Multinational Ownership, Intellectual Property Rights and Knowledge Diffusion from Foreign Direct Investment

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Abstract

In this paper we extend the vertical linkages model by Markusen and Venables (1999) to include (a) differing degrees of multinational (MNE) ownership in their foreign affiliates and (b) knowledge diffusion, in addition to demand and supply linkages. We investigate the intra- and inter-industry effects of changes in MNE ownership on local firms' productivity via demand linkages, price effects and knowledge diffusion. Moreover, we also consider the mediating influence of national intellectual property rights protection (IPP). Given the ambiguous predictions of our model, we also investigate these issues empirically in a panel of 1222 large firms spread out over 20 countries and 18 manufacuring industries during the period 2000-2005: We find that in countries with low IPP, the occurence of intra-industry productivity effects is conditional on the cost structure of local firms. Moreover, inter-industry productivity effects are largely absent. Conversely, in countries with high IPP, both intra-industry and inter-industry productivity effects are high. Also, the relationship beween productivity effects and MNE ownership varies both within and between industries, as well as between conditional and unconditional productivity effects. We interpret this empirical evidence as a confirmation of our theoretical conjecture that intra-industry knowledge diffusion is dominated by unintended spillovers, whereas inter-industry knowledge diffusion is dominated by intended knowledge transfers.

1 Introduction

In an attempt to better disentangle the conditions under which Foreign Direct Investment (FDI) induces knowledge spillovers, academic research has increasingly take into account the heterogeneity of multinationals (MNEs) and their

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foreign subsidiaries (Feinberg and Keane, 2005; Smeets, 2008). Whereas FDI used to be treated as a rather bulky and homogeneous concept (Lipsey, 2002), scholars have started to acknowledge the heterogeneity of MNEs in *inter alia* investment motives (Girma, 2005; Driffield and Love, 2007), market orientation (Girma et al. 2008) and country of origin (Javorcik et al., 2004; Girma and Wakelin, 2007), and the subsequent consequences for host-country knowledge spillovers.

A particularly promising strand of research has considered differences in MNE ownership over foreign affiliates as a determining factor of knowledge spillovers (Blomström and Sjöholm, 1999; Dimelis and Louri, 2002; Javorcik, 2004; Javorcik and Spatareanu, 2008). Internalization theory suggests that increased MNE ownership over a foreign affiliate induces the parent to transfer more proprietary knowledge or technology abroad, thus increasing the potential for knowledge diffusion (Rugman, 1981; Hennart, 1982; Davies, 1992). Moreover, studies on MNE input sourcing suggest that increased MNE ownership has consequences for the extent of local input sourcing, thus affecting the extent of backward linkages (Tavares and Young, 2006; Javorcik, 2008).

Empirical studies usually distinguish minority from majority ownership (Blomström and Sjöholm, 1999; Dimelis and Louri, 2004), or shared ownership from fully owned subsidiaries (Javorcik, 2004; Javorcik and Spatareanu, 2008) and indeed find that the distinction matters. However, none of these studies considers the effect of MNE ownership as a continuous variable, which veils a lot of the potential variation. Moreover, although some theoretical studies investigate the relationship between intra-firm knowledge transfer and MNE ownership (Müller and Schnitzer, 2006), theoretical contributions on the relationship between MNE ownership and intra and inter-industry knowledge diffusion are largely absent.

This paper first picks up on the latter observation: We introduce shared ownership between a MNE and a local (host-country) partner in the foreign subsidiary as a variable of interest in a theoretical model by Markusen and Venables (1999), and then consider its host-country intra and inter-industry effects. Specifically, in addition to considering only pecuniary externalities, as is common in most theoretical models, we also consider actual knowledge diffusion. In doing so, the analysis explicitly considers two forms of knowledge diffusion: First, knowledge spillovers, which are unintended knowledge flows (i.e. externalities) from the MNE to its host-country environment. Second, knowledge transfers, which are intended (and internalized) flows of knowledge from the MNE to its host-country environment. A final contribution of the paper is that it also considers institutional heterogeneity - notably intellectual property rights protection (IPP) - and how this interacts with the two types of knowledge diffusion just mentioned.

