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Publication date
2011

Document Version
Submitted manuscript

CPB Netherlands Bureau for Economic Policy Analysis

CPB Discussion Paper | 168

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CPB Discussion Paper

No 168

February 2011

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ISBN 978-90-5833-495-4

Abstract in English

We study the extent to which a country's strength of Intellectual Property Rights (IPR) protection mediates knowledge spillovers from Foreign Direct Investment (FDI). Following the opposing views in the IPR debate, we propose a negative effect of IPR strength on *unintentional* horizontal (intra-industry) knowledge diffusion, and a positive effect on *intentional* vertical (inter-industry) knowledge diffusion. Using a unique firm-level dataset of large, publicly traded firms in 22 (mostly) developed countries, we find partial support for these expectations. Strong IPR indeed reduces horizontal knowledge diffusion, while it stimulates backward (to suppliers) knowledge diffusion. Somewhat unexpectedly however, we also find that forward (to customers) knowledge diffusion decreases with IPR strength. In general, and in line with earlier literature, the results regarding backward knowledge diffusion are most robust to changes in model specification. Our results contribute to the debate regarding the desirability of strengthening national IPR systems, and suggest that local firms might indeed benefit from this through their (backward) linkages with multinationals. Additionally, our results suggest that the moderating effect of IPR strength might partly explain the inconclusive results in the FDI knowledge diffusion literature.

Key words: Intellectual property rights, knowledge diffusion, multinationals, FDI
JEL codes: F23, O33, O34

Abstract in Dutch

In deze studie onderzoeken we het effect van nationale bescherming van intellectueel eigendom (IE) op kennisdiffusie van multinationals. We verwachten dat een toename van IE bescherming enerzijds tot minder horizontale kennisdiffusie naar concurrenten leidt, omdat deze vorm van diffusie vaak *onbedoeld* (d.w.z. een externaliteit) is. Anderzijds zal verticale kennisdiffusie naar leveranciers en afnemers toenemen, omdat het risico op oneigenlijk gebruik na deze *doelbewuste* kennistransfer daalt. Onze analyse van 2500 grote bedrijven in 22 (ontwikkelde) landen gedurende de periode 2000-2005 is deels conform deze verwachtingen. Kennisdiffusie naar concurrenten neemt af, en kennisdiffusie naar leveranciers neemt toe wanneer IE bescherming stijgt. Kennisdiffusie naar afnemers neemt echter ook onverwacht toe in dit geval. De resultaten met betrekking tot kennisdiffusie richting leveranciers zijn het meest robuust. Onze resultaten suggereren dat een toename van IE bescherming in het voordeel van lokale bedrijven is wanneer deze stevige toeleveringsrelaties hebben met multinationals. Verder bieden onze resultaten een gedeeltelijke verklaring voor het gebrek aan eenduidige resultaten in de literatuur rondom kennisdiffusie van multinationals.

Knowledge diffusion from FDI and Intellectual Property Rights

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Abstract

We study the extent to which a country's strength of Intellectual Property Rights (IPR) protection mediates knowledge spillovers from Foreign Direct Investment (FDI). Following the opposing views in the IPR debate, we propose a negative effect of IPR strength on *unintentional* horizontal (intra-industry) knowledge diffusion, and a positive effect on *intentional* vertical (inter-industry) knowledge diffusion. Using a unique firm-level dataset of large, publicly traded firms in 22 (mostly) developed countries, we find partial support for these expectations. Strong IPR indeed reduces horizontal knowledge diffusion, while it stimulates backward (to suppliers) knowledge diffusion. Somewhat unexpectedly however, we also find that forward (to customers) knowledge diffusion decreases with IPR strength. In general, and in line with earlier literature, the results regarding backward knowledge diffusion are most robust to changes in model specification. Our results contribute to the debate regarding the desirability of strengthening national IPR systems, and suggest that local firms might indeed benefit from this through their (backward) linkages with multinationals. Additionally, our results suggest that the moderating effect of IPR strength might partly explain the inconclusive results in the FDI knowledge diffusion literature.

Keywords: Intellectual Property Rights, knowledge diffusion, multinationals, FDI

1 Introduction

Over the past couple of decades, many countries have witnessed important developments towards a stronger system of Intellectual Property Rights (IPR) protection (Maskus, 2000; Branstetter et al., 2006). Nonetheless, there has been considerable debate regarding the desirability of a

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strong IPR system. On the one hand, proponents argue that it will induce innovation worldwide, and enhance cross-country technology transfer. On the other hand, it has been argued that increased IPR will shift the rents of innovation towards multinationals (MNEs) as they are better able to appropriate technological developments, at the expense of small (national) firms. Stated differently, strong IPR reduces static efficiency by increasing the marginal costs of knowledge diffusion, but supports dynamic efficiency by stimulating innovation (Maskus, 2000).

Empirical research has so far remained relatively silent on the matter.[1] Two important recent exceptions are Branstetter et al. (2006) and Branstetter et al. (2010). Branstetter et al. (2006) investigate how US MNEs respond to increased IPR strength by means of parent-affiliate international technology transfer. They offer convincing evidence that such transfers increase significantly following IPR reform. Branstetter et al. (2010) additionally show that industry-level value added increases after IPR reform, which they take as evidence that reduced imitative local activity is more than offset by increased MNE activity and activity of non-imititating local firms. However, these two studies do not address the effects on local *firms* due to potential changes in MNE knowledge diffusion.

Our aim in this study is to assess the mediating impact of national IPR strength on MNE knowledge diffusion to local firms. To this end, we employ a unique firm-level dataset spanning 22 (mostly) developed countries during the period 2000-2005. In our empirical setup, we exploit the conceptual difference between horizontal (intra-industry) *versus* vertical (inter-industry) knowledge diffusion. In particular, we argue that horizontal knowledge diffusion is dominated by unintentional spillovers, which IPR systems aim to reduce. By contrast, vertical knowledge diffusion is dominated by intentional transfers, which are encouraged under strong IPR. We are thus able to assess the relative importance of the two opposing effects of increased IPR strength on FDI knowledge diffusion.

The empirical results partly corroborate our expectations. Whithout accounting for the impact of IPR strength, we find no robust knowledge diffusion effect from MNEs in any direction. Yet when allowing for knowledge diffusion to vary with IPR strength, we find robust evidence that backward knowledge diffusion (transfer towards suppliers) increases with stronger IPR. Somewhat unexpectedly, forward knowledge diffusion (transfer towards customers) decreases

[1] There is a rather large literature on the impact of IPR strength on the amount and composition of trade and FDI countries receive (e.g Maskus and Penubarti, 1995; Lee and Mansfield, 1996; Smith, 2001; Javorcik, 2004*a*). However, the consequences for technology transfer or innovation in general remain unclear from these studies.

with IPR strength. Finally, and in line with expectations, horizontal knowledge spillovers are also affected negatively by stronger IPR. The results regarding backward diffusion are most robust to changes in model specifications.

The local benefits following Foreign Direct Investments (FDI) by MNEs has been the domain of a large literature studying knowledge spillovers from FDI (Javorcik, 2004*b*). These studies have become notorious for their widely divergent findings (cf. Görg and Strobl, 2001; Görg and Greenaway, 2004; Smeets, 2008). It has been argued that this is because many empirical estimates simultaneously incorporate positive knowledge diffusion effects, as well as negative consequences of inward FDI activity due to e.g. competitive pressures (Aitken and Harrison, 1999). Conditioning the impact of MNE activity in a way which induces positive effects to dominate negative effects (or vice versa) may partly help to solve the ambiguity (Castellani and Zanfei, 2006). National IPR strength is such a conditioning mechanism. Yet so far, none of the studies in this field has considered the impact of national IPR strength on the extent of knowledge spillovers from FDI, presumably because of lack of cross-country firm-level data (Javorcik, 2008).

