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Resumé

Dette papir indeholder det første studie, der tester betydningen af definitionen af udenlandsk ejerskab i forbindelse med estimationen af produktivitetsfølgevirkninger fra udenlandsk til indenlandsk ejede firmaer; et vigtigt aspekt i lande med en udbredt brug af holding-selskaber. Derudover bevæger det sig ud over standardrammerne ved ikke alene at teste produktivitetsfølgevirkninger på aggregeret niveau, men ved også at teste betydningen af både de indenlandsk og de udenlandsk ejede firmaers karakteristika. Den empiriske analyse er den første til at udnytte detaljerigdommen, som officielle danske paneldata på firmaniveau byder på. Analysen viser signifikant negative følgevirkninger på aggregeret niveau, men resultaterne varierer kraftigt på tværs af brancher. Den afslører også, at det fører til skæve resultater, hvis firmaer under indirekte udenlandsk kontrol ikke inkluderes i gruppen af udenlandsk ejede firmaer, som det er tilfældet i nogle studier. Med hensyn til de indenlandsk ejede firmaers karakteristika viser analysen, at en høj eksportorientering og høj konkurrence dæmper nogle af de negative produktivitetsfølgevirk-ninger. Endelig viser beregningerne, at de negative følgevirkninger hovedsageligt stammer fra udenlandsk ejede firmaer (i) med lav produktivitet, (ii) med høj import-/eksportorientering og (iii) ultimativt kontrolleret af investorer uden for Skandinavien.

Productivity Spillovers from FDI: Ownership Structures, Domestic Firm Characteristics, and FDI Characteristics*

Jannick Damgaard†

28 April 2011

Abstract

This paper is unique in testing the importance of the foreign ownership definition when estimating productivity spillovers from foreign direct investment (FDI) to domestic firms; a crucial aspect in countries with a widespread use of holding companies. In addition, it moves beyond the standard framework by not only analyzing aggregate productivity spillovers, but also testing the importance of both domestic firm characteristics and FDI characteristics. The empirical analysis is the first one to exploit the rich details offered by official Danish firm-level panel data. The analysis displays significant evidence of negative spillovers at the aggregate level, but the results differ widely across industries. It also reveals that not including firms under indirect foreign control in the group of foreign firms, as is done in some studies, leads to biased results. With regard to domestic firm characteristics, high export orientation and high competition mitigate some of the negative productivity spillovers. Finally, the estimations show that the negative spillovers largely stem from foreign firms (i) with low productivity, (ii) with high foreign trade orientation, and (iii) ultimately controlled by investors outside Scandinavia.

JEL Classification Numbers: *D24, F21, F23, O33*

Keywords: *Productivity, spillovers, FDI, determinants*

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1 Introduction

Many countries spend considerable resources on maintaining and attracting foreign direct investment (FDI). For example, Head (1998) reports that the state of Alabama gave Mercedes an incentive package worth approximately USD 230 million in 1994 for setting up a new 3,000-worker plant. Similarly, Siemens was paid GBP 50 million to locate a 1,000-worker factory in Tyneside, in Northeast England (Haskel, Pereira and Slaughter, 2007) while the Danish government investment promotion agency, *Invest in Denmark*, offers advice and services free of charge from seventeen offices worldwide to investors considering relocation, consolidation, or setting up new production facilities in Denmark. Governments often justify promotional expenses with the claim that FDI leads to increased economic competitiveness, e.g. through positive productivity spillovers to domestic firms from foreign firms[1] belonging to multinational enterprises (MNEs) (Harding and Javorcik, 2007). This paper exploits the rich details offered by official Danish firm-level data to study aspects of ownership structures, domestic firm characteristics, and FDI characteristics that have not been tested before in connection with productivity spillovers from FDI.

Since the pioneering study by Caves (1974), a large number of analyses have examined the existence of productivity spillovers. From time to time, researchers have paused to assess the current situation[2], but the empirical evidence remains mixed. Some studies support the hypothesis of positive spillovers while other studies estimate them to be insignificant or even negative. In a meta-analysis, Görg and Strobl (2001) investigate whether certain aspects of a study's design affect the results and reach the conclusion that studies based on cross-sectional data are more likely to yield positive spillovers than studies based on panel data. Lipsey and Sjöholm (2005), on the other hand, argue that the econometric method does not seem to be the crucial determinant for the mixed evidence. Instead, they suggest that differences across time and countries in domestic firms' ability to absorb the superior technology of foreign firms could be the key factor.

Even though Lipsey and Sjöholm (2005) present their explanation as an alternative to Görg and Strobl (2001), the two theories are not necessarily contradictory. For instance, it seems plausible that cross-sectional studies would have a tendency to overestimate productivity spillovers since MNEs may have a tendency to enter the most productive industries. A regular analysis based on cross-sectional data would not be able to reveal the cause-and-effect relationship between highly productive industries and foreign presence. Similarly, it

[1] In this paper, a foreign firm is defined as a firm under foreign control; a more detailed definition can be found in Section 3.

[2] Literature reviews include Blomström and Kokko (1998), Görg and Greenaway (2004), Keller (2004), Crespo and Fontoura (2007), and Smeets (2008)

is conceivable that the sign and significance of productivity spillovers would differ across studies depending on the circumstances in the host country as, for example, the absorptive capacity is likely to be different in a developed country with a highly skilled and flexible labor market than in a developing country with a rigid and low-skilled labor force. Consequently, just because one study finds negative productivity spillovers, it does not imply that one can reject all the studies that find positive spillovers or vice versa. Nevertheless, researchers should draw on the important methodological advances which have been developed in the field of estimation of productivity spillovers from FDI in the past decade and in addition, carry out sensitivity analyses to ensure that the results are robust.

This paper is unique in specifically examining whether the definition used to identify foreign firms has an impact on the estimation of productivity spillovers from FDI. In addition, it moves beyond the standard framework by not only analyzing aggregate productivity spillovers, but also testing the importance of both domestic firm and FDI characteristics. In order to test these aspects, the empirical analysis, as the first one[3], is based on official Danish firm-level panel data. The empirical estimations display considerable evidence of negative short-term productivity spillovers at the aggregate level, meaning that an increased foreign firm presence in Denmark generally hampers domestic firms' productivity in the short run.[4] At the industry level, however, both positive and negative spillovers are observed. The analysis of foreign firm definitions reveals that not including firms under indirect foreign control in the group of foreign firms, as is done in some studies, leads to biased results. It also finds that domestic firms with high export orientation and those domestic firms operating in the most competitive industries are less affected by the negative spillovers than other firms. With regard to the FDI characteristics, the estimations show that foreign firms that are ultimately owned by investors from the two other Scandinavian countries, Norway and Sweden, do not have a negative impact on domestic firms' productivity, just as limited foreign trade orientation among foreign firms mitigates the negative effects. The presence of the most productive foreign firms even has a positive effect on domestic firms' productivity.

The remainder of the paper is structured as follows. Section 2 summarizes the literature on productivity spillovers while Section 3 describes the development and the special characteristics of FDI in Denmark. In Sections 4 and 5, the estimation strategy and data are presented. Section 6 contains the econometric analysis, and Section 7 concludes the paper.

[3]Malchow-Møller, Markusen and Schjerning (2009) use official Danish firm-level data to assess wage rather than productivity effects from foreign firm presence.

[4]As official Danish statistics on foreign firms have only been produced from 2002 onwards, it is only possible to study short-term productivity spillovers in this paper.

2 Literature on Productivity Spillovers from FDI

The literature on FDI is based on the supposition that MNEs display higher productivity than domestically-oriented enterprises. The presumption of high productivity in foreign firms can explain the interest of policy makers in attracting FDI, hoping that the high performance levels will spill over to domestic firms.[5] Dunning (1993) presents his widely used OLI framework to explain why firms engage in FDI. According to his theory, a firm will expand and locate in other countries if the following three advantages exist: Ownership advantages, Locational advantages, and Internalization advantages. Ownership advantages include patents, copyrights, trademarks, superior technology, management techniques, and marketing strategies that will affect productivity in a positive way. Empirical studies for Canada (Globerman, Ries and Vertinsky, 1994), Germany (Temouri, Driffield and Higón, 2008), UK (Griffith, 1999), and the US (Doms and Jensen, 1998) support the hypothesis of higher productivity among foreign firms compared to domestic firms. A firm possessing ownership advantages can serve foreign markets through exports, licensing, or FDI; the latter option will only be chosen in case both locational and internalization advantages exist. Examples of locational advantages are low production costs, favorable regulations and tax policies, a large physical distance between home and host country, advanced infrastructure, and a skilled labor force. The main internalization advantage is to keep control over ownership advantages. In other words, MNEs try to prevent knowledge spillovers to its competitors in the host economy.

2.1 Productivity Spillover Channels

The early literature primarily focused on horizontal spillovers, i.e. productivity spillovers[6] from foreign firms to domestic firms within the same industry. The presence of foreign firms can affect the productivity of domestic firms through four main spillover channels, see Figure 1.[7] The first spillover channel is the *demonstration* effect, suggesting that domestic firms can increase their productivity by observing and imitating foreign firms' products, production processes, managerial or organizational innovations (see, e.g., Das (1987) and Wang and Blomström (1992).

[5] In addition, policy makers would be interested in employment and tax effects.

[6] This paper applies a broad definition of the term *productivity spillovers* and includes all transmission mechanisms from foreign to domestic firms whether they are pure externalities or not.