Our theoretical results demonstrate the opposing influences of pecuniary effects, direct and indirect demand effects, and knowledge diffusion on domestic firms, following from an increase in MNE ownership in foreign affiliates. Nonetheless, we are able to derive some (conditional) unambiguous predictions: We find that forward or downstream host-country effects following an increase in MNE ownership are generally positive, provided that there is sufficient upstream competition. Backward or upstream effects are also positive in countries with high IPP, provided that *inter alia* downstream demand elasticities and local input shares are sufficiently high. The intra-industry effects are generally positive in low-IPP countries, provided that the share of fixed costs in total costs of domestic firms is sufficiently high.

We then take these theoretical predictions to the data, by employing a firm-level panel dataset, containing 1222 large domestic firms and 351 foreign subsidiaries with varying degrees of MNE ownership, active in 20 countries and 18 industries during the period 2000-2005. Our theoretical findings on the inter-industry effects are largely confirmed by the data. The empirical results on the intra-industry effects are not entirely in line with the theoretical expectations, which we argue might be due to some assumptions in the model. Generally speaking, the empirical results suggest that high-IPP countries are better able to reap the benefits of MNE investment than low-IPP countries.

The empirical part of the paper also provides two methodological advantages over some of the earlier studies already undertaken in this area (cf. Blomström and Sjöholm, 1999; Dimelis and Louri, 2002; Javorcik, 2004; Javorcik and Spatareanu, 2008). First, unlike earlier studies, we utilize a cross-country sample which allows us to investigate how institutional heterogeneity (such as differences in IPP regimes) interacts with the relationship between MNE ownership and host-country productivity effects. Second, in stead of considering dichotomous or discrete differences in MNE ownership (e.g. minority *versus* majority, or shared ownership *versus* full ownership), we treat MNE ownership as a continuous variable in the empirical part as well. Given the *ex ante* theoretical ambiguity of the relationship between MNE ownership and knowledge diffusion, next to the usual parametric regression techniques we also employ semi-parametric regression techniques which allows us to refrain from specifying a specific functional form regarding the relationships of interest.

The rest of this paper is structured as follows: Section 2 develops a theoretical model, based on Markusen and Venables (1999) and extends it with the theoretical elements mentioned above. Section 3 analyzes the within and between industry-effects of changes in MNE ownership on local firms, and how these effects depend on the extent of IPP. Section 4 outlines the empirical methodology and gives an overview of the data used in this paper. Section 5 presents the estimation results of the empirical model. Finally, Section 6 concludes.

2 The model

Before discussing the setup of the model, it is instructive to consider Figure 1 below, which presents a schematic representation of the theoretical model. A MNE sets up a shared foreign subsidiary in sector k in the host economy to produce for and sell on the local market. As such, it competes with local firms that are also active in sector k, but at the same time it also spills over knowledge to these firms. These are intra-industry or horizontal knowledge spillovers. The industry the MNE invests in may be a downstream industry – receiving inputs from local firms in j as indicated by situation A – or an upstream industry – delivering inputs to firms in industry l. If situation A is at hand, local firms active in sector j supply the foreign subsidiary and local firms in sector k with intermediates, but at the same time also receive knowledge transfer from the foreign subsidiary, e.g. through supplier assistance (Javorcik, 2008). This type of knowledge transfer is called backward or upstream knowledge transfer. If situation B is relevant, the foreign subsidiary and local firms in sector k may also function as input suppliers themselves, selling intermediates to local firms in sector l. Simultaneously, these local sector l firms may receive knowledge transfer from the foreign subsidiary, e.g. in the form of increased input quality (Javorcik, 2008). Whichever situation occurs, these types of knowledge transfer are inter-industry or vertical in nature. In addition to vertical knowledge transfer, changes in the demand and supply of goods along the input and output linkages will cause backward and forward demand effects, leading to pecuniary spillovers.