By focusing on the impact of IPR strength, our study thus also adds to the literature on knowledge spillovers from FDI in general. Moreover, our study shows that IPR systems achieve what they are supposed to achieve, which is to correct a market faillure by decreasing knowledge externalities. However, we also find that MNEs more easily share their knowledge and technology with their local suppliers under strong IPR, thus enhancing the local host-country knowledge base. A simple back-of-the-envelope evaluation suggests that the positive effects on backward knowledge diffusion tend to outweigh the negative effects through decreased horizontal and forward knowledge diffusion, although this conclusion depends somewhat on how conservatively one wishes to interpret the estimation results.

The rest of this paper is structured as follows. Section 2 formulates the theoretical expectations regarding the impact of IPR on MNE knowledge diffusion. It characterizes the nature of the different diffusion effects and relates these to IPR strength. Section 3 describes the data and the methodology. Section 4 presents the empirical results and robustness checks. Finally, Section 5 concludes.

2 FDI knowledge diffusion: spillovers and transfers

Many studies have documented significant productivity advantages of MNEs and their foreign affiliates over national (host-country) firms (Blomström and Sjöholm, 1999; Markusen, 2002). The recent heterogeneous firms literature has attributed this productivity advantage to the high fixed costs of foreign investment, leading only the most productive firms to engage in FDI (Helpman et al., 2004). Accordingly, there is a lot of potential for knowledge or technology to diffuse from MNE affiliates to relatively backward local firms. As such, MNEs play an important role in international cross-country technology diffusion.

The literature on knowledge diffusion from FDI has generally distinguished three channels along which knowledge or technology can diffuse between MNE affiliates and host-country firms (cf. Görg and Greenaway, 2004; Javorcik, 2004*b*): First, MNE products and practices may be copied or imitated by local firms, which is the so-called *demonstration effect*. Second, MNEs might assist their suppliers and customers in various aspects of e.g. quality control or product management. These effects thus work through *vertical linkages*. Third, workers employed by MNE affiliates may be (re)employed by local firms, so that knowledge diffuses through *labor turnover*. Although many studies have empirically scrutinized these effects empirically, surveys of this literature have repeatedly pointed out their widely divergent results (Blomström and Kokko, 1998; Görg and Strobl, 2001; Görg and Greenaway, 2004; Smeets, 2008).

One of the reasons for this ambiguity may be due to the methodology employed, which usually relates (changes in) local firms' Total Factor Productivity (TFP) to inward MNE activity. Even though knowledge diffusion can be expected to increase TFP, it has been pointed out that negative productivity effects might also arise simultaneously. For instance, Aitken and Harrison (1999) argue that local firms' productivity might decline due to an adverse competition effect generated by MNE activity. In particular, if firms incur fixed costs of production, MNEs may find it optimal to draw demand from their local competitors and force them back up their average cost curve. If the production contraction is large enough, this could outweigh any positive productivity effects. Adverse productivity effects could also arise for local suppliers and customers of MNEs (Javorcik, 2008). If the MNE acts a monopsonist towards its local suppliers, their (revenue based) TFP could be adversely affected due to the downward pressure on their price margins. Similarly, MNEs might act as monopolists towards their local customers by forcing them to pay higher prices relative to the local suppliers that they displace.

In sum, measured productivity responses of local firms due to MNE activity can go either way, and generally empirical estimates will incorporate both the positive and negative effects. Yet if we can establish conditions under which the positive effects dominate the negative effects (or vice versa), we might be able to partly solve this ambiguity (Castellani and Zanfei, 2006). Because national IPR sytems influence the knowledge diffusion impact of MNEs while leaving its competition effects (relatively) unaffected, the strength of national IPR systems provides such a conditional mechanism. As we will argue, however, the way the impact is conditional on IPR strength crucially depends on the distinction between horizontal and vertical FDI knowledge diffusion due to the different nature of the knowledge diffusion implied.

Knowledge diffusion in general may be thought of to occur both intentionally as well as unintentionally. In the latter case, it constitutes an externality and therefore a market failure, and it is usually termed a knowledge spillover. Intentional knowledge diffusion is usually coined a knowledge transfer, comprising the intra-firm diffusion of knowledge studied in Branstetter et al. (2006) or the deliberate transfer of knowledge to local firms in order to ascertain quality in the supply chain (Javorcik, 2008). A well designed IPR system corrects the market faillure that occurs due to knowledge spillovers by providing innovators with sufficient means to appropriate their ideas and inventions. By reducing the possibility for knowledge spillovers, this should induce them to increase the resources invested in innovation, as their private optimal investment shifts closer towards the social optimum. However, it is also expected to increase knowledge transfer exactly because it reduces the risk of ex-post expropriation, as demonstrated in Branstetter et al. (2006) for intra-MNE technology transfer. Consequently, a trade-off arises from increasing national IPR strength: On the one hand, knowledge diffusion diminishes through decreased spillovers. On the other hand, knowledge diffusion surges through increased transfers.

We argue that these two different types of knowledge diffusion are naturally related to the direction of knowledge diffusion from FDI. First consider horizontal knowledge diffusion. Conceptually, this constitutes knowledge diffusion towards local competitor firms within the industry (Saggi, 2002), occuring mainly through labor turnover and demonstration effects (Mansfield and Romeo, 1980; Javorcik, 2008). MNE affiliates have nothing to gain by intentionally engaging in such knowledge diffusion, as it will erode the competitive edge they have over local host-country firms. Indeed, as noted by Blomström and Kokko (1998), "[...] pure demonstration effects often take place unconsciously [...]" (p.15). This type of knowledge diffusion thus constitutes a true externality, and hence is dominated by knowledge spillovers.

Vertical knowledge diffusion on the other hand occurs between MNEs and their local suppliers and customers, i.e. through vertical linkages. Conceptually, this is a very different kind of diffusion, as it is mainly intentional. The reason is that MNEs have much to gain from increased input and (final) output quality, as it further establishes and strengthens their competitive position in local markets. Recent survey evidence documented by Javorcik (2008), designed to investigate the implications of foreign entry for domestic Czech and Latvian firms, corroborates this view. For instance, fourty percent of Czech supplying firms report having received some kind of MNE assistance, such as personnel training, leasing of machinery, or assistance with technology (cf. Figure 5, p.151 in Javorcik, 2008).[2] Hence, (inter-firm) knowledge transfer plays a key role in vertical knowledge diffusion from FDI.

The different nature of horizontal *versus* vertical MNE knowledge diffusion leads to two opposing expecations.[3] First, increased IPR strength should reduce the amount of knowledge spillovers. Hence, given adverse horizontal competition effects, we expect that positive knowledge diffusion effects dominate in low IPR countries (and vice versa in high IPR countries). Second, increased IPR reduces the risks of knowledge transfer by strengthening the means to appropriate knowledge and technology by MNEs. Consequently, we expect vertical knowledge diffusion to rise with increased IPR strength (in the same spirit as the increased intra-MNE technology transfer documented in Branstetter et al. (2006)), so that they dominate adverse vertical competition effects in high IPR countries (and vice versa in low IPR countries). These divergent expectations allow us to test the trade-off embodied in increasing national IPR strength. Additionally, they offer a potential explanation for the widely divergent findings in (single country)

[2]A substantially smaller amount of Czech MNE customers (6 percent) report having received assistance on how to use MNE inputs. Hence, vertical knowledge diffusion from MNEs appears to be more substantial upstream than downstream.

[3]Two comments are in order. First, by arguing that horizontal (vertical) knowledge diffusion will be dominated by knowledge spillovers (transfers), we do not deny that in practice both horizontal and vertical knowledge diffusion will be a mix of spillovers and transfers. However, given the different nature of the relationships between the MNE and the receiving local firms (competitors versus suppliers or customers), overall we would expect spillovers to drive horizontal knowledge diffusion and transfers to drive vertical knowledge diffusion. Second, we only focus on first-order effects here. That is, we do not consider knowledge spillovers among local upstream or downstream firms that might result after vertical FDI knowledge transfer. Nor do we consider knowledge transfers between local firms that might result after horizontal FDI knowledge spillovers. Given that these effects are indirect (i.e. of higher order), we do not expect these to dominate the outcomes.

studies on FDI knowledge diffusion.