[7] While some of the productivity spillover theories have been derived in a mathematical modeling framework, the majority have not been formalized and are partly based on anecdotal evidence. This section provides a brief summary of the most important theories without going into further detail as the primary aim of this paper is to test the productivity spillover effects empirically on new data and data dimensions that have not been tested before.

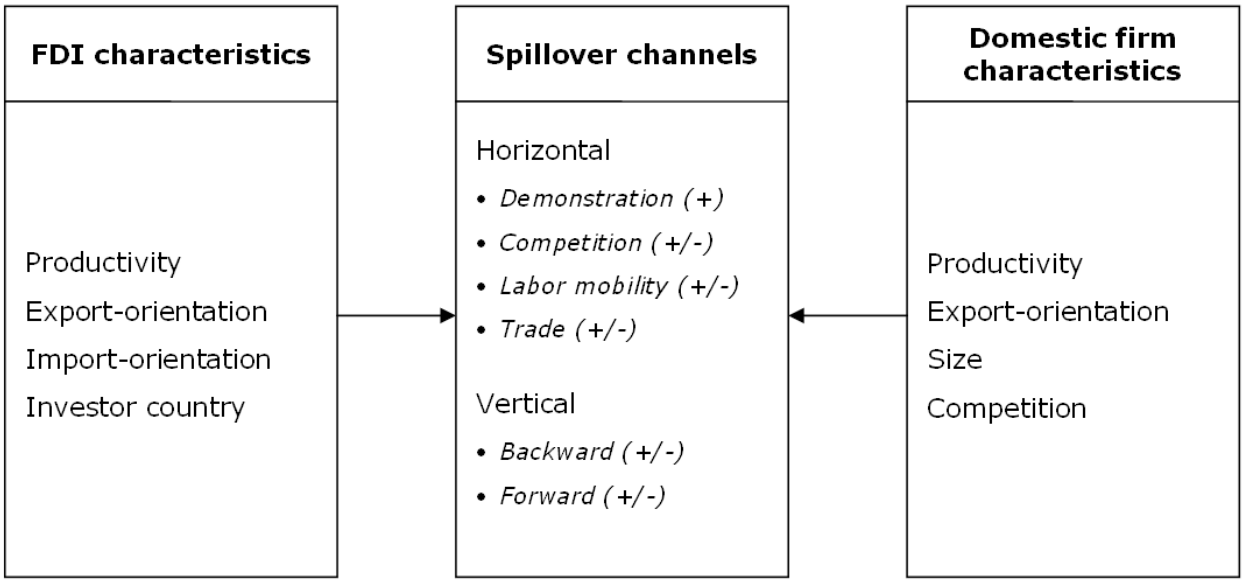
The second channel is *competition* and unlike the demonstration effect, this channel can have a positive as well as a negative impact on the productivity of domestic firms. On the one hand, the emergence of foreign firms in a country will force domestic firms to reduce X-inefficiency in order to stay competitive, thereby boosting their productivity (see, e.g., Caves, 1974; Markusen and Venables, 1999; Glass and Saggi, 2002). On the other hand, as pointed out by Aitken and Harrison (1999), foreign firms are likely to win market shares from domestic firms when entering or expanding production in a country. The domestic firms' loss of market shares will force them to reduce production and move up their given average cost curves under the assumption of increasing returns to scale, thus hampering their productivity.

Labor mobility is the third channel and is also associated with both positive and negative effects. Fosfuri, Motta and Rønde (2001) and Glass and Saggi (2002) set up models to illustrate how superior knowledge embedded in foreign firms can be transmitted to domestic firms by hiring staff who have previously worked at and received training in foreign firms. This spillover channel is not a pure externality as foreign firms typically pay a wage premium[8], and a domestic firm would normally have to match that wage premium to attract employees from foreign firms. Domestic firms will be willing to match the wage if the knowledge of an employee in a foreign firm can significantly increase its productivity. At the same time, the wage premium paid by foreign firms can potentially have a negative impact on the productivity of domestic firms because foreign firms can use the premium to poach the best-performing employees from domestic firms as suggested by Sinani and Meyer (2004) and Javorcik (2008).

The fourth and final spillover channel is *trade*, which can also have counterbalancing effects on domestic firms' productivity. On the positive side, foreign firms are generally more export-oriented than domestic firms because they have better distribution networks and knowledge about consumers' tastes in other markets. Non-exporting domestic firms may observe the behavior of and learn from foreign firms in this regard and start exporting. The result would be increased production, which would enhance productivity of domestic firms (see, e.g., Aitken, Hanson and Harrison, 1997; Greenaway, Sousa and Wakelin, 2004). An increased presence of foreign firms in an industry could, however, also have a negative impact on the productivity of domestic firms. Just as foreign firms have a tendency to display higher export shares than domestic firms, the same will be the case for import shares. If increased foreign presence in an industry is due to the crowding out of domestic firms, domestic suppliers to that industry may face lower demand because the foreign firms

[8]A possible explanation for the empirically observed wage premium is that foreign firms want to prevent employees from moving to competitors once they have received training

Figure 1: Productivity spillover channels, domestic firm and FDI characteristics



Source: Author's schematization.

are more likely to use foreign suppliers, forcing the domestic suppliers to raise prices. In such a case, domestic firms in the given industry face higher input prices, which will have a negative effect on their productivity.

In the 1970s–1990s, the vast majority of empirical research on productivity spillovers focused solely on horizontal spillovers. Nevertheless, early on, Lall (1980) highlighted the role of vertical spillovers; that is spillovers from foreign firms to domestic suppliers (backward linkages) and from foreign firms to domestic buyers (forward linkages). The theories of vertical spillovers were formalized in the 1990s (see, e.g., Rodriguez-Clare, 1996; Markusen and Venables, 1999), and a number of empirical studies on vertical spillovers were published in the 2000s (see, e.g., Kugler, 2000; Schoors and Tol, 2002; Javorcik, 2004). The idea behind vertical spillovers is that whereas foreign firms will try to prevent knowledge spillovers to intra-industry competitors, they often have an incentive to share their knowledge with suppliers and buyers. For instance, if foreign firms source their inputs domestically, they may train the domestic suppliers to make sure that their products live up to certain quality standards. Similarly, foreign firms producing advanced products will promote these products to potential domestic buyers who may be able to increase productivity by using these new products in their production processes. Foreign firms may also be able to supply products at a lower price due to their ownership advantages, thereby boosting the productivity of domestic buyers. In addition, the four spillover channels mentioned above are not restricted to firms within the same industry, but are likely also to have an inter-industry impact. For example, domestic firms may benefit from imitating foreign firms in other industries, but

they may also lose their most productive employees to these firms.

2.2 Domestic Firm Characteristics

Despite a large number of empirical studies, there is no clear evidence with regard to the sign and magnitude of aggregate productivity spillovers from FDI. A plausible explanation for the varying results is that circumstances differ across countries, meaning that some of the mentioned spillover channels will work more efficiently in some countries than in others. Moreover, the aggregate results represent the net effect of all productivity spillover channels, and it is difficult to disentangle the effects. Still, some researchers have tried to dig one step deeper to investigate why some domestic firms benefit more from foreign presence than others. One approach for going into further detail is to examine domestic firm characteristics and their link with the ability to learn from foreign firms.

Productivity — In connection with domestic firm characteristics, productivity is believed to play a central role for spillovers. Findlay (1978) and Wang and Blomström (1992) posit that productivity spillovers increase with the technological gap between foreign and domestic firms because the potential for catching up via imitation is enhanced, thereby suggesting that domestic firms with low productivity will benefit most from foreign presence. Cohen and Levinthal (1989), Glass and Saggi (1998), and Kinoshita (2001) also recognize the importance of domestic firms' productivity, but they argue that some level of absorptive capacity, generated through investments in R&D or human capital, is necessary to identify the value of new information, assimilate it, and apply it to commercial ends. If a large technological gap is seen as an indicator of low absorptive capacity, productivity spillovers and the technological gap will be inversely related, meaning that domestic firms with high productivity will benefit most from foreign presence. As a result of the two contradicting theories, it is not possible to come up with a unambiguous hypothesis.

Hypothesis 1: The productivity of domestic firms has an impact on productivity spillovers from FDI; the net impact can be positive, neutral, or negative.

Export orientation — The argument has been made that export-oriented domestic firms already face significant competition on international markets (Blomström and Sjöholm, 1999). On the one hand, a high export orientation means that the importance of and interaction with the domestic market is reduced, thus limiting the spillover potential from FDI. On the other hand, export-oriented domestic firms are likely to have a higher capacity to absorb new technology and will also, as highlighted by Barrios and Strobl (2002) and Schoors and Tol (2002), be in a better position to resist the competitive pressure.

Hypothesis 2: The export orientation of domestic firms has an impact on productivity spillovers from FDI; the net impact can be positive, neutral, or negative.

Size — The size of domestic firms is also hypothesized to have an impact on their ability to take advantage of new knowledge and technology from foreign firms as domestic firms with few employees will often not have the necessary production scale to imitate the production processes of foreign firms (Crespo and Fontoura, 2007). In addition, the total staff turnover in small firms is *ceteris paribus* lower than in firms with many employees, therefore limiting the scope for spillovers through labor mobility.

Hypothesis 3: The size of domestic firms has a positive impact on productivity spillovers from FDI.