<< INSERT FIGURE 1 ABOUT HERE >>

In what follows we will first focus on part A of Figure 1. That is, we will first consider the situation in which the MNE has a shared subsidiary in the downstream sector (k) of the host economy and receives supplies from the upstream sector (j). After having derived the model for this setup, we will also indicate how the model changes when considering part B, where the foreign subsidiary is active in the upstream sector (k), supplying local firms in the downstream sector (l).

In our model there are two types of firms: Multinationals (m) and national firms (n), the latter of which can be further classified as local partners (lp), downstream firms (d) and upstream firms (u). We assume that MNEs require a local partner to set up a foreign subsidiary in the host country: The resulting shared subsidiary can be thought of as an International Joint Venture (IJV).[1] This IJV competes with the downstream firm d, and both of them are supplied by the upstream firm u.

The theoretical model below builds on and extends Markusen and Venables (1999). These authors develop a multi-sector partial equilibrium model, where they analyze the effect of MNE entry in a downstream industry on the number of local firms active in upstream and downstream industries. The effects of MNE entry work via competition effects and demand linkages (leading to pecuniary externalities). Our setup resembles theirs in a number of ways: We also utilize a two industry setup, in which each industry is characterized by Dixit-Stiglitz monopolistic competition. Further, we also look at pecuniary externalities via

[1] A couple of remarks apply here: First, note that we assume that the MNE needs a local partner, i.e. we do not model the decision between a greenfield versus a shared subsidiary nor the search process for a suitable partner. Second, even though the shared subsidiary may be thought of as an IJV, we assume that the national firm is completely absorbed in the partnership and does not have any remaining operations of its own. From that perspective, the partnership may have more resemblance to a partial acquisition. Third, we assume that there is always a sufficient supply of local partners.

demand linkages between the upstream and downstream industries. Yet our model also differs from theirs in two important aspects: First, we introduce shared ownership between the MNE and a local partner in the foreign subsidiary, as investigating the effect of a change in MNE ownership on the productivity of local firms is the primary focus of this paper. Second, next to pecuniary spillovers, we also introduce direct and explicit knowledge diffusion. Moreover, we disentangle these knowledge diffusion effects into knowledge spillovers (horizontal) and knowledge transfers (vertical), and consider their contingency on IPP protection. Further, in the subsequent analysis we do not consider the effect of MNE entrance or ownership on the entry or exit of local firms, by keeping the number of firms constant when taking total derivatives (cf. Section 3).

Once again recall that we first consider part A of Figure 1, where $IJVs$ are active in the downstream industry (together with local downstream firms d) and are supplied by local upstream firms u. We model the price index of the inputs produced by local upstream firms in CES fashion and denote it by:

$$P_U = \left(n_u p_u^{1-\sigma}\right)^{1/(1-\sigma)} \tag{1}$$

where n_u are the number of local upstream firms, p_u are individual prices of upstream inputs and $\sigma > 1$ is the elasticity of substitution between any two input varieties. Suppose for the moment that total demand for inputs from the downstream sector is given by I. Then, multiplying P_U by I gives total costs of input supply, or equivalently, total expenditures on inputs. Hence, we can apply Shephard's lemma to derive demand for individual inputs x_u:

$$x_u = p_u^{-\sigma} I P_U^{\sigma} \tag{2}$$

In the downstream sector we have a similar industry structure, but here both national firms and IJVs are active. Hence, the price index in the downstream sector is given by:

$$P_D = (n_d p_d^{1-\varepsilon} + n_{IJV} p_{IJV}^{1-\varepsilon})^{1/(1-\varepsilon)}$$

where n_d (n_{IJV}) is the number of local firms (IJVs) active in the downstream sector, p_d (p_{IJV}) are the prices these firms charge, and $\varepsilon > 1$ is the elasticity of substitution between any two varieties. The volume of total consumer demand for these downstream products is given by Y and total expenditure on downstream goods is given by $YP_D^{-\eta}$ where η is the elasticity of demand with respect to the price index P_D. Similar to Markusen and Venables (1999), we assume that $\varepsilon > \eta .> 1$. Again applying Shephard's lemma we obtain individual demands:

$$\begin{aligned} x_d &= p_d^{-\varepsilon} Y P_D^{\varepsilon-\eta} \\ x_{IJV} &= p_{IJV}^{-\varepsilon} Y P_D^{\varepsilon-\eta} \end{aligned} \tag{3}$$