3 Data and methodology

3.1 Data and variables

Our firm-level data are derived from Thomson's Worldscope database. Our access to this database provides us with a sample that contains a panel of about 2,500 non-financial local firms and 324 foreign-owned firms that are active in 22 countries and 16 manufacturing industries (at the 2-digit ISIC Rev. 3 level) during the period 2000-2005. Data on ownership was derived from the "Who owns whom" database, from which we could subtract data on ownership shares and identities for all the firms in our sample for the year 2004. We use this information in constructing the horizontal and vertical MNE presence variables below. Table 1 presents some descriptive statistic regarding the allocation of (foreign owned) firms accross the countries in our sample. In the Appendix we provide more details regarding the exact construction of the firm-level dataset.

<< INSERT TABLE 1 ABOUT HERE>>

Our main independent variables of interest concern the presence of MNEs, both within the local firms' own industries, as well as in upstream and downstream industries. Intra-industry MNE presence is measured as follows (cf. Javorcik, 2004*b*):

$$\text{Horizontal}_{jt} = \frac{\sum_{i=1}^{n_j}(\rho_i \times \text{Sales}_{it})}{\sum_{i=1}^{N_j} \text{Sales}_{it}} \tag{1}$$

where i, j and t index firms, industries and years respectively, n_j denotes the total number of foreign owned firms in industry j, and ρ_i denotes the share of foreign ownership in firm i.[4] N_j denotes the total number of firms in industry j. *Sales* denote firm-level sales.

In line with Javorcik (2004*b*) we use industry-level input and output shares (constructed from the OECD Input-Output tables) to compute vertical linkages.[5] Specifically, if α_{jk} denotes the output share of industry j flowing to industry k (with $j \neq k$), backward linkages (to supplying

[4] We omit country subscripts k but note that all MNE presence variables are computed per country.

[5] The most recent I-O tables available for the period of study are for 2002. We use these tables to compute (constant) input-output shares for the entire sample period.

industries) are computed as:

$$\text{Backward}_{jt} = \sum_{j \neq k} (\alpha_{jk} \times \text{Horizontal}_{kt}) \tag{2}$$

where *Horizontal* is defined as in (1). Similarly, letting σ_{jk} denote the share of inputs obtained by industry j from industry k, we construct forward linkages as:[6]

$$\text{Forward}_{jt} = \sum_{j \neq k} (\sigma_{jk} \times \text{Horizontal}_{kt}) \tag{3}$$

Table 2 presents the average degree of foreign ownership per industry, as well as its standard deviation. In industries such as "Motor vehicles" and "Food and beverages" the average foreign ownership share is relatively low, contrary to industries such as "Wood and wood products". It might be the case that there are unobserved industry-level characteristics which cause these average ownership shares to diverge accross industries. In the empirical specification we therefore include fixed effects (FE) to account for this possibility.

<< **INSERT TABLE 2 ABOUT HERE**>>

We follow the extant literature on knowledge diffusion from FDI and consider the effect of *Horizontal*, *Backward* and *Forward* on local firms' productivity (Görg and Strobl, 2001; Javorcik, 2004*b*; Blalock and Gertler, 2008). In order to do so, we first estimate industry-level production functions, explaining value added from capital and labor inputs (at the two-digit ISIC Rev. 3 level).[7] Next to an idiosyncratic component, the error term in this production function contains a measure of firm-level productivity. Because of this, the error term is correlated with factor inputs, as the (variable) input decisions are made partly in response to the productivity contained in the error term (Olley and Pakes, 1996; Levinsohn and Petrin, 2003). As is standard in the literature, we follow the procedure in Olley and Pakes (1996) to correct for this simultaneity bias. Table A.1 in the Appendix compares the coefficients for labor and capital stocks obtained in this way with those obtained through simple OLS. In the majority of

[6] Javorcik (2004*b*) nets out MNE exports when computing *Horizontal* in this case, since such exports are not destined for the local market. Due to lack of firm-level export data, we cannot follow this approach.

[7] Preferably, we would have estimated country-industry specific production functions, as the parameters in the production function are likely to vary both accross industries as well as countries. However, in many cases this yields too few observations to generate consistent parameter estimates.

cases the Olley-Pakes coefficients deviate in the expected way from the OLS coefficients.[8]

We further add two firm-level control variables: First, we incorporate a measure of firm size, which is the (log of) total assets of firms. The expected effect of this variable is positive, as many studies have demonstrated a positive correlation between firm size and productivity (e.g. Haltiwanger et al., 1999). Second, we also include the the share of firm sales in total industry-level sales, to capture the firm's competitive power. Again, we expect this variable to enter with a positive sign (e.g. Aitken and Harrison, 1999).

In order to measure the strength of the national IPR systems of the countries in our sample, we employ the widely-used Ginarte and Park-index of IPR strength (Ginarte and Park, 1997; Javorcik, 2004*a*). This IPR index is a composite of five different components, that capture (1) the extent of coverage, (2) whether or not a country participates in international patent agreements, (3) whether there are provisions for loss of protection, (4) the quality of enforcement mechanisms, and (5) the duration of protection.[9] Each individual component is rated on a scale from 0 (weak IPR protection) to 1 (strong IPR protection), so that the (unweighted) index varies between 0 and 5.[10] The most recent values relevant for our sample period are for 2000 and 2005.[11] In the main specifications below, we use the 2000 index, which corresponds to IPR strength at the start of our sample. This should mitigate concerns that IPR strength develops in response to MNE knowledge diffusion, for instance when MNEs that intensively transfer technology to their suppliers actively lobby for strengthening national IPR systems (cf. Ahlquist and Prakash, 2008). In the robustness analysis we also run our model with the 2005 IPR index. Table 1 presents the IPR index for each country in our sample. Because the countries in our sample are mainly developed countries whose IPR systems are already quite well developed, the variation on the index is relatively low. The minimum score is 2.9 for Hong Kong, versus a maximum of 5 for the United States.

In order to investigate if the theoretical expectations are also borne out by the raw data, we first inspect some simple correlations. Specifically, we divide our sample into high *versus* low IPR countries, where we use the median index (4.2) as the cutoff. We then plot industry-level

[8]Levinsohn and Petrin (2003) describe an alternative approach to Olley and Pakes (1996) which can be used when there are a lot of firms with zero investment. Given that we only look at large, publicly traded firms in our sample, this is not a problem in our case.

[9]A more elaborate discussion of these individual components and how they have been measured can be found in Ginarte and Park (1997).

[10]It should be noted that this measure tends to capture *de jure* IPR strength rather than *de facto* IPR strength.

[11]We thank professor Park for sharing the updated dataset with us.

correlations between the (log) TFP of local firms and the *Horizontal*, *Backward* and *Forward* shares as defined above. Figures 1-3 plot these correlations, distinguishing between high and low IPR countries.

<< INSERT FIGURES 1-3 ABOUT HERE>>

All figures show clearly diverging and opposite correlations between MNE sales shares and local TFP for high *versus* low IPR countries. A couple of features are noteworthy: First, the patterns correspond to the theoretical expectations formulated in Section 2. Specifically, Figure 1 shows a clear positive correlation between *Horizontal* and TFP only for low IPR countries. For *Backward* and *Forward*, by contrast, Figures 2 and 3 show that a positive correlation only exists for high IPR countries. This accords well with the theoretical prediction that better IPR facilitates the transfer of knowledge, but reduces knowledge spillovers. Second, *Horizontal* correlates negatively with TFP in high IPP countries, and *Backward* and *Forward* correlate negatively with TFP in low IPR countries. This corresponds to our contention that adverse competition effects generated by MNE presence will dominate any positive knowledge diffusion effects in high IPR countries (for *Horizontal*) or low IPR countries (for *Backward* and *Forward*). Finally, the correlations in Figure 3 are substantially less pronounced than in the other two figures. This corresponds to the general findings in the literature, mentioned in Section 2, that no or only small effects of forward linkages can be found(Javorcik, 2008; Kugler, 2006).

Despite the correspondence between these figures and our expectations, it is also clear that there is large variation along the predicted fits. We will have to turn to more formal econometric analysis to see if these patterns are robust to various controls for observed and unobserved heterogeneity. Before presenting the results, we first briefly discuss the empirical model.