Competition — Finally, the level of competition in a domestic industry may play a role for the size and magnitude of productivity spillovers. Domestic firms operating in highly competitive industries are used to competing against a large number of firms and are likely to be in a better position to adapt to new situations and compete against foreign firms than domestic firms operating in less competitive industries. Theoretical models by Glass and Saggi (1998) and Wang and Blomström (1992) support this view.

Hypothesis 4: The competition level of the domestic industry has a positive impact on productivity spillovers from FDI.

2.3 FDI Characteristics

Another potential determinant of the sign and magnitude of productivity spillovers is the FDI characteristics, i.e. the type of FDI coming into a country.

Productivity — The productivity of foreign firms can be seen as the other side to the story of the technological gap discussed in Section 2.2. It may be argued that the largest positive spillover potential comes from the most productive foreign firms because these firms possess the most advanced technology and hence offers favorable imitation possibilities. Conversely, it could be argued that the technological gap between the most productive foreign firms and the domestic firms is too large, meaning that the spillover potential from the least productive foreign firms would actually be highest even though they may not possess the same advanced technology as the most productive foreign firms.

Hypothesis 5: The productivity of foreign firms has an impact on productivity spillovers from FDI; the net impact can be positive, neutral, or negative.

Export orientation — Foreign trade orientation of foreign firms and its relevance with regard to productivity spillovers seems to be a less explored area in the literature. On the one hand, a high export orientation among foreign firms means that domestic firms can study export behavior and will only be subject to limited foreign firm competitive pressure in the domestic market. On the other hand, they still risk losing their best-performing employees to the foreign firms and, perhaps more importantly, the possibility of imitating foreign firm behavior is severely reduced when the foreign firms only engage in the local economy to a limited extent.

Hypothesis 6: The export orientation of foreign firms has an impact on productivity spillovers from FDI; the net impact can be positive, neutral, or negative.

Import orientation — Like export orientation, the role of import orientation has received little attention in the literature. Nevertheless, Rodriguez-Clare (1996) makes an implicit reference to import orientation, arguing that backward spillovers depend on transport costs. In case of high import orientation, the scope for positive backward spillovers is hampered because it diminishes the role and use of domestic suppliers. Furthermore, foreign firms with high import shares are hypothesized to interact less with domestic firms, reducing the general spillover potential.

Hypothesis 7: The import orientation of foreign firms has a negative impact on productivity spillovers from FDI.

Investor country — Lastly, the literature mentions the investor country of the FDI as a possible spillover determinant because cultural and linguistic barriers may affect the potential for spillovers (Crespo and Fontoura, 2007). A high proportion of Danes are proficient in English, but Norwegian and Swedish are closely related to Danish, making the linguistic barrier between the Scandinavian countries small even when the native languages are spoken. Furthermore, due to the close historical roots, the cultural differences within Scandinavia are negligible compared to differences between the Danish and, for instance, American and Asian cultures. The cultures of all three Scandinavian countries are characterized by being informal with a relatively low level of authority distance. Because of the similarities, Danish firms are likely to be in a favorable position to assimilate and absorb advanced production processes from Scandinavian MNEs.

Hypothesis 8: FDI from Norway and Sweden has a positive impact on productivity spillovers compared to FDI from other countries.

3 FDI in Denmark

Denmark has a small, open economy and can be considered to be a representative OECD country in terms of *stock of inward FDI/GDP ratio*, see left-hand panel of Figure 2.[9] The Danish inward FDI position grew steadily at an average annual rate of 5.6 percent in the period from 2002 to 2008 so that the end-2008 position corresponds to 44 percent of GDP. Despite high wages and taxes, Denmark remains an attractive destination for FDI due its location as a gateway to the Nordic market, its well-educated labor force, and its highly flexible labor market. The total FDI position can be broken down by equity capital, intercompany debt, and special purpose entities (SPEs), with FDI equity capital being the largest component, see right-hand panel of Figure 2. The main recipients of FDI in Denmark are the *financial intermediation*, *trade and transport*, and *manufacturing* industries, and the largest investor country is Sweden followed by the Netherlands, Luxembourg, Great Britain, and Germany.

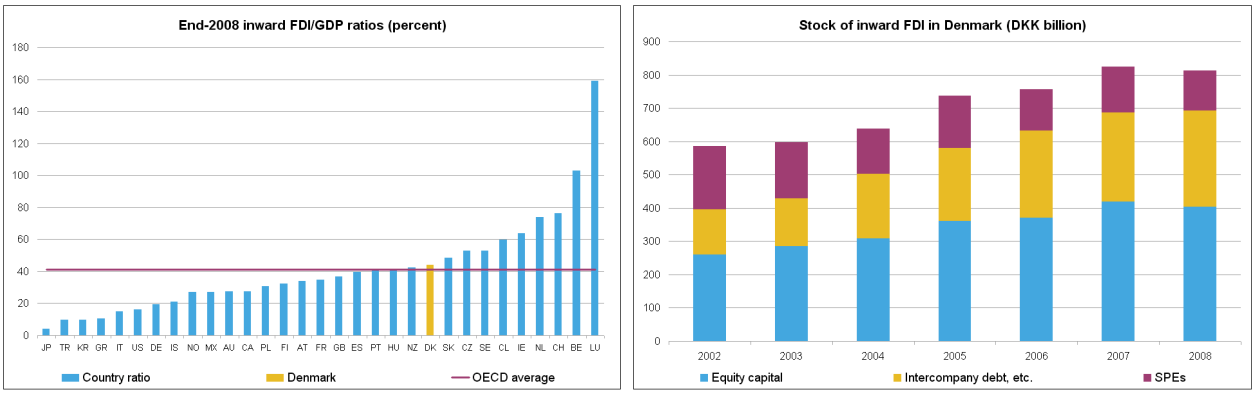
By definition, FDI statistics are financial data, measuring financial cross-border investments between entities in an FDI relationship. Such a relationship is defined according to control or significant influence; the operational threshold for significant influence is 10 percent equity ownership (OECD, 2008; IMF, 2009). Despite its status as a set of financial statistics, FDI statistics are sometimes used for real-economic analysis.[10] However, the use of FDI statistics for this purpose is associated with a number of problems. For example, SPEs are typically set up for tax reasons as empty shell companies that own equity abroad. They do not have any, or at least very limited production and employment, and thus do not impact the real economy of a country. The share of SPEs in Denmark has been reduced from 33 percent in 2002 to 15 percent of total inward FDI in 2008, but is still significant. Even if SPEs are removed from FDI statistics, it is difficult to establish a direct link between FDI positions and the production of foreign firms. One reason is that foreign capital funds' acquisitions of Danish firms in recent years have primarily been financed through bank loans, which are not recorded as FDI (Jayaswal et al., 2006). In addition, data for intercompany loans may be distorted by the establishment of cash pools in MNEs.

Another potential problem is with ownership structures. Assume that Firm A, resident

[9]The high ratios in the Benelux countries can to a large extent be explained by the widespread existence of special purpose entities (SPEs) in these countries.

[10]For instance, ECB (2008) states that *"for a host country or the foreign firms which receives the investment, [FDI] can provide a source of new technologies, capital, processes, products, organisational technologies and management skills, and as such can provide a strong impetus to economic development"*. In addition, OECD (2008) suggests that aggregate FDI data expressed as a percentage of GDP can be used as an indicator of globalization. However, due to its status as a set of financial statistics, empirical studies on productivity spillovers generally only use information about foreign ownership and base the analyses on real-economic variables such as output, value added, or employment.

Figure 2: Stock of inward FDI/GDP ratios for OECD and composition of Danish FDI



Source: UNCTAD (2009) and Danmarks Nationalbank.

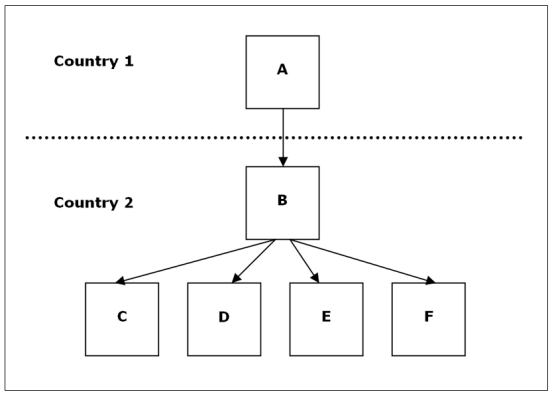
in Country 1, owns Firm B in Country 2 that in turn owns Firms C, D, E, and F in Country 2 as illustrated in the left-hand panel of Figure 3. While all firms in this case are in an FDI relationship, only the equity that Firm A holds in Firm B will be included in FDI statistics. The equity capital in Firms C, D, E, and F will be excluded as this is not direct cross-border investment, and only intercompany loans from Firm A to Firms C, D, E, and F will be recorded in FDI statistics. The ownership structure in this example is commonly used in Denmark where investments in real production facilities often take place via holding companies. For instance, when foreign investors in 2005/06 acquired TDC, the largest Danish telecommunications provider, the actual acquisition took place through the holding company Nordic Telephone Company that was set up for the purpose. Foreign AffiliaTes Statistics (FATS) have been developed to describe the real-economic activities of foreign firms.[11] It applies a slightly different definition of foreign firms than FDI statistics: *(i)* The ownership threshold is 50 percent rather than 10 percent, and *(ii)* it includes all firms controlled by a foreign investor, regardless of whether the control is direct or indirect. In other words, whereas only Firm B is a foreign firm (as defined by FDI equity) according to FDI statistics, Firms B, C, D, E, and F are all foreign firms in a FATS setting.[12]

