreign share | 0.123*** | 0.122*** | 0.269*** | 0.269*** | 0.216*** | 0.217*** |
| | (0.00243) | (0.00242) | (0.00180) | (0.00180) | (0.0018) | (0.0018) |
| Horizontal linkages | 0.164*** | 0.0626*** | 0.134*** | -3.288*** | 0.164*** | -0.500*** |
| | (0.00479) | (0.00610) | (0.00448) | (0.384) | (0.0064) | (0.020) |
| Backward linkages | -0.0485*** | -0.0438** | 0.836*** | 1.256 | -0.808*** | -0.945*** |
| | (0.0133) | (0.0177) | (0.00860) | (0.804) | (0.013) | (0.041) |
| Forward linkages | -0.388*** | -0.246*** | -0.988*** | -19.74*** | -0.311*** | -0.160*** |
| | (0.0170) | (0.0209) | (0.0106) | (0.948) | (0.013) | (0.043) |
| Trade variable (see Column heading) | -0.00469*** | 0.00313** | -0.0864*** | -1.342*** | -5.521*** | -7.157*** |
| | (0.000390) | (0.00138) | (0.0192) | (0.0420) | (0.020) | (0.061) |
| Interaction with horizontal linkages | | 0.0375*** | | 0.795*** | | 4.679*** |
| | | (0.00158) | | (0.0891) | | (0.13) |
| Interaction with backward linkages | | -0.00835 | | -0.0969 | | 1.168*** |
| | | (0.00557) | | (0.187) | | (0.30) |
| Interaction with forward linkages | | -0.114*** | | 4.358*** | | -1.061*** |
| | | (0.00734) | | (0.220) | | (0.31) |
| Observations | 337,609 | 337,609 | 1,138,031 | 1,138,031 | 977,082 | 977,082 |
| R-squared | 0.916 | 0.916 | 0.841 | 0.841 | 0.860 | 0.860 |

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

**Table 7. Spillovers at the sector level**

| Industry | Industry name | Horizontal | Backward | Forward | Nb obs. | R-squared |
|---|---|---|---|---|---|---|
| 1 | Agriculture, hunting, forestry & fishing | -0.560*** | 0.178 | 2.621*** | 13,389 | 0.945 |
| 2 | Mining & quarrying (energy) | 0.194* | -0.626** | -0.202 | 812 | 0.973 |
| 3 | Mining & quarrying (non-energy) | -0.0918 | -0.114 | 1.090*** | 5,986 | 0.946 |
| 4 | Food, beverages & tobacco | -0.196*** | 0.299*** | -0.853*** | 37,800 | 0.983 |
| 5 | Textiles, leather & footwear | 0.146** | 2.784*** | -1.378*** | 23,750 | 0.981 |
| 6 | Wood & cork products | 0.250*** | -2.973*** | -0.505*** | 12,839 | 0.979 |
| 7 | Pulp, paper & printing | 0.414*** | -0.364*** | 1.574*** | 27,459 | 0.975 |
| 8 | Coke, refined petroleum & nuclear fuel | -0.0284 | -2.307*** | 0.756* | 684 | 0.985 |
| 9 | Chemicals (incl. pharmaceuticals) | 0.200*** | -0.834*** | 0.432*** | 10,782 | 0.982 |
| 11 | Rubber & plastic products | 0.0966*** | -1.755*** | 0.410*** | 15,131 | 0.984 |
| 12 | Other non-metallic mineral products | -0.227*** | -0.557*** | -0.494*** | 18,030 | 0.984 |
| 13 | Iron, steel & non-ferrous metals | -0.0601 | -0.0123 | -0.526** | 4,112 | 0.990 |
| 15 | Fabricated metal (ex. machinery & equipment) | -0.442*** | -1.544*** | 0.413*** | 42,734 | 0.976 |
| 16 | Machinery & equipment, nec. | 0.0699* | -2.182*** | 0.00454 | 25,457 | 0.978 |
| 17 | Office, accounting & computing machinery | 0.0618 | -0.332 | -1.004 | 947 | 0.977 |
| 18 | Electrical machinery & apparatus, nec. | -0.188*** | -1.169*** | -0.474*** | 9,049 | 0.982 |
| 19 | Radio, television & communication equipment | -0.220*** | -0.770*** | -0.119 | 3,925 | 0.974 |
| 20 | Medical, precision & optical instruments | -0.170*** | -1.049*** | 0.912*** | 5,787 | 0.976 |
| 21 | Motor vehicles, trailers & semi-trailers | -0.136** | -1.886*** | -0.763** | 5,855 | 0.986 |
| 22 | Other transport equipment | -0.348*** | -0.460*** | 1.128*** | 3,453 | 0.973 |
| 25 | Manufacturing nec. & recycling (incl, furniture) | -0.355*** | 0.0377 | 0.0659 | 14,785 | 0.973 |
| 26 | Production & distribution of electricity, gas & steam | -0.541*** | 0.908** | 0.580*** | 4,284 | 0.976 |
| 29 | Collection, purification & distribution of water | -1.248*** | -2.960*** | -0.128 | 1,742 | 0.977 |
| 30 | Construction | -0.607*** | 1.155*** | -0.121* | 106,553 | 0.963 |
| 31 | Wholesale & retail trade; repairs | -0.572*** | -3.576*** | 1.029*** | 321,934 | 0.979 |
| 32 | Hotels & restaurants | 0.140*** | 2.169*** | -1.612*** | 29,909 | 0.966 |
| 33 | Land transport; transport via pipelines | 0.852*** | -0.115 | 1.278*** | 26,860 | 0.960 |
| 34 | Water transport | -0.746*** | 1.850*** | -0.206 | 1,465 | 0.975 |
| 35 | Air transport | -0.785*** | -2.276** | -0.713 | 515 | 0.972 |
| 36 | Supporting transport & travel agency activities | 0.555*** | -3.139*** | 2.636*** | 17,053 | 0.956 |
| 37 | Post & telecommunications | -0.0491 | 1.029 | -2.143** | 2,634 | 0.967 |
| 38 | Finance & insurance | 0.271*** | -2.594*** | -0.580 | 2,956 | 0.967 |
| 39 | Real estate activities | -0.129 | 0.460* | 0.605*** | 29,546 | 0.927 |
| 40 | Renting of machinery & equipment | 0.323*** | -0.673** | 0.753*** | 6,076 | 0.958 |
| 41 | Computer & related activities | -0.775*** | 2.305*** | -1.718*** | 15,141 | 0.947 |
| 42 | Research & development | 0.0532 | 1.134* | -1.060 | 1,528 | 0.958 |
| 43 | Other Business Activities | 0.0822*** | 0.955*** | 1.074*** | 50,708 | 0.969 |
| 45 | Education | -0.0856 | 1.839** | 1.291*** | 2,695 | 0.949 |
| 46 | Health & social work | 0.575*** | -2.898*** | 3.013*** | 14,302 | 0.968 |
| 47 | Other social & personal services | 0.402*** | 0.827*** | 1.170*** | 23,065 | 0.951 |

*** p<0.01, ** p<0.05, * p<0.1