3.2 Empirical strategy

As mentioned in the previous section, we follow the extant literature on FDI knowledge diffusion and investigate the impact of intra and inter-industry MNE presence on local firms' TFP. Our approach differs from previous studies in that we allow this impact to vary with the strength of national IPR systems. Our empirical model looks as follows:

$$\begin{aligned} TFP_{ijkt} =& \beta_0 + \beta_1 \text{Horizontal}_{jkt} + \beta_2 \text{Backward}_{jkt} + \beta_3 \text{Forward}_{jkt} + \beta_4 \text{Horizontal}_{jkt} IPR_k \\ & + \beta_5 \text{Backward}_{jkt} IPR_k + \beta_6 \text{Forward}_{jkt} IPR_k + \mathbf{X}_{it}\gamma + \varepsilon_{ijkt} \\ & \text{s.t. } \varepsilon_{ijkt} = \eta_i + \phi_j + \mu_k + \nu_t + \epsilon_{ijkt} \end{aligned} \tag{4}$$

where i, j, k and t index firm, industry, country and year respectively, and $\mathbf{X}$ is a vector with the two firm-level controls described in the previous section. The error term ε is a composite of unobserved firm, industry, country, and time specific heterogeneity, and an idiosyncratic component ϵ.

Following the discussion in Section 2 regarding horizontal FDI knowledge diffusion, we expect β_4 to be negative, because knowledge spillover effects decrease in high IPR countries and negative competition effects start to dominate. Accordingly, we expect β_1 to be positive because it mainly captures the positive horizontal knowledge spillovers effects in low IPR countries. In contrast, for backward and forward knowledge diffusion we expect the individual effects β_2 and β_3 to be negative, because weak IPR regimes generate little vertical knowledge diffusion, so that adverse vertical competition effects dominate. Accordingly, β_5 and β_6 should be positive, since increased IPR strength increases vertical knowledge diffusion.

In order to account for the unobserved heterogeneity, we run model (4) with firm fixed effects (FE). Since none of the firms in our sample switches industries or countries, this simultaneously takes care of all unobserved heterogeneity, except for ν_t.[12] In order to take care of this latter component, we also run the model including year FE. Additionally, we have to account for the multiple levels of observation in our model when computing standard errors (Moulton, 1990). The standard practice in the literature is to cluster standard errors at the industry level (Javorcik, 2004*b*; Javorcik and Spatareanu, 2008). However, since we also have multiple countries in our sample, we also have to address the possibility that firms operating in the same country might be simultaneously exposed to country-level shocks. Therefore, we cluster our standard errors at the country-industry level.[13]

Another well-known issue in the FDI knowledge diffusion literature is the potential endo-

[12]This also implies that including any time-invariant industry or country-level variables - such as the IPR index - individually in the model is not necessary, as these will be accounted for in the fixed effects.

[13]This yields a total of 338 clusters, which should be sufficient for computing robust standard errors (Moulton, 1990).

geneity of the MNE sales share variables. Specifically, if MNEs choose to invest mainly in the most productive industries or regions of a host-country, this could induce a reverse causality when estimating the model in (4). However, finding proper instruments for the MNE presence variables is notoriously difficult, especially in our setup with multiple countries and industries. We address this issue in two alternative ways. First, we also run the model including one-period lagged values of the MNE presence variables, to establish Granger causality (Granger, 1969). Second, instead of running a GLS FE model, we also experiment with running the model by means of the system GMM estimator by Blundell and Bond (1998). This approach simultaneously estimates two equations: The level equation in (4), as well as its first-differenced counterpart. It then uses lagged first-differences as instruments for the MNE variables in the level equation, and lagged levels as instruments for the MNE variables in the first-differenced equation. The key assumptions for these instruments to be valid is that the idiosyncratic component of the error term ϵ_{ijkt} is not serially correlated, and that the explanatory variables are not correlated with future realizations of the error term. We report results for formal tests of these assumptions below.[14]

4 Results

We first run the model in (4) without including the IPR interaction terms, in order to consider the unmoderated impact of MNE presence. Table 3 presents the results. Column 1 is the GLS FE model without year dummies. As can be seen, none of the MNE variables has a significant impact on TFP, except for $Forward$, which is negative. Column 2 adds the year dummies to control for unobserved time heterogeneity. In addition to $Forward$, now $Backward$ is also significant but with a positive sign. Column 3 uses lagged values of the MNE variables in order to partly address the endogeneity issue. None of the MNE knowledge diffusion effects are robust to this change in specification, as both the effects of $Backward$ and $Forward$ turn insignificant. Finally, column 4 runs the model in (4) using the system GMM estimator by Blundell and Bond (1998) to control for the endogeneity of the MNE variables. Again, none of the MNE effects are robust to this alternative estimation method. However, inspection of both

[14]When applying system GMM estimation, we employ STATA's XTABOND2 command by Roodman (2009). We follow the various suggestions in this paper when estimating the model.

the Sargan and Hansen test statistics for instrument validity indicates that the instruments are not exogenous. Taken together, these results mirror the ambiguity in the literature and underline the notion that the estimated coefficients incorporate both positive and negative productivity effects simultaneously.

<< INSERT TABLE 3 ABOUT HERE >>

The two firm-level control variables consistently show up with a positive and significant coefficient, indicating that both absolute firm size and relative (to the industry) firm size are conducive to a firm's TFP. The only exception is the impact of firm size (*assets*) in the GMM specification, which is negative and significant. Although this result is somewhat puzzling, we recall that this specification suffers from instrument endogeneity, which might bias the results. In terms of explanatory power, given the multiple levels of observation in our analysis the GLS models perform reasonably well, with R^2's between 8.2% and 14%.

We now add the interactions with national IPR strength to the model. Table 4 presents the results. The setup is the same as in Table 3. First consider the baseline specification in column 1. Results are very different from those in Table 3. Specifically, the results for $Horizontal$ and $Backward$ are in line with expectations: The individual effect of $Horizontal$ is positive whereas the interaction with IPR is negative, indicating that horizontal knowledge spillovers are positive in low IPR countries, but decrease with IPR strength. For $Backward$ this is exactly the opposite: Backward linkages are negative in low IPR countries, but positive knowledge transfers effects increase with IPR strength. These results corroborate the correlations shown in Figures 1 and 2. The effects of $Forward$, however, are not in line with expectations. Forward effects are positive in low IPR countries but decrease with IPR strength. As we discuss in the next section, this might be due to the fact that we only include manufacturing firms in our sample. Finally, as shown in the bottom of the table, the F-statistic that tests whether the additional explanatory power of this model over that in column 1 in Table 3 is statistically sufficient is significant at 1% (the critical value is 3.78).[15]

<< INSERT TABLE 4 ABOUT HERE >>

[15] The statistic is computed as $((R_2^2 - R_1^2)/(K_2 - K_1))/((1 - R_2^2)/(N - K_2 - 1))$ where R^2 is the R-squared, K is the number of estimated parameters, N is the number of observations, and subscripts 1 and 2 index the model excluding and including interactions respectively. The R^2 reported in Table 4 does not differ from that in Table 3 due to rounding at two decimals. The increased explanatory power, albeit small, is still statistically significant due to the relatively large number of observations in our model.

Column 2 adds year dummies to the model. Even though all coefficients decrease somewhat in absolute value, all effects remain robust to this change in specification. Column 3 uses one-year lagged values of the MNE variables. This leaves the signs of all coefficients intact, but $Horizontal$ and its interaction with IPR become insignificant. Finally, column 4 employs the system GMM estimator. The results mirror those in column 3, although the coefficient estimates decrease substantially in absolute value. As before, however, the Sargan and Hansen test statistics indicate that the instruments are not exogenous at regular significance levels. As in column 1, the F-statistics all indicate a significant increase in explanatory power over the models reported in Table 3.[16]

Table 5 presents the results of five different robustness analyses. All models include the 1-year lagged MNE variables, except when indicated otherwise. Column 1 reruns the model while excluding Hong Kong from the sample. The reason for doing so is that Hong Kong displays a strong gap in terms of IPR strength relative to the other countries in the sample, which might drive some of the results.[17] As can be seen, the results for $Backward$ and $Forward$ are robust to this exclusion. Moreover, $Horizontal$ and its interaction with IPR becomes significant again, with the expected signs.