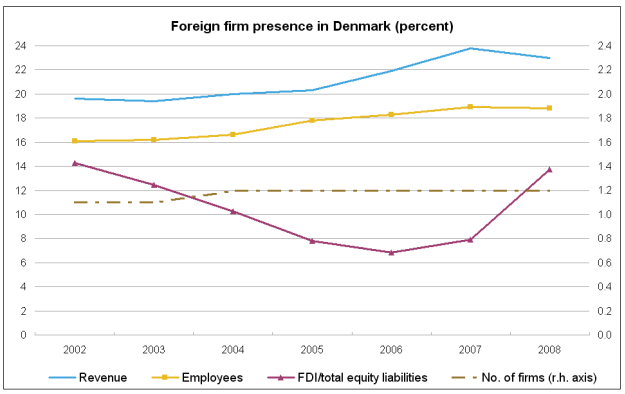
The right-hand panel of Figure 3 illustrates the importance of foreign firms in Denmark according to the FATS definitions. While only 1.2 percent of the private firms in 2008 were classified as foreign, these firms respectively accounted for 23 and 19 percent of the total private revenue and employment. By comparison, inward FDI equity capital accounted for less than 14 percent of total Danish equity liabilities. It comes as no surprise that foreign

[11]The principles of FATS are described in detail in Eurostat (2007) while documentation on the closely related Activities of Multinational Enterprises (AMNE statistics) can be found in OECD (2008).

[12]It should be mentioned that some countries collect FDI statistics at enterprise group level rather than at firm level, thus adding to the complexity of foreign firm definitions applied in macroeconomic statistics.

Figure 3: Example of holding company structure; data for foreign firm presence in Denmark





Note: The example in the left-hand panel is the author's schematization of a typical holding company structure. The right-hand panel is based on FATS data from Statistics Denmark and FDI/financial accounts statistics from Danmarks Nationalbank.

firms' share of total production and employment is larger than the FDI equity share of total equity liabilities since, in the case of holding company structures, only the equity in the holding company and not in the underlying affiliates is recorded in FDI statistics.[13]

A number of studies have investigated whether productivity spillovers from minority FDI differ from those from majority FDI (see, e.g., Blomström and Sjöholm, 1999; Dimelis and Louri, 2002; Abraham, Konings and Slootmaekers, 2007), but this paper is the first one to examine the importance of ownership structures and the definitions used to identify foreign firms. Most empirical studies do not state whether they are restricted to direct ownership or if they also include indirect ownership. One exception is Javorcik and Spatareanu (2008) who explicitly mention that they only consider direct ownership. In contrast, this study uses the FATS definition of foreign firms including both direct and indirect foreign majority holdings as a baseline case as foreign investors will undoubtedly have an impact on a firm whether they control it directly or indirectly through a holding company. Nevertheless, an alternative foreign firm definition including only direct foreign majority holdings will be tested as well to compare the effect of using two different foreign firm definitions.

[13]Furthermore, FDI equity capital is recorded at book value in the Danish FDI statistics whereas total equity liabilities in the Danish financial accounts are estimated using price-to-book value (P/B) adjustments that usually exceed unity because accounting standards only capture intangibles to a limited extent (Kumah, Damgaard and Elkjær, 2009). The difference in valuation principles also partly explains the significant drop in the FDI equity share of total equity liabilities from 2002 to 2007 and the sudden increase in 2008. The reason is that the P/B adjustment used in the financial accounts rose considerably up to the financial crisis in 2008 where it dropped severely.

4 Estimation Strategy

The estimation strategy in this study is based on a micro panel data approach. Over the last decades, the common estimation strategy applied in the empirical studies on productivity spillovers has gradually developed from aggregate cross-sectional data analysis to firm-level panel data analysis. The main advantage of estimating spillovers on detailed panel data is that it allows for the possibility of isolating effects of unobserved differences between firms. Whereas cross-sectional data can be used to detect correlation, the temporal ordering in panel data enhances the possibilities of making causal inferences. For instance, the early studies on productivity spillovers (see, e.g., Caves, 1974; Globerman, 1979) found that high foreign presence and productivity were correlated, but based on this information, one cannot directly conclude that high foreign presence in an industry leads to high productivity. Instead, it might be that high productivity in a domestic industry attracts foreign firms. The use of panel data allows us to study the dynamics of the data and make inferences based on these.

The first step in the empirical analysis is to estimate firm-level total factor productivity based on industry-level production function estimations. Recent literature on the estimation of production functions recognizes the endogeneity issue caused by the correlation between unobservable productivity shocks and input levels, leading to biased OLS estimates.[14] To address this issue, the LP procedure, as suggested by Levinsohn and Petrin (2003), is applied. The starting point is a Cobb-Douglas production function for industry j:

$$v_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \eta_{it}, \tag{1}$$

where v_{it}, l_{it}, and k_{it} denote the logarithmic values of value added, labor, and capital, respectively, for firm i in year t.[15] The error terms in the model are represented by ω_{it} and η_{it}. Whereas η_{it} is uncorrelated with input choices, ω_{it} is a state variable that impacts the firms' input decision rules. The LP procedure estimates ω_{it} as a function of capital and intermediate input in an attempt to address the simultaneity bias. The production functions are estimated on domestic firms only as the productivity of *domestic* firms is the scope of this study. The parameter estimates from industry-specific production functions are then used to estimate total factor productivity expressed in logs (*tfp*) for a given firm in a given year in the following way:

[14] See Griliches and Mareisse (1998) for an overview of the production function estimation history.

[15] Production functions are sometimes extended to include an R&D variable, but such a variable is omitted from this analysis due to data restrictions. In addition, some studies distinguish between employees with different educational backgrounds. However, such an approach will not be used in this study as many Danish firms only have a single or very few employees, thus resulting in a large number of zero observations if the labor variable is broken down by categories.

$$\widehat{tfp_{it}} = v_{it} - \widehat{\beta}_l l_{it} - \widehat{\beta}_k k_{it}. \tag{2}$$

The second step in the estimation strategy is to create measures for the spillover variables. The measure for horizontal spillovers, *HZ*, is constructed as foreign firms' share of total industry output and is designed to capture intra-industry spillovers. If Y denotes output, and F is an indicator variable for foreign firms, *HZ* can be calculated in the following way:

$$HZ_{jt} = \sum_{i \in j} Y_{it} F_{it} \left(\sum_{i \in j} Y_{it} \right)^{-1}. \tag{3}$$

The measures for vertical spillovers are constructed by combining information from annual input-output (IO) tables with the *HZ* variable. Specifically, the measure for backward linkages, *BW*, is calculated as:

$$BW_{jt} = \sum_{k \neq j} \alpha_{jkt} HZ_{kt}, \tag{4}$$

where α_{jkt} represents the proportion of industry j's total output that is supplied to domestic industry k for intermediate consumption. To separate vertical spillovers from horizontal spillovers, intra-industry sourcing is excluded from the calculations ($k \neq j$). This measure is aimed at capturing the effect that the presence of foreign firms has on the productivity of their domestic suppliers. Similarly, the measure for forward spillovers, *FW*, can be calculated as:

$$FW_{jt} = \sum_{k \neq j} \gamma_{jkt} HZ_{kt}, \tag{5}$$

where γ_{jkt} represents the proportion of industry j's total input that is purchased from domestic industry k. This measure is aimed at capturing the effect that the presence of foreign firms has on the productivity of the domestic customers.[16]

The above measures are used to estimate the baseline model with *tfp* as the dependent variable. However, as proposed by Haskel et al. (2007), the model is estimated in first differences to eliminate the effect of unobserved firm-, industry-, and region-specific factors

[16]To illustrate how the vertical spillover measures are constructed, assume that an economy consists of three industries: agriculture (10 percent foreign presence), manufacturing (30 percent foreign presence), and services (40 percent foreign presence). If 20 percent of the manufacturing industry's output is sold to the agricultural industry and 50 percent to the services industry (the remaining 30 percent goes to private consumption and exports), the backward spillover measure for the manufacturing industry will be 0.22 (=0.2*0.1 + 0.5*0.4). Similarly, if 60 percent of the manufacturing industry's input is supplied by the agricultural industry and 25 percent by the services industry (the remaining 15 percent is imported), the forward spillover measure for the manufacturing industry will be 0.16 (=0.6*0.1 + 0.25*0.4).

such as superior management and high-quality infrastructure that are correlated with both firm productivity and foreign presence. Since there may be factors not only affecting firms' productivity levels, but also their growth potential, industry and time dummy variables, α_j and α_t, are included to capture industry-specific differences in growth potential and economy-wide productivity shocks. The exact model specification is given by:

$$\Delta\widehat{tfp_{it}} = \beta_0 + \beta_{HZ}\Delta HZ_{jt} + \beta_{BW}\Delta BW_{jt} + \beta_{FW}\Delta FW_{jt} + \beta_{COMP}\Delta COMP_{jt} + \alpha_j + \alpha_t + \varepsilon_{it}, \quad (6)$$

where *COMP* is a competition measure. The dependent variable is constructed at firm level while the regressors represent industry-level variables. Moulton (1990) demonstrates that merging micro data with aggregated variables may result in seriously downward biased standard errors. To address this issue, the standard errors are adjusted for industry-year clustering.