<< INSERT TABLE 5 ABOUT HERE >>

Our sample exhibits a lot of observations with a zero value on either $Horizontal$, $Backward$, and $Forward$, as there are many country-industry pairs that do not have any (vertical) MNE activity. In order to ensure that these zero values do not drive our results, column 2 in Table 5 excludes them from the sample. The results for all MNE variables are robust to this sample reduction and remain significant. All coefficient estimates increase somewhat across the board.

The choice of a one-year lag might not be sufficient to account for the endogeneity of MNE activity, nor for knowledge diffusion to take full effect. Therefore, in column 3 we repeat the analyses while using two-year lags for the MNE variables.[18] The results for $Horizontal$ and $Vertical$ are robust and retain their expected signs. However, in this case $Forward$ and its

[16] We do not report a F-statistic for the system GMM model because this model does not yield a (meaningful) R^2.

[17] The 2000 IPR index for Hong Kong is 2.9, whereas Canada and Norway, who are next in line, exhibit an IPR index of 3.9. The standard deviation of the 2000 IPR index is 0.48 including Hong Kong, whereas it is 0.33 excluding Hong Kong.

[18] Mansfield and Romeo (1980) document an average lag between intra-MNE technology transfer and inter-firm technology diffusion between 1.5 and 4 years. Our choice of a two-year lag is within this range. Due to the short time-span of our panel, using deeper lags substantially reduces the number of observations.

interaction with IPR become insignifcant.

As mentioned in Section 3.1, we also have IPR index values for the year 2005, which corresponds to the end of our sample period. Although using this index might raise concerns regarding the endogeneity of IPR strength to MNE knowledge diffusion, column 4 uses the 2005 IPR index as a robustness check.[19] The results stronlgy resemble those in column 3 of Table 4, with *Horizontal* and its interaction insignificant, *Backward* and its interaction with IPR showing up significantly and with the expected signs, while *Forward* and its interaction are significant but with the wrong signs.

Finally, a concern might be that instead of IPR strength, our IPR index is actually picking up on economic development in general, given that IPR strength and economic development tend to be related.[20] This might confound our estimates in two ways. On the one hand, firms in developed countries arguably have high absorptive capacity which supports the extent to wich they benefit from knowledge diffusion (Cohen and Levinthal, 1989). On the other hand, because of the small technology gap between local firms and foreign investors, it might be argued that they have little room to benefit from MNE knowledge diffusion (Griffith et al., 2004). The former argument could explain the positive impact of IPR on backward diffusion, whereas the latter could underly the negative impact of IPR on horizontal and forward diffusion. To investigate this, in column 5 of Table 5 we include acountry's (log) GDP per capita, as well as its interaction with the three diffusion variables. [21] The results show that interacting with GDP yields all of the *Horizontal* results insignificant. The *Backward* and *Forward* results are more robust. In particular, the interactions with IPR remain (marginally) significant. GDP itself has a positive effect on local firms' productivity, possibly as a result of tougher competition in larger, more developed markets (Melitz and Ottaviano, 2008).[22]

Finally, in order to illustrate the moderating effect of IPR, Figure 4 shows the predicted impact of *Horizontal*, *Backward* and *Forward* for the different IPR values that the countries

[19] Given the short time-span of our sample, the changes in the IPR index are not very substantial. In particular, only two countries in our sample exhibit such a change: Korea (from 4.2 to 4.33) and Singapore (from 4.05 to 4.21).

[20] The correlation coefficient between IPR (in 2000) and log GDP per capita in our sample is 0.23.

[21] Data on per capita GDP are taken from the Penn World Tables, version 6.3 (Heston et al., 2009). It is measured in constant international (PPP) US dollars.

[22] Because of the apparent strong impact of excluding Hong Kong from the sample, we also ran the models in columns 2-5 excluding Hong Kong. The most notable effect is that in this case, also *Horizontal* and its interaction with IPR becomes significant with the expected signs. The results are not presented but are available upon request.

in our sample exhibit.[23]

<< INSERT FIGURE 4 ABOUT HERE >>

The figure shows that for *Horizontal* (*Backward*), the implied positive (negative) effects on TFP in the low IPR countries of our sample are relatively small. Moreover, the total impact of *Horizontal* is small in general compared to the effects of both *Backward* and *Forward*. Additionally, the figure demonstrates that even in the country with the lowest IPR strength in our sample, the forward productivity effects are negative.[24] All in all, the vertical impact of MNE activity seems to substantially outweigh the horizontal impact.

5 Discussion and conclusion

Acknowledging that MNEs are an important vehicle for international technology diffusion, we investigate the impact of national IPR protection on horizontal and vertical knowledge diffusion from FDI to domestic host-country firms. The debate regarding the costs and benefits of strengthening national IPR systems centers around two arguments: On the one hand, stronger IPR protection decreases static efficiency as it raises the marginal costs of knowledge diffusion by limiting knowledge externalities or spillovers. On the other hand, it enhances dynamic efficiency by stimulating innovation and international technology transfer. Even though previous empirical research has examined parts of this debate, so far no study has investigated the ultimate impact of increasing IPR protection on national (domestic) firms. To study these two arguments, we exploit the different nature of horizontal (intra-industry) knowledge diffusion and vertical (inter-industry) knowledge diffusion. As the former mainly constitutes an externality or spillover, increased IPR strength should diminish its occurence. The opposite holds for vertical diffusion, as this occurs mainly through (inter-firm) knowledge transfer.

Our results partly corrobarate these expectations. They are strongest and most robust for backward or upstream knowledge diffusion, i.e. from MNEs to their local suppliers. We consistently find that increased IPR strength induces stronger and more positive backward knowledge diffusion. For horizontal and forward knowledge diffusion, the effects are somewhat less robust.

[23]The bars in the figure display the coefficient estimates for the three MNE variables, taking into account the different IPR levels. We use the estimates of column 1 in Table 5 as the basis for this figure, because it excludes Hong Kong, which appears to be a clear outlier in our sample in terms of IPR strength.

[24]Note that this is due to the fact that the individual (i.e. non-interacted) effects of the MNE variables capture the effects in countries with zero IPR, which we do not have in our sample.

Horizontal knowledge spillovers indeed seem to decrease with increased IPR strength, as expected. However, this result is somewhat sensitive to the use of lagged realizations of MNE activity. The results for forward or downstream knowledge diffusion do not correspond well with our expectations: Increased IPR strength seems to depress forward knowledge diffusion, and even generates strong negative effects on local firms, most likely due to competition effects. However, this result is also somewhat senstive to the use of lagged realizations of MNE activity, as well as to changing the measure of IPR strength. Moroever, as suggested by Javorcik (2008), forward knowledge diffusion might be particularly salient for downstream service firms, which we do not consider here. Within manufacturing, adverse competition effects might indeed dominate positive knowledge diffusion, as MNEs can more easily force higher input prices and hence lower margins on their downstream customers.

Overall, our results seem to suggest that both arguments in the IPR protection debate have some empirical bite. The question then arises which of the two effects dominates. This question is not easily answered, as our results and the specific coefficient estimates tend to vary across the different specifications. Moreover, it is difficult to pick a preferred specification. Still, we briefly attempt a back-of-the-envelope evaluation to put some numbers to the debate, using the estimates of column 1 in Table 5 as our point of departure.[25] First consider the impact of horizontal knowledge spillovers. In the countries with the lowest 2000 IPR index (Canada and Finland with an index of 3.9), a one standard deviation increase of horizontal MNE activity (1.93) increases local firms' TFP by approximately 8.7%.[26] The corresponding backward and forward impacts of MNE activity are -9.2% and 5.6% respectively, generating a net increase of 5.1%.[27] Redoing these calculations for the country with the highest IPR index (the United States with an index of 5) yields $Horizontal$, $Backward$ and $Forward$ effects of -29.5%, 41.6% and -19.7% respectively, yielding a net effect of -7.6%. These calculations seem to imply that the (contemporaneous) static efficiency argument for low IPR has more merit for domestic firms than the dynamic efficiency argument for high IPR. However, we also noted that only the backward effects of MNE activity are robust across all specifications. If we only take these

[25]This particular specification excludes Hong Kong as an outlier in terms of IPR strength, and the coefficient estimates are approximately in-between the extremes of the various estimates reported in Section 4.