To test the importance of domestic firm characteristics with regard to productivity spillovers, the model is estimated on split samples. One way of making the data split would be to divide the sample into, for instance, a group of small firms and a group of large firms and estimate productivity spillovers for each group. However, size is likely to be dependent on the industry in the sense that firms are generally large in certain industries and small in other industries. As a consequence, such a data split would not allow separating the effect of size from the effect of the general industry characteristics. In an attempt to isolate the dimension effect, the data splits are made *within* industries in this study. As the competition variable is only defined at the industry level, the split for this dimension is made at the industry level. The significance of the FDI characteristics is investigated by splitting the foreign firms into groups *within* industries as well and constructing the spillover variables separately for these groups.

5 Data

The dataset used for the empirical analysis is obtained from Statistics Denmark and consists of accounting and employment information for all firms operating in Denmark in the period 2002-07. Only firms with positive values of the variables value added, number of employees (full time equivalents), fixed capital, and inputs are included in the final data. Value added and inputs are deflated to 2000-prices by using implicit price indices at the industry level calculated from the detailed Danish IO tables in fixed and current prices prior to the production function estimation. An implicit price index constructed from Statistics

Denmark's national accounts tables for fixed assets is used to deflate the fixed assets variable to 2000-prices.

The residency of the ultimate controlling investor is the official foreign firm identification used by Statistics Denmark for production of FATS, and this variable is merged to the data. Information about the residency of the immediate investor is also included to make it possible to test the effect of using different foreign firm definitions in the estimations.

Next, the data are categorized according to the 130-industry breakdown used in the Danish IO tables. Only industries with foreign presence of at least 5 percent of output in the period 2002-07 are included, reducing the number of industries in the data to 62. Firms in industries with lower foreign presence are omitted from the analysis as spillovers are likely to be small or non-existing if foreign presence is low.[17] In addition, this approach helps avoiding spurious findings that could potentially be the result of estimating a model on independent variables with very little variation because not only the levels, but also the changes in foreign firm presence are low in industries with limited foreign presence.

Finally, the Danish Competition and Consumer Authority's competition index is added to the data. The competition index is constructed at the industry level as an average of the following seven indicators: concentration, import-corrected concentration, entry rate, mobility, rate of return, wage premia, and public regulation. Productivity dispersion is normally included as an eighth indicator in the calculation of the competition index, but it has been excluded for the purpose of this paper to avoid endogeneity by using similar variables, i.e. productivity measures, on both sides of the regression equation. The competition index is defined in the range [0-2]; a high value indicates low competition and vice versa.

Table 1 displays descriptive statistics for all variables included in the analysis. While total factor productivity is firm-specific, the spillover and competition measures are defined at the industry level. The firm-specific variables are generally highly right-skewed (the mean exceeds the 75th percentile) due to the existence of many small-scale firms. Interestingly, the horizontal spillover measure based on ultimate foreign control, *HZ_uci* is approximately 50 percent higher than the measure based on direct foreign control, *HZ_dir*. This finding illustrates that by only basing the spillover measures on firms with direct foreign ownership, the presence of firms under foreign control is severely underestimated.

[17] The chosen cut-off value of 5 percent foreign presence is in a strict sense arbitrary. As an area for future research, it would be useful to study in further detail what an appropriate cut-off value could be, e.g. through a combination of quantitative and qualitative analyses.

Table 1: Summary statistics

Variable	Description	Mean	Std. dev.	25%	75%	No. of obs.
			Firm-specific variables			
V	Value added (DKK - 2000 prices)	5.77E+06	7.90E+07	6.41E+05	3.11E+06	315,518
K	Fixed assets (DKK - 2000 prices)	8.91E+06	2.05E+08	2.55E+05	2.05E+06	315,518
M	Inputs (DKK - 2000 prices)	1.44E+07	1.37E+08	7.94E+05	6.02E+06	315,518
L	Labor (no. of full time equivalents)	11.872	126.816	1.000	8.000	315,518
Δtfp		0.014	0.554	−0.159	0.196	225,732
			Industry-specific variables			
HZ	Horizontal spillover measure (ratio)	0.330	0.214	0.178	0.434	372
BW	Backward spillover measure (ratio)	0.062	0.051	0.022	0.093	372
FW	Forward spillover measure (ratio)	0.063	0.039	0.047	0.071	372
$COMP$	Competition measure (index 0-2)	0.755	0.223	0.606	0.856	372
ΔHZ		0.016	0.100	−0.020	0.032	310
ΔBW		0.002	0.010	−0.002	0.006	310
ΔFW		0.004	0.023	−0.001	0.005	310
$\Delta COMP$		−0.003	0.130	−0.063	0.050	310
HZ_uci	Horizontal spillover measure (ratio)	0.340	0.216	0.181	0.435	248
BW_uci	Backward spillover measure (ratio)	0.064	0.053	0.023	0.094	248
BW_uci	Forward spillover measure (ratio)	0.066	0.045	0.050	0.073	248
ΔHZ_uci		0.017	0.079	−0.016	0.031	186
ΔBW_uci		0.003	0.009	−0.001	0.007	186
ΔFW_uci		0.007	0.029	0.001	0.006	186
HZ_dir	Horizontal spillover measure (ratio)	0.226	0.185	0.109	0.283	248
BW_dir	Backward spillover measure (ratio)	0.042	0.041	0.013	0.064	248
FW_dir	Forward spillover measure (ratio)	0.042	0.034	0.031	0.045	248
ΔHZ_dir		0.011	0.096	−0.017	0.021	186
ΔBW_dir		0.001	0.007	−0.001	0.004	186
ΔFW_dir		0.004	0.021	−0.001	0.004	186

Note: The table displays summary statistics based on data for the period 2002-07 with the exception of variables with the extensions _uci and _dir; the latter variables are based on data for the period 2004-07 because data on direct ownership are only available for that period. The _uci variables define foreign firms as firms with a foreign ultimate controlling investor while the _dir variables instead consider the residency of the immediate investor.

6 Empirical Results

Prior to the estimation of productivity spillovers, a test is made as to whether foreign firms are more productive than domestic firms as assumed in the theoretical literature on productivity spillovers. An analysis regressing total factor productivity on a full set of industry dummies and an indicator variable for foreign firms reveals that foreign firms are indeed more productive than domestic firms in the Danish case. The result is robust to the addition of firm output to the list of regressors and clearly supports the theoretical basis for the analysis in this paper.[18]

6.1 Baseline Case and Robustness Checks

The starting point of the empirical analysis in this paper is to estimate the aggregate effects that the presence of foreign firms has on the productivity of domestic firms and to test the robustness of the findings, see Table 2. The baseline case shows that both horizontal and backward spillovers are negative while forward spillovers are insignificant in the Danish case (1). The negative horizontal spillovers may be explained by the fact that foreign firms "steal" market shares and employees from domestic firms. The negative backward spillovers are likely to be the result of higher import shares among foreign than domestic firms[19], thus leading to lower demand in the supplying domestic industries and forcing the domestic firms up their cost curve. The parameter estimate of the competition variable is also negative. In other words, an increase in the competition level in an industry (corresponding to a decrease in the competition index variable used in the regression analysis) has a positive impact on the productivity of domestic firms in that industry.

The next step is to test the robustness of the results. In their meta-analysis on FDI productivity spillovers, Görg and Strobl (2001) find that the choice of variable to capture foreign presence can affect the outcome of the analysis. In the baseline case, the foreign presence measures are based on output, but the robustness tests show that the results are robust to the use of labor/value added rather than output in the construction of the measures, illustrating that the choice of foreign presence indicator does not seem to be an issue in the Danish case ((2)-(3)).

[18]Using German firm-level data, Temouri, Driffield and Higón (2008) find that foreign firms are generally more productive than domestic firms, but their analysis also shows that there are no significant productivity differences between domestic firms belonging to German MNEs and foreign firms, highlighting the importance of the MNE dimension with regard to productivity. Unfortunately, the dataset used for this study does not allow a distinction between between domestic firms belonging to Danish MNEs and other domestic firms.

[19]An analysis regressing import shares on a full set of industry dummies and an indicator variable for foreign firms confirms that foreign firms have higher import shares than domestic firms.

A second type of robustness checks is to base the industry selection on different criteria than the 5 percent foreign presence criterion used in the baseline case ((4)-(5)). The overall picture is still negative productivity spillovers even though there are differences between the three cases. The 10 percent criterion is not used since it eliminates too many observations. The use of all industries with foreign presence is not chosen because it includes too many industries with a small variation in the spillover variables, thereby leading to very high and possibly spurious parameter estimates.

Another selection-related issue is the possibility that MNEs cherry-pick and acquire domestic firms with the highest growth potential (Görg et al., 2009). In that case, the domestic firms with the highest growth potential would leave the panel while the domestic firms with the lowest growth potential would stay in the panel, which could explain the negative spillover effects found in the estimations. To test this hypothesis, the model is estimated only on domestic firms that have not been foreign-owned at some point during the period 2002–2007. The empirical findings from the baseline model are fully robust with regard to this test (6).

It is also tested if the results are robust to the choice of estimation approach. An alternative to the first-difference estimation strategy is to estimate a fixed effect (FE) model. The FE specification eliminates the effect of unobserved firm-, industry-, and region-specific factors by replacing each observation by the difference between the observation and the variable mean. The main results are robust to this procedure, suggesting that the method used to remove unobserved effects does not affect the outcome of the analysis (7). Additionally, the model is estimated in second differences instead of first differences as productivity spillovers may take some time to set in (8). Estimating the model in longer differences has the advantage of giving more weight to persistent changes in the variables, but reduces the sample size. Nevertheless, the specification in second differences leads to similar results as the first-difference specification. Moreover, the production functions are estimated using a standard OLS approach rather than the LP approach to correct for endogeneity (9). The results are almost identical to the baseline case, but forward spillovers are also significantly negative when using the OLS approach. Nevertheless, the LP approach is preferred because it addresses endogeneity.

Table 2: Baseline Case and Robustness Checks

Regressor	**(1) Baseline**	**(2) Labor**	**(3) Value added**	**(4) 10 percent**	**(5) All**
ΔHZ	−1.351***	−1.925***	−1.908***	−0.106	−0.929***
	0.302	*0.321*	*0.309*	*0.249*	*0.276*
ΔBW	−3.516***	−4.007***	−3.961***	−3.193***	−8.854***
	0.561	*0.644*	*0.573*	*0.893*	*1.862*
ΔFW	−2.283	−2.193	−0.104	−4.896**	15.189***
	1.612	*1.354*	*1.357*	*2.000*	*4.148*
$\Delta COMP$	−0.623***	−0.605***	−0.517***	−0.674***	−0.487***
	0.209	*0.199*	*0.199*	*0.210*	*0.188*
HZ	-	-	-	-	-
BW	-	-	-	-	-
FW	-	-	-	-	-
$COMP$	-	-	-	-	-
No. of obs.	225,732	225,732	225,732	169,920	269,781
Adjusted R^2	0.018	0.020	0.020	0.009	0.037

Note: The table displays the results of estimating Equation 6 in the baseline case and with various amendments. Standard errors clustered by industry-year are reported in italics. *, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively. (1): The baseline case. (Domestic firms in industries with at least 5 percent foreign presence in terms of output are included in the estimation of Equation 6. The model is specified in first differences, and total factor productivity is estimated according to the LP method.) (2): Foreign presence variables based on number of employees (full time equivalents) rather than output. (3): Foreign presence variables based value added rather than output. (4): Only domestic firms in industries with foreign presence in terms of output of at least 10 percent rather than 5 percent are included. (5): Domestic firms in all industries with some foreign presence in terms of output are included. *(Continued on next page)*

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Regressor	**(6) Selection**	**(7) FE**	**(8) t-2**	**(9) OLS**	**(10) Levels**
ΔHZ	−1.388***	−0.821***	−1.704***	−0.729***	-
	0.308	*0.177*	*0.303*	*0.172*	
ΔBW	−3.501***	−2.387***	−3.845***	−2.368***	-
	0.559	*0.417*	*0.614*	*0.607*	
ΔFW	−1.984	0.526	−2.330	−3.414**	-
	1.630	*0.605*	*1.545*	*1.377*	
$\Delta COMP$	−0.637***	−0.936***	−0.675***	−0.846***	-
	0.211	*0.121*	*0.206*	*0.173*	
HZ	-	-	-	-	0.154**
					0.068
BW	-	-	-	-	0.542
					0.480
FW	-	-	-	-	1.195***
					0.427
$COMP$	-	-	-	-	−0.086
					0.057
No. of obs.	222,892	294,009	157,071	225,732	315,518
Adjusted R^2	0.018	0.030	0.035	0.011	0.409

Note: (6): Only domestic firms that have *not* been foreign-owned at some point during the period 2002–07 are included. (7): Equation 6 estimated as a fixed effect model rather than in first differences (the Δ variables are constructed as $x_{ijt} - \bar{x}_{ij}$ instead of as $x_{ijt} - x_{ijt-1}$). (8): Equation 6 estimated in second differences rather than in first differences (the Δ variables are constructed as $x_{ijt} - x_{ijt-2}$ instead of as $x_{ijt} - x_{ijt-1}$). (9): The production function is estimated as a simple OLS regression rather than using the LP method to correct for endogeneity (Equation 1 is estimated without ω_{it}). (10): Equation 6 estimated in levels rather than in first differences.

Finally, to illustrate the difference between the use of cross-sectional and panel data, the model specification is estimated in levels, as a pooled regression, rather than in first differences (10). As pointed out by Görg and Strobl (2001), cross-sectional models do not take into account the dynamics of the data and have a tendency to overestimate productivity spillovers. This theory is supported by the Danish data, which reveal a significantly positive relationship between levels of productivity and the horizontal/forward measures. However, this finding cannot be used to conclude that high foreign presence leads to increased productivity of domestic firms because causality can only be tested by exploiting the time dimension of the data. As shown in the first-difference estimation, increased foreign presence actually leads to lower productivity among domestic firms. Put differently, foreign firms generally choose to enter the most productive Danish industries[20], but increased foreign presence hampers the productivity of Danish firms.

6.2 Ownership Structures

The second part of the empirical analysis examines the importance of ownership structures and the foreign firm definition applied in the study, see Table 3. The baseline case from Table 2 is included in Table 3 to facilitate comparisons across models (1). Because data on immediate ownership is only available from 2004 and not from 2002 as in the baseline case, the baseline specification is applied to data for the period 2004-07 to allow for a direct comparison that will not be affected by the time period. The analysis reveals that the baseline results do not change when the model is estimated on data for a shorter period (2).

The model is now re-estimated using a different foreign firm definition so that only firms controlled directly by a foreign investor are classified as foreign as done in some studies, for instance in Javorcik and Spatareanu (2008). As shown in Table 1, this definition implies that a significant proportion of output produced by firms under ultimate foreign control is classified as Danish even though firms indirectly controlled by a foreign investor will be subject to the same demands and will benefit from access to similar foreign technology, advice, management techniques, etc. as firms under direct foreign control.

The estimation of the model solely based on direct foreign control leads to a more positive picture than is actually the case since the negative horizontal spillovers are now less significant and, more importantly, forward spillovers are significantly positive (3). Foreign firms often produce advanced products, and increased foreign firm presence eases the access to such

[20]Since level estimations should always be interpreted with care, one cannot with certainty conclude whether foreign firms choose to enter the most productive Danish industries because of their high productivity or because of other characteristics such as excess profitability or market access that may be positively correlated with productivity.

Table 3: Estimations based on different foreign firm definitions

Regressor	**(1) Baseline**	**(2) Ultimate investor**	**(3) Direct investor**
ΔHZ	−1.351***	-	-
	0.302		
ΔBW	−3.516***	-	-
	0.561		
ΔFW	−2.283	-	-
	1.612		
$\Delta COMP$	−0.623***	−1.010***	−1.458***
	0.209	*0.272*	*0.281*
ΔHZ_uci	-	−1.328***	-
		0.414	
ΔBW_uci	-	−3.100***	-
		0.652	
ΔFW_uci	-	−0.644	-
		1.739	
ΔHZ_dir	-	-	−0.696**
			0.348
ΔBW_dir	-	-	−3.751***
			0.816
ΔFW_dir	-	-	2.880**
			1.426
No. of obs.	225,732	137,648	139,255
Adjusted R^2	0.018	0.013	0.011

Note: The table displays the results of estimating Equation 6 with the following foreign firm definitions and data. (1): Foreign firms defined as firms with a non-resident ultimate controlling investor; data for the period 2002-07. (2): Foreign firms defined as firms with a non-resident ultimate controlling investor; data for the period 2004-07. (3): Foreign firms defined as firms with a non-resident direct controlling investor; data for the period 2004-07. Standard errors clustered by industry-year are reported in italics. *, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively.

products for firms operating in the domestic economy. If firms under indirect foreign control are capable of taking full advantage of the advanced products in their production processes by exploiting superior technology or advice received from their foreign ultimate investor, it may explain the positive forward spillovers since the firms under indirect foreign control are

classified as domestic firms in this specification. The lesson is that other studies that only consider direct foreign control may get biased results, particularly in countries where the use of holding companies is common.

6.3 Domestic Firm Characteristics

While the empirical analysis so far has considered productivity spillovers at the aggregate level, focus will now turn to the results at a more detailed level. Table 4 includes industry-specific results and reveals that productivity spillovers vary widely across industries. At first glance, it may seem surprising that insignificant productivity spillovers is the most common outcome when the aggregate results display negative spillovers. Nevertheless, one has to consider that there is a large variation in the number of domestic firms in each industry, and a number of the largest domestic industries display negative spillovers, thus explaining the negative results at the aggregate level. Even though the aggregate analysis displays strong evidence for negative productivity spillovers, there are a number of cases at the industry level where increased foreign firm presence has a positive effect on domestic firms' productivity.