[26]Recall that TFP is measured in logs, so that the coefficients can be interpreted as semi-elasticities. Hence, the total impact is computed as $0.747 \times 1.93 - 0.180 \times 1.93 \times 3.9$.

[27]The standard devations of $Backward$ and $Forward$ are 0.74 and 2.19 respectively. Also note that this net effect is a national average. Different firms are affected asymmetrically, depending on their various relationships with respect to MNEs.

into account, it is clear that strong national IPR systems are strongly preferred over weak IPR systems. A similar conclusion follows if we only consider the combined effects of horizontal and backward, or forward and backward effects.

Somewhat disappointingly then, it still proves to be difficult to have the final verdict out on the desirability of strong national IPR systems. If we take a conservative approach regarding our estimation results, we should only consider the backward knowledge diffusion effects of MNEs as being robust. In that case, our results make a strong case for strengthening national IPR systems, as this will stimulate MNE-supplier knowledge and technology transfer, yielding strong productivity gains for local firms in upstream industries. It also implies that FDI policies only aimed at attracting inward MNE activity by themselves are not sufficient to ensure domestic benefits. Developing a strong system of IPR protection and facilitating linkages between local suppliers and MNEs appear to be necessary conditions for policy in this regard.

Finally, our study suffers from some shortcomings that provide opportunities for future research. We only mention the two most salient ones here. First, our sample consists only of very large firms, which could seriously bias the coefficient estimates. Given that these large firms often dominate local markets and are prone to have strong linkages with each other and foreign MNEs, it is likely that the competition effects will be more adverse, biasing our results downward. At the same time, however, larger firms will be more productive and technologically advanced, making their knowledge transfers more effective. This could lead to an upward bias in our results. Working with samples including small(er) firms seems warranted to get rid of these biases. Second, the countries in our sample are all (fairly) well developed, which could also bias our results in various ways. The literature on the importance of absorptive capacity and technological distance in relation to FDI knowledge diffusion would imply that the local firms in these countries are particularly well equiped to benefit from foreign MNE activity (Cohen and Levinthal, 1989; Griffith et al., 2004). Additionally, the variation in national IPR system strength is seriously limited in this sample of countries. Effectively, we have no countries with truly weak IPR, which again might lead to (too) favourable results regarding the knowledge diffusion impact of MNE activity. Because of these reasons, expanding the sample of countries to include a more heterogeneous country population is strongly desirable. Fortunately, given the increased availability of detailed firm-level dataset in countries across the globe, as well as datasets combining such data for various countries simultaneously, such research opportunities should prove to be within reach in a not too distant future.

Acknowledgements

We thank Holger Görg, Peter Nunnenkamp, Enrico Pennings, Horst Raff, and participants of the 2008 European Trade Study Group, the 2009 European Economic Association Meeting, and seminars at the University of Nijmegen, the CPB Netherlands Bureau for Economic Policy Analysis, the Kiel Institute for the World Economy, and the Amsterdam Business School for useful comments and suggestions. Any remaining errors are our own.

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Appendix

For the purposes of this paper, we collected information for all publicly listed non-financial firms in 22 countries, i.e. all countries where a sufficient number firms with reliable data were present in the Worldscope database. However, for Japan and the United States, because of time and cost constraints, we collected information only on one third of the firms present in the database, accounting for a representative sample in terms of size and 4-digit industry. More precisely, in each of these countries we first divided the firms into ten groups according to size. Within each of these ten groups we then ordered the firms by their 4-digit primary SIC code. Within each of these industries we then selected every third firm from the total.

In order to obtain information on the extent of foreign (and local) ownership, we supplemented these data with information from the “Who owns whom” database, for which we only had access for the year 2004. In several cases the information in this dataset was not satisfactory. In such cases we augmented the dataset with information from other sources, primarily company websites and annual reports. In particular, for firms with dual-class shares the information from Thomson turned out to be insufficient, since it reflects the ownership structure of only one class of shares. In many instances (especially in Scandinavia), these are actually the shares with subordinate voting rights, mostly because the shares with full voting rights are not listed. We identified the companies with dual class shares via Thomson Datastream. Fifteen companies of this type for which we could not find data from alternative sources were excluded from the sample.

In some cases the total percentage of shareholdings reported by Thomson was greater than 100%. For five of these companies we could not find information from alternative sources and excluded them from the dataset. In some cases the fraction of total shareholding reported in "Who owns whom" is quite low, raising doubts about the presence of all substantial shareholders in this dataset. For companies where the fraction of total shareholding reported was less than 10%, we collected information using other sources, and were often able to identify investors holding very substantial fractions of shares. For forty-eight of these companies we could not find additional ownership information, so that we excluded them from the dataset. Finally, we excluded companies where the largest equity stake at the moment of reporting was larger than 20% and was held by the company itself (four companies) or a broker-dealer firm (five companies). This procedure resulted in a dataset of about 2,500 firms from 22 industrial countries.

Table 1: Country-level sample descriptives

Country	Local firms (N)	MNEs (N)	IPR index (2000)	Country	Local firms (N)	MNEs (N)	IPR index (2000)
Australia	93	23	4.19	Japan	483	13	4.19
Austria	18	4	4.71	South Korea	175	10	4.2
Belgium	28	11	4.05	Netherlands	45	10	4.38
Canada	120	18	3.9	New Zealand	2	7	4
Denmark	20	7	4.19	Norway	34	1	3.9
France	150	24	4.05	Singapore	101	19	4.05
Germany	150	38	4.52	Spain	35	8	4.05
Hong Kong	137	54	2.9	Sweden	67	4	4.38
Ireland	13	2	4	Switzerland	80	12	4.38
Israel	15	4	4.05	United Kingdom	252	27	4.19
Italy	73	11	4.33	Uinted States	408	17	5

Table 2: Average foreign ownership shares per industry

Industry	Average ownership (%)	Standard Deviation
Food products and beverages	38.48	22.52
Textiles	46.77	27.75
Wood and wood products	83.57	14.59
Paper and paper products	60.70	21.88
Coke, petroleum and fuel	55.11	18.41
Chemicals	42.22	28.81
Rubber and plastic products	54.61	26.78
Other non-metallic and mineral products	60.27	26.29
Basic metals	45.31	29.53
Fabricated metal products	42.76	19.10
Machinery and equipment	45.74	24.07
Electrical machinery and apparatus	42.25	24.08
Medical precision and optical instruments	50.43	15.83
Motor vehicles	36.00	18.05
Furniture	54.18	25.40
Construction	53.98	13.70

Table 3: The impact of MNE activity on local productivity: Baseline estimates

	(1)	(2)	(3)	(4)
Horizontal	0.004	−0.001	−0.005	−0.002
	(0.007)	(0.007)	(0.011)	(0.002)
Backward	0.040	0.051**	0.038	0.006
	(0.028)	(0.022)	(0.036)	(0.008)
Forward	−0.012***	−0.010***	−0.005	−0.000
	(0.004)	(0.003)	(0.004)	(0.002)
Log total assets	0.238***	0.095***	0.259***	−0.011**
	(0.027)	(0.033)	(0.029)	(0.005)
Salesshare	1.215***	1.668***	1.205***	0.058***
	(0.209)	(0.226)	(0.231)	(0.022)
Constant	1.944***	3.667***	1.688***	0.020
	(0.347)	(0.421)	(0.377)	(0.079)
N	14,151	14,151	12,027	11,465
Rsq	0.08	0.14	0.09	
Sargan statistic				131.1***
Hansen statistic				71.2***
AR1				−5.60***
AR2				1.25
No. instruments				58

*** p<0.01, **p<0.05, *p<0.1. Robust standard errors clustered at the country-industry level within parentheses. All GLS models in columns 1-3 are estimated with firm FE. Column 2 includes year FE (not reported). Column 3 uses one-year lagged realizations of MNE activity. Column 4 is estimated using system GMM. The lagged dependent variable is not reported.

Table 4: The impact of MNE activity on local productivity: National IPR strength

	(1)	(2)	(3)	(4)
Horizontal	0.113***	0.065*	0.071	−0.003
	(0.036)	(0.036)	(0.073)	(0.015)
× IPR	−0.033***	−0.020*	−0.024	−0.000
	(0.011)	(0.011)	(0.023)	(0.004)
Backward	−1.475***	−1.085**	−1.351*	−0.198*
	(0.569)	(0.544)	(0.739)	(0.118)
× IPR	0.374***	0.279**	0.342*	0.053*
	(0.139)	(0.132)	(0.183)	(0.030)
Forward	0.570***	0.428**	0.516**	0.074**
	(0.181)	(0.167)	(0.235)	(0.034)
× IPR	−0.137***	−0.103***	−0.123**	−0.018**
	(0.043)	(0.040)	(0.055)	(0.008)
Log total assets	0.235***	0.094***	0.255***	−0.009**
	(0.026)	(0.033)	(0.029)	(0.004)
Salesshare	1.236***	1.677***	1.209***	0.066***
	(0.209)	(0.225)	(0.231)	(0.020)
Constant	1.994***	3.691***	1.749***	0.079
	(0.339)	(0.414)	(0.372)	(0.065)
N	14,151	14,151	12,027	11,465
Rsq	0.08	0.14	0.09	
F-statistic	10.7***	5.2***	6.7***	
Sargan statistic				167.5***
Hansen statistic				111.4***
AR1				−5.68***
AR2				1.25
No. instruments				100

*** p<0.01, **p<0.05, *p<0.1. Robust standard errors clustered at the country-industry level within parentheses. All GLS models in columns 1-3 are estimated with firm FE. Column 2 includes year FE (not reported). Column 3 uses one-year lagged realizations of MNE activity. Column 4 is estimated using system GMM. The lagged dependent variable is not reported.

Table 5: The impact of MNE activity on local productivity: Robustness analyses

	(1)	(2)	(3)	(4)	(5)
Horizontal	0.747***	0.982***	0.513***	0.061	0.913*
	(0.185)	(0.260)	(0.140)	(0.070)	(0.534)
× IPR	−0.180***	−0.237***	−0.127***	−0.021	−0.053
	(0.044)	(0.057)	(0.032)	(0.020)	(0.035)
× GDP					−0.067
					(0.045)
Backward	−2.558***	−3.792***	−2.192**	−1.216*	−5.179***
	(0.810)	(1.053)	(0.930)	(0.728)	(1.435)
× IPR	0.624***	0.923***	0.535**	0.309*	0.210*
	(0.197)	(0.253)	(0.224)	(0.180)	(0.114)
× GDP					0.421***
					(0.137)
Forward	0.435**	0.596**	0.411	0.478**	0.661*
	(0.219)	(0.288)	(0.262)	(0.231)	(0.390)
× IPR	−0.105**	−0.143**	−0.097	−0.114**	−0.066**
	(0.052)	(0.068)	(0.062)	(0.055)	(0.030)
× GDP					−0.038
					(0.032)
Log total assets	0.274***	0.293***	0.304***	0.255***	0.131***
	(0.029)	(0.050)	(0.028)	(0.029)	(0.033)
Salesshare	1.044***	1.472***	0.829***	1.208***	1.482***
	(0.227)	(0.401)	(0.217)	(0.231)	(0.256)
Log GDP per capita					2.680***
					(0.220)
Constant	1.548***	1.219*	1.202***	1.743***	−24.37***
	(0.375)	(0.652)	(0.370)	(0.321)	(2.035)
N	11,382	4745	9730	12,027	12,027
Rsq	0.11	0.11	0.13	0.09	0.17

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust standard errors clustered at the country-industry level within parentheses. All models are estimated with firm FE and one-year lagged MNE variables, unless indicated otherwise. Column 1 excludes Hong Kong from the sample. Column 2 excludes observations with zero MNE activity. Column 3 uses two-year lagged realizations of MNE activity. Column 4 uses the 2005 IPR index. Column 5 includes (log) GDP per capita as an additional control variable.

Table A1: Labor and capital coefficients in OLS and OP production function regressions

Industry	β_L^{OLS}	β_L^{OP}	Deviation OP-OLS (Expected: -)	β_K^{OLS}	β_K^{OP}	Deviation OP-OLS (Expected: +)
Food products and beverages	0.574	0.446	-	0.484	0.553	+
Textiles	0.356	0.342	-	0.266	0.566	+
Wood and wood products	0.261	0.255	-	0.371	0.502	+
Paper and paper products	0.368	0.358	-	0.431	0.505	+
Coke. petroleum and fuel	0.385	0.390	+	0.503	0.602	+
Chemicals	0.756	0.723	-	0.159	0.192	+
Rubber and plastic products	0.341	0.349	+	0.421	0.632	+
Other non-metallic and mineral products	0.513	0.507	-	0.507	0.475	-
Basic metals	0.367	0.345	-	0.485	0.555	+
Fabricated metal products	0.395	0.340	-	0.221	0.552	+
Machinery and equipment	0.342	0.309	-	0.613	0.591	-
Electrical machinery and apparatus	0.643	0.561	-	0.284	0.299	+
Medical precision and optical instruments	0.556	0.477	-	0.351	0.359	+
Motor vehicles	0.806	0.772	-	0.219	0.283	+
Furniture	0.605	0.605	0	0.437	0.456	+
Construction	0.666	0.674	+	0.148	0.205	+

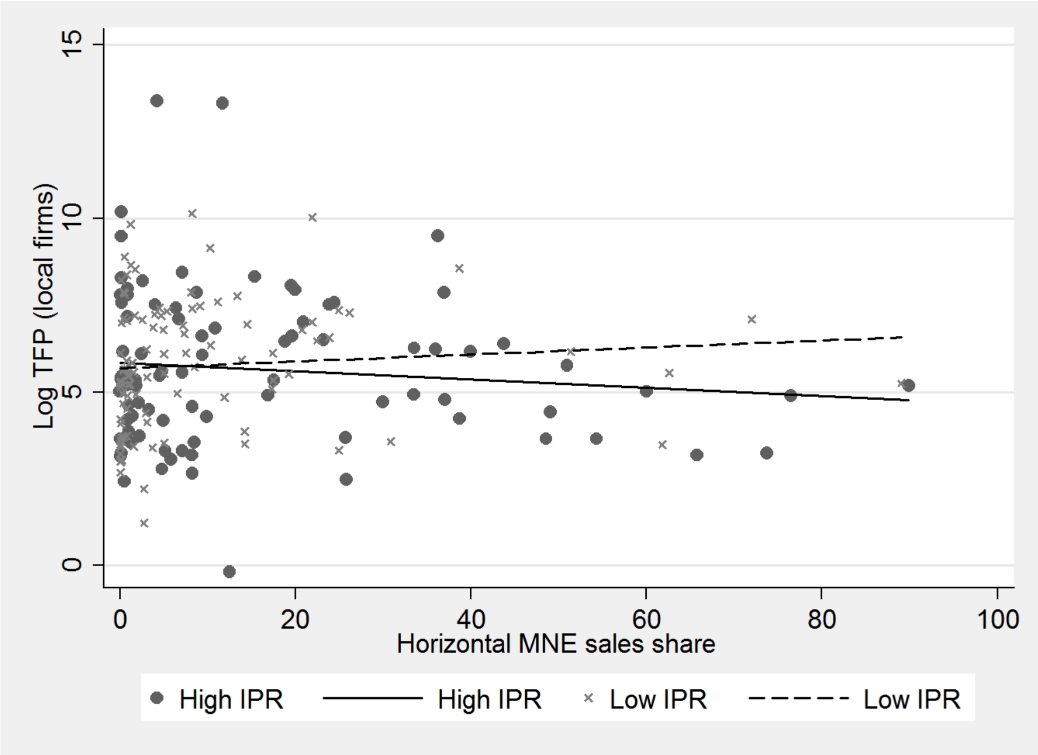

Figure 1: Correlation between local firms' TFP and horizontal MNE activity: High *versus* low IPR countries.