Table 4: Parameter significance in industry-level estimations of productivity spillovers

Industry	**ΔHZ**	**ΔBW**	**ΔFW**	**No. of obs.**
Extr. of crude petroleum, natural gas etc.	.	.	.	44
Extr. of gravel, clay, stone and salt etc.	.	.	.	420
Processing etc. of fish and fish products	−	0	−	428
Processing etc. of fruit and vegetables	+	+	+	136
Mfr. of vegetable and animal oils and fats	.	.	.	25
Mfr. of starch, chocolate and sugar products	+	0	0	603
Mfr. of bread, cakes and biscuits	.	.	.	200
Mfr. of beverages	.	.	.	153
Mfr. of textiles and textile products	−	−	0	1,424
Mfr. of pulp, paper and paper products	−	0	0	535
Publishing of newspapers	.	.	.	120
Publishing activities, excluding newspapers	−	0	0	2,001
Printing activities etc.	−	−	0	3,577
Mfr. of refined petroleum products etc.	.	.	.	7
Mfr. of industrial gases and inorganic basic chemicals	.	.	.	23
Mfr. of dyes, pigments and organic basic chemicals	.	.	.	52
Mfr. of plastics and syntethic rubber	.	.	.	73
Mfr. of paints, printing ink and mastics	0	0	0	152
Mfr. of pharmaceuticals etc.	+	−	−	142
Mfr. of detergents and other chemical products	+	+	−	413

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Industry	ΔHZ	ΔBW	ΔFW	No. of obs.
Mfr. of rubber products and plastic packing goods etc.	−	0	−	806
Mfr. of builders' ware of plastic	.	.	.	258
Manufacture of other plastic products n.e.c.	+	+	−	1,080
Mfr. of glass and ceramic goods etc.	−	−	0	429
Mfr. of cement, bricks, tiles, flags etc.	.	.	.	113
Mfr. of concrete, cement, asphalt and rockwool products	0	−	0	969
Mfr. of basic ferrous metals	.	.	.	48
First processing of iron and steel	−	+	−	107
Mfr. of basic non-ferrous metals	−	0	0	72
Mfr. of construct. materials of metal etc.	−	0	+	7,581
Mfr. of hand tools, metal packaging etc.	−	+	+	2,804
Mfr. af marine engines, compressors etc.	−	−	+	837
Mfr. of other general purpose machinery	+	0	0	1,946
Mfr. of agricultural and forestry machinery	0	0	−	1,103
Mfr. of machinery for industries etc.	0	−	0	2,636
Mfr. of domestic appliances n.e.c.	0	+	0	169
Mfr. of office machinery and computers	−	+	0	174
Mfr. of other electrical machinery and apparatus	−	0	+	2,222
Mfr. of radio and communicat. equipm. etc.	0	−	0	543
Mfr. of medical and optical instrum. etc.	0	0	−	1,460
Manufacture of motor vehicles etc.	0	−	+	473
Mfr. of transport equipment excl. ships, motor vehicles etc.	−	+	+	231
Mfr. of furniture	−	0	0	2,458
Sale of motor vehicles, motorcycles etc.	−	−	0	8,311
Repair and maintenance of motor vehicles	0	−	+	11,361
Ws. and commis. trade, exc. of m. vehicles	−	−	−	40,683
Retail trade of food etc.	.	.	.	13,870
Re. sale of clothing, footwear etc.	−	−	−	11,010
Other retail sale, repair work	0	0	−	28,126
Hotels etc.	0	+	−	3,925
Restaurants etc.	0	0	−	22,597
Other scheduled passenger land transport	+	−	+	226
Air transport	0	−	0	97
Cargo handling, harbors etc.; travel agencies	−	−	0	1,701
Activities of other transport agencies	−	0	+	2,365
Post and telecommunications	0	+	−	1,028
Renting of machinery and equipment etc.	−	−	0	2,423
Computer activities exc. software consultancy and supply	0	0	−	2,275
Software consultancy and supply	+	0	0	8,013
Consulting engineers, architects etc.	0	−	−	9,237

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Industry	**ΔHZ**	**ΔBW**	**ΔFW**	**No. of obs.**
Advertising	0	+	−	4,126
Other business activities	−	−	+	15,311
Total	**62**	**62**	**62**	**225,732**
+	*15*	*13*	*13*	
0	*23*	*28*	*30*	
−	*24*	*21*	*19*	

Note: The table displays parameter significance at a 10 percent level when the model specification given in Equation 6 is applied for each of the 62 industries. +, 0, and − indicate positive, insignificant, and negative parameter estimates, respectively. For confidentiality reasons, certain results cannot be displayed at the industry level (indicated by .), but they are included in the totals/aggregates.

The next step in the analysis is to investigate the effect that certain domestic firm characteristics have on their ability to benefit from foreign firm presence, see Table 5.

Productivity — The empirical analysis based on Danish data reveals that both the group of the most and least productive domestic firms experience negative horizontal and backward spillovers and insignificant forward spillovers (1).[21] According to Hypothesis 1, the productivity of domestic firms can have positive as well as negative effects on productivity spillovers, and the empirical results indicate that the opposing effects neutralize each other.

Just as there are two contradicting strands in the theoretical discussion on the role of domestic firm productivity with regard to productivity spillovers, the empirical evidence is mixed. Based on Romanian data, Javorcik and Spatareanu (2008) find that horizontal spillovers are insignificant for industry leaders, but negative for other domestic firms. Conversely, Griffith, Simpson and Redding (2002) show that UK firms with a large technological gap have a tendency to catch up faster than UK firms with a small technological gap.

Export orientation — Another outcome of the empirical analysis is that domestic firms with both high and low export orientation experience negative horizontal and backward spillovers, but only domestic firms with low export orientation experience negative forward spillovers (2).[22] This finding may be explained by the fact that export-oriented firms are better at taking advantage of the products supplied by foreign firms operating in Denmark

[21] Only the sign and significance of the parameter estimates are considered when comparing two groups in this paper; the size of the parameter estimate is not taken into consideration.

[22] The 80th percentile rather than the median is used to make the export orientation split since the majority of domestic firms do not export.

because the export-oriented firms are used to competitive pressure and finding ways to improve efficiency. Hypothesis 2 states that domestic firms' export orientation can have both positive and negative effects on productivity spillovers, and the empirical results show that the positive effect dominates the negative effect.

Barrios and Strobl (2002) and Schoors and Tol (2002) estimate productivity spillovers on Spanish and Hungarian data, respectively, and also find that export-oriented domestic firms gain more from foreign firm presence than non-export-oriented domestic firms.

Size — According to Hypothesis 3, size is believed to play a role with regard to productivity spillovers as large firms have the necessary scale to imitate advanced production technology introduced by foreign firms. The empirical analysis, however, shows that both large and small firms, in terms of number of employees, experience negative horizontal and backward spillovers and insignificant forward spillovers (3). A possible explanation for the lack of differences between large and small firms could be that even though small firms have less production scale, they are quicker at adjusting to the new situation that occurs when foreign firms increase their presence in the market. A turnaround often takes longer in larger firms.

In comparison, based on Romanian data, Merlevede and Schoors (2006) find that backward spillovers are generally positive for large firms, but often negative for small firms.

Competition — Lastly, the importance of competition is examined. The estimations show that while horizontal and backward spillovers are negative for domestic firms in both the most and least competitive industries, forward spillovers are only negative in the least competitive industries (4). These results are in line with Hypothesis 4, suggesting that there is a positive relationship between competition and foreign firm presence gains, and are similar to the ones based on domestic firms' export orientation. This similarity may be explained by the fact that both export-oriented firms and firms operating in competitive industries are used to high competition and are able to adapt to a new situation in a better way than other firms.

Smeets (2008) points out that empirical studies do not appear to have studied the effect of the host-industry competition level with regard to productivity spillovers. Nevertheless, Javorcik and Spatareanu (2008) do consider the relationship between concentration, which can be seen as a competition proxy, and productivity spillovers in the case of Romania. Contrary to the Danish case and the theoretical literature, they find that domestic firms in the most concentrated industries benefit more from foreign presence than firms in less concentrated industries.

Table 5: Domestic firm characteristics

Regressor	**(1) Productivity**		**(2) Export orientation**		**(3) Size**		**(4) Competition**	
	High	Low	High	Low	Large	Small	High	Low
ΔHZ	−1.011***	−1.614***	−1.469***	−1.346***	−1.603***	−1.036***	−2.007***	−0.678**
	0.301	*0.411*	*0.456*	*0.339*	*0.338*	*0.383*	*0.444*	*0.325*
ΔBW	−3.982***	−3.031***	−6.342***	−2.635***	−4.719***	−2.192**	−2.573***	−5.490***
	0.623	*0.859*	*0.996*	*0.613*	*0.646*	*0.863*	*0.581*	*1.076*
ΔFW	−2.650	−2.019	2.215	−3.653**	−2.941	−2.115	0.212	−5.228***
	1.966	*1.965*	*2.384*	*1.745*	*1.832*	*1.840*	*1.911*	*1.971*
$\Delta COMP$	−0.796***	−0.509***	−0.886**	−0.549***	−0.679***	−0.593***	−0.365*	−0.753**
	0.279	*0.205*	*0.349*	*0.197*	*0.310*	*0.193*	*0.185*	*0.327*
No. of obs.	112,739	112,993	39,170	186,562	110,455	115,277	150,894	74,838
Adjusted R^2	0.036	0.017	0.038	0.016	0.035	0.013	0.022	0.016

Note: The table displays the results of estimating Equation 6 in the baseline case for different groups of domestic firms. Standard errors clustered by industry-year in italics. *, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively. (1): Domestic firms with total factor productivity exceeding the median within a given industry are classified as high; the rest are classified as low. (2): Domestic firms with an export share of output exceeding the 80th percentile within a given industry are classified as high; the rest are classified as low. (3): Domestic firms with number of employees (full time equivalents) exceeding the median within a given industry are classified as large; the rest are classified as small. (4): Domestic firms in the top 50 percent of the 62 industries with regard to the Danish competition index excluding the productivity measure (reverse ordering as low competition index indicates high competition) are classified as high; the rest are classified as low.