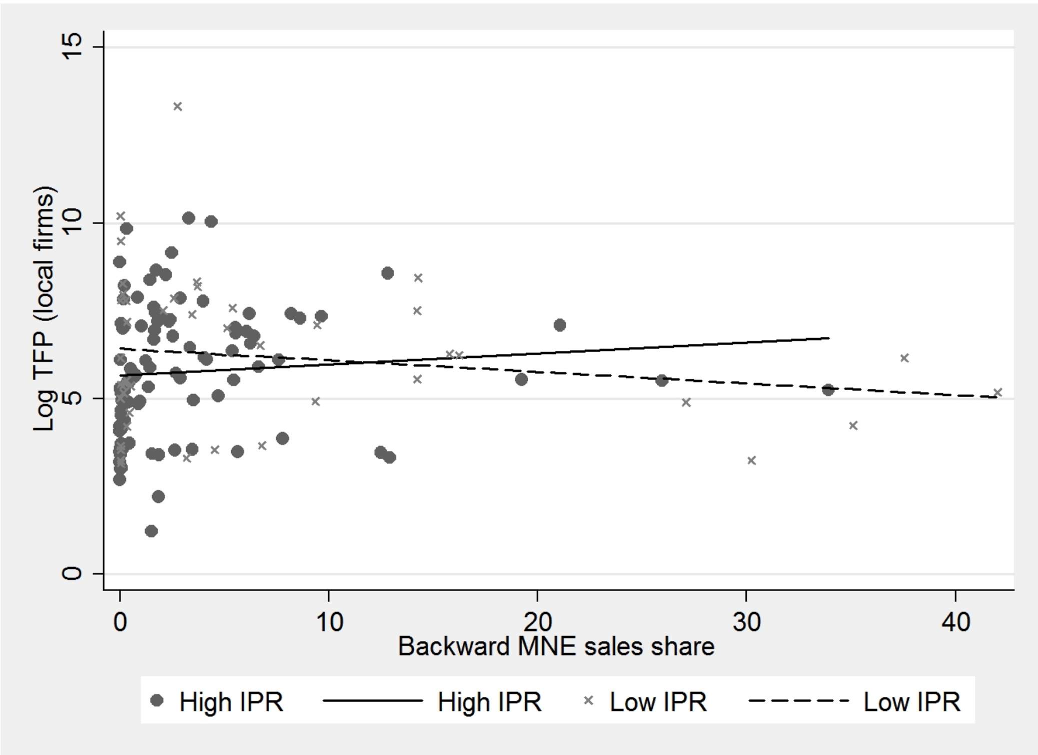

Figure 2: Correlation between local firms' TFP and downstream MNE activity: High *versus* low IPR countries.

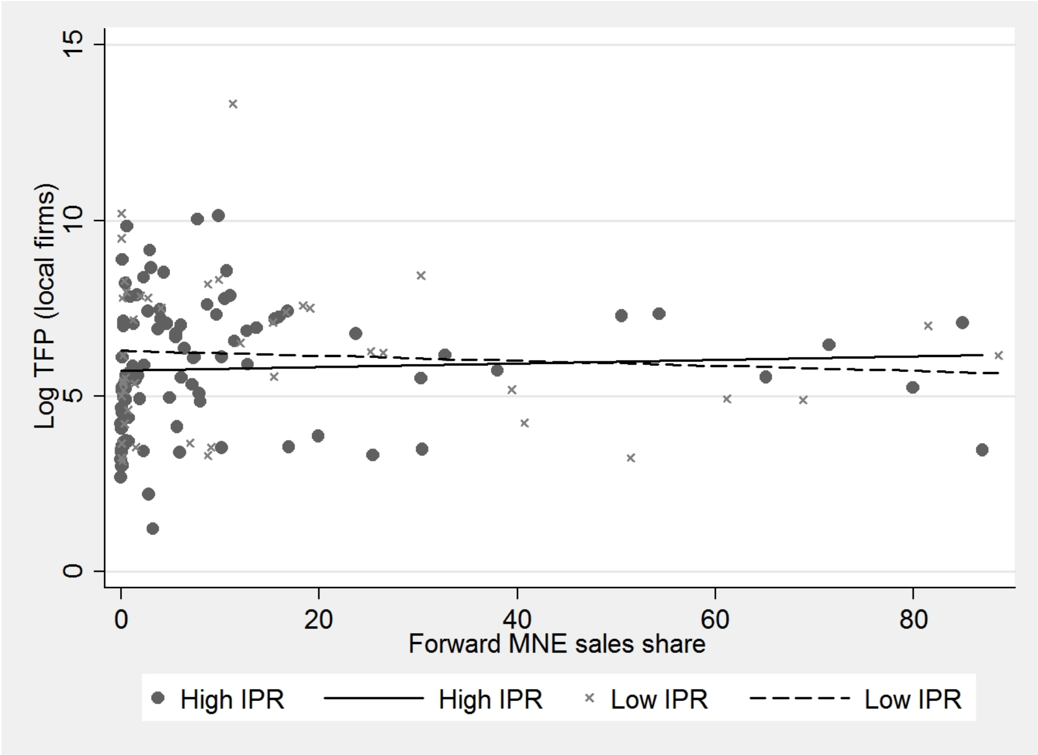

Figure 3: Correlation between local firms' TFP and upstream MNE activity: High *versus* low IPR countries.

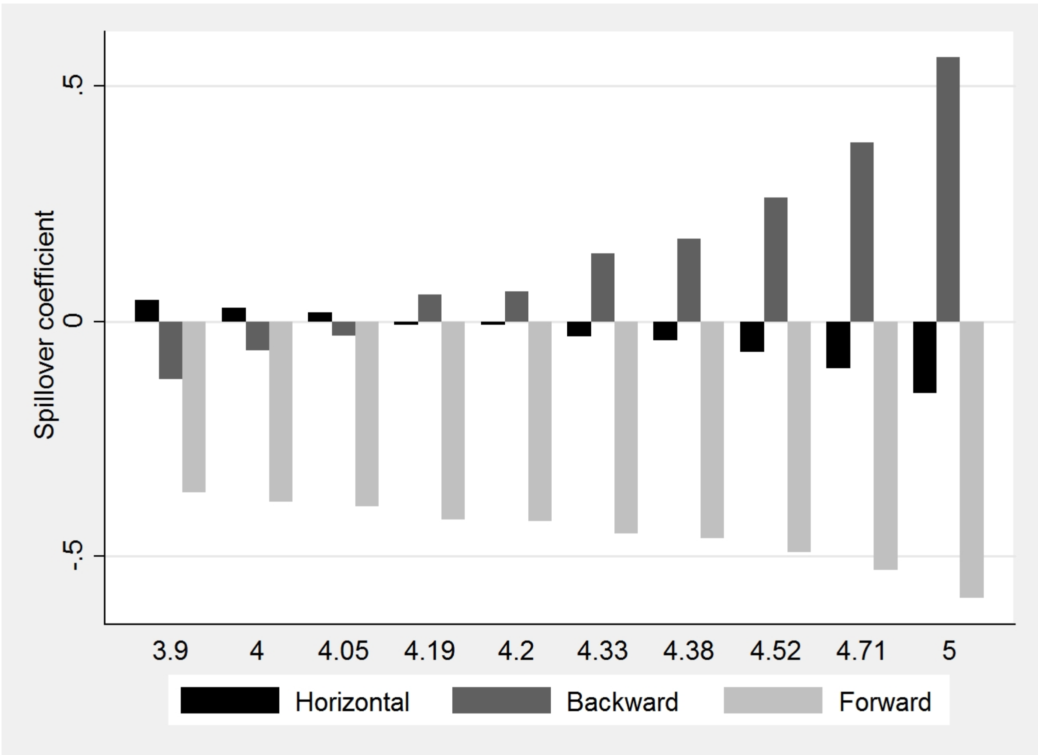

Figure 4: Estimated horizontal, backward and forward coefficients at various levels of the IPR index.

Publisher:

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T (070) 3383 380

February 2011 | ISBN 978-90-5833-495-4