6.4 FDI Characteristics

The final part of the empirical analysis deals with the characteristics of the foreign firms and investigates whether certain types of foreign firms generate different productivity spillovers than other types of firms, see Table 6. Such information would be valuable to policy makers when deciding what kind of FDI they should attempt to attract.

Productivity — As mentioned, the productivity of foreign firms can be seen as the other side to the story of the technological gap. The estimations show that the negative productivity spillovers stem from the presence of the least productive foreign firms (1). The most productive foreign firms display neutral horizontal and forward spillovers and positive backward spillovers. The positive backward spillovers may be explained by the most productive foreign firms' ability to train domestic suppliers, which may be a factor leading to their own success and, more importantly in this connection, leads to increased productivity of domestic suppliers. It is conceivable that the least productive foreign firms provide a limited imitation potential, which means that negative competition effect will dominate the picture. The most productive foreign firms will also win market shares from domestic firms, but the catching-up potential that they present to domestic firms offsets the negative effects. According to Hypothesis 5, the productivity of foreign firms can have opposing effects, but the empirical results show that domestic firms benefit more from the presence of the most productive foreign firms than they do from the presence of the least productive foreign firms.

Export orientation — Only the measures constructed on the basis of the most export-oriented firms are significantly negative (2). The reason may be that these firms are less in contact with domestic firms, limiting the potential for positive spillovers to take place. Even though these firms are export-oriented, they still crowd out domestic firms to some extent, which can explain the negative spillovers. Hypothesis 6 identifies both positive and negative effects from export orientation of foreign firms on productivity spillovers to domestic firms, and the empirical results demonstrate that the negative effect is the strongest. Put differently, domestic firms benefit more from the presence of the least export-oriented foreign firms than from the presence of the most export-oriented foreign firms.

Other empirical studies do not appear to have focused on the foreign trade orientation of the FDI entering a country, making a comparison to other studies impossible.

Table 6: FDI characteristics

Regressor	(1) Productivity	(2) Export orientation	(3) Import orientation	(4) Country similarities
ΔHZ_high	−0.542	−1.518***	−0.896**	−0.123
	0.401	*0.477*	*0.399*	*0.334*
ΔBW_high	3.070**	−5.439**	−6.823***	−0.998
	1.380	*2.439*	*1.990*	*2.762*
ΔFW_high	−3.465	1.481	−5.141	−1.468
	2.420	*2.227*	*3.791*	*1.968*
ΔHZ_low	−2.177***	−0.350	−1.463***	−1.605***
	0.623	*0.382*	*0.351*	*0.363*
ΔBW_low	−17.400***	−0.795	1.187	−4.257***
	3.096	*3.538*	*2.708*	*1.623*
ΔFW_low	0.621	−4.759	4.522	0.401
	6.439	*3.579*	*4.536*	*1.853*
$\Delta COMP$	−0.486***	−0.615***	−0.567***	−0.640***
	0.188	*0.215*	*0.197*	*0.211*
No. of obs.	225,732	225,732	225,732	225,732
Adjusted R^2	0.020	0.019	0.020	0.019

Note: The table displays the results of estimating Equation 6 with each of the three spillover measures broken into in two categories, depending on foreign firm characteristics within each industry. Standard errors clustered by industry-year in italics. *, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively. (1)-(3): Spillover measures with the extension _high (_low) are constructed on basis of foreign firms with total factor productivity/export share/import share equal to or above (strictly below) the median among foreign firms in a given industry. (4): Spillover measures with the extension _high (_low) are constructed on basis of foreign firms ultimately controlled by an investor from Norway or Sweden (a country outside Scandinavia).

Import orientation — With regard to import orientation, both the presence of foreign firms with high and low import orientation are associated with negative horizontal productivity spillovers, but only the presence of foreign firms with high import orientation leads to negative backward spillovers (3). The negative backward spillovers can be explained by the fact that the high import shares in the most import-oriented foreign firms lead to lower demand in the supplying industries and thus have a negative impact on the supplying firms' productivity as they will move up their cost curve. In other words, the results support Hypothesis 7 saying that domestic firms benefit more from the presence of the least than the most import-oriented foreign firms.

Investor country — Finally, the estimations show that only increased foreign presence of firms ultimately controlled by investors outside Scandinavia have a negative impact on the productivity of domestic firms whereas increased presence of firms under Norwegian or Swedish control do not affect domestic firms' productivity on a net basis (4). This result supports Hypothesis 8, stating that domestic firms benefit more from the presence of Scandinavian than other MNEs, and may be explained by the fact that the cultural and linguistic barriers within Scandinavia are relatively small, thus paving the way for positive spillovers to neutralize the negative effects. For instance, Danish firms may find it easier to imitate and adopt management techniques from Scandinavian MNEs than from MNEs with a different origin as the Scandinavian countries share a tradition for less hierarchical organizational structures than many other countries.

Other studies have also examined the nationality of the investor. For instance, Abraham, Konings and Slootmaekers (2007) find that FDI from Hong Kong, Macau, and Taiwan has a more positive effect on domestic firm productivity in China than FDI originating from other countries. Even though they hypothesize that this finding could be linked to the technological gap, smaller cultural and linguistic barriers may also play a role.

7 Conclusion

A unique contribution of this paper has been to investigate the effect of applying different foreign firm definitions. While the definition of foreign firms may, on the surface, seem like a minor technical detail, the widespread use of holding companies in many countries has made the topic an important one. It is often difficult to obtain access to official firm-level data due to confidentiality constraints, and data from commercial providers are sometimes used instead. However, such data rarely contain high-quality information on full group structures, which explains why some researchers only consider direct foreign control when

Table 7: Summary of hypotheses and empirical findings

Hypothesis		**Empirical finding**
Domestic firm characteristics:		
1:	The productivity of domestic firms has an impact on productivity spillovers from FDI; the net impact can be positive, neutral, or negative	Neutral impact
2:	The export orientation of domestic firms has an impact on productivity spillovers from FDI; the net impact can be positive, neutral, or negative	Positive impact
3:	The size of domestic firms has a positive impact on productivity spillovers from FDI	Neutral impact
4:	The competition level of the domestic industry has a positive impact on productivity spillovers from FDI	Positive impact
FDI characteristics:		
5:	The productivity of foreign firms has an impact on productivity spillovers from FDI; the net impact can be positive, neutral, or negative	Positive impact
6:	The export orientation of foreign firms has an impact on productivity spillovers from FDI; the net impact can be positive, neutral, or negative	Negative impact
7:	The import orientation of foreign firms has a negative impact on productivity spillovers from FDI	Negative impact
8:	FDI from Norway and Sweden has a positive impact on productivity spillovers compared to FDI from other countries	Positive impact

Note: The aggregate results display significant evidence of negative short-term productivity spillovers, see Table 2. Table 7 illustrates the *impact* of domestic firm characteristics and FDI characteristics on productivity spillovers and not the *sign* of the productivity spillovers. For example, when Hypothesis 4, stating that the competition level of the domestic industry has a positive impact on productivity spillovers from FDI, is confirmed, it does not necessarily imply that productivity spillovers are positive in the most competitive industries. As can be seen from Table 5, it only implies that there are less negative productivity spillovers in the most competitive industries than in the least competitive industries.

defining foreign firms. In case of holding company structures, this practice misses many firms ultimately under foreign control, and the estimations in this paper reveal that it may severely bias the results, making it impossible to neglect the issue.

The theoretical literature on productivity spillovers from FDI identifies positive as well as negative effects, and empirical studies from a number of countries show that the sign of the net effect differs across countries. This paper exploits the rich detail level offered by official Danish firm-level panel data, making it possible to test the importance of various domestic firm characteristics and FDI characteristics with regard to productivity spillovers. The analysis shows that aggregate productivity spillovers effects are negative, but the results

differ widely across industries. It also finds that domestic firms with high export orientation and domestic firms operating in the most competitive industries experience less negative spillovers than other domestic firms. With regard to FDI characteristics, the estimations reveal that the negative effects largely stem from an increased presence of foreign firms (i) with low productivity, (ii) with high foreign trade orientation, and (iii) ultimately controlled by investors outside Scandinavia. The hypotheses and the empirical findings with regard to domestic firm characteristics and FDI characteristics are summarized in Table 7.

Based on the results found in this paper, it is tempting to ask the following question: Why do Denmark and other countries spend resources on attracting FDI when empirical studies often find that FDI has a negative impact on the productivity of domestic firms? The answer to the question is that FDI is also associated with many other effects, which have not been examined here. For instance, in the case of greenfield investment, FDI may have a positive impact on both job creation and the total tax base. Moreover, only short-term productivity spillovers have been analyzed in this paper, and despite the negative short-term effects, an increased presence of foreign firms may stimulate the competitiveness of the entire economy in the medium to long run.

Nevertheless, it seems sensible to spend more resources on analyzing in further detail the whole range of effects that FDI has on the economy. This paper has contributed with an analysis of the short-term productivity effects, but it would be useful to investigate job and tax effects as well as longer-term productivity effects. As demonstrated above, such analyses can be used to identify the types of FDI that have the most positive influence on the economy. This kind of information would be extremely valuable to policymakers when defining a strategy regarding which types of FDI a country should attempt to target.

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