First consider the profit function of the IJV which is given by:

$$\Pi_{IJV} = p_{IJV} x_{IJV} - (F_{IJV} + \beta_{IJV} x_{IJV}) \left[\alpha P_U + (1-\alpha) w\right] \tag{4}$$

where p denotes price, x denotes output, F are fixed costs, β are marginal production costs, w is the wage rate of labor, and α is the share of inputs sourced from the upstream sector ($0 \leq \alpha \leq 1$). Note that the amount of inputs sourced from the upstream sector depends on the amount of fixed costs and variable costs. The remaining share $(1-\alpha)$ is spent on labor as an additional production factor.

As mentioned, the IJV is a partnership between a MNE (m) and a local partner (lp). We assume that the contribution of both firms in terms of technology and knowledge to the IJV is proportional to their ownership shares in the IJV, which is given by ρ for the MNE and $(1-\rho)$ for the local partner. These contributions translate into the fixed and marginal production costs of the IJV and are modelled as follows:

$$\begin{aligned} F_{IJV} &= \rho F_m + (1-\rho) F_n \\ \beta_{IJV} &= \rho \beta_m + (1-\rho) \beta_n \end{aligned} \tag{5}$$

where we assume $F_{lp} = F_d = F_u \equiv F_n$, i.e. fixed costs of all national firms are equal, regardless of their type, and similarly for β. In line with earlier literature (Blomström and Sjöholm, 1999), as well as with the firm characteristics in our own sample (see Section 5), we assume that $F_m < F_n$ and $\beta_m < \beta_n$ i.e. the MNE is more productive than a national firm, both in terms of fixed costs as well as marginal costs. Hence, the larger the ownership share of the MNE in the IJV, the lower IJV fixed and marginal costs will be, which is in line with the literature on internalization or transaction costs and technology transfer (Davies, 1992).

A key issue of this paper is the nature and extent of knowledge diffusion from the IJV to the national firms. As we already explained, we make an explicit distinction between unintended knowledge spillovers on the one hand, and intended knowledge transfer on the other. This distinction is especially important in the present context, since we conjecture that the type of knowledge diffusion is contingent on the direction of diffusion, i.e. horizontal or vertical.

Specifically, we argue that knowledge spillovers from the IJV are most likely to flow horizontally, i.e. to downstream firms d active in the same sector, for the IJV has nothing to gain from intentionally transferring knowledge or technology to its competitors. Moreover, since these firms are active in the same sector, their absorptive capacity can be expected to be relatively high. Intentional knowledge transfers on the other hand, are more likely to flow vertically, i.e. from the IJV to local upstream firms u (in situation A of Figure 1), since the IJV will benefit from this by increased quality or decreased prices of inputs. Indeed, there exists ample evidence of MNEs that assist their suppliers in terms of technology transfer, or transfer of best practices or quality standards (Javorcik and Spatareanu, 2005; Javorcik, 2008).[2]

In the context of knowledge diffusion, the extent of IPP also becomes relevant (Branstetter et al., 2006) since the purpose of IPP is to reduce knowledge

[2] We do not consider explicit learning within the IJV by any of the two parties involved (for an analysis of this type, see Müller and Schnitzer, 2006).

spillovers. As a consequence we may expect opposite effects of IPP on (horizontal) knowledge spillovers on the one hand, and (vertical) knowledge transfer on the other hand: If IPP functions properly, horizontal knowledge spillovers should be reduced. At the same time however, due to the decreased risk of expropriation of knowledge, this increases the incentives for the IJV to (vertically) transfer knowledge. Hence, upstream knowledge transfer should increase with IPP.[3]

As we have assumed that MNE knowledge transfer to the IJV takes effect through fixed and marginal costs, it is only natural to assume that knowledge diffusion from the IJV to downstream and upstream firms will also affect their fixed and marginal cost structures. Hence, for local downstream firms, we model fixed and marginal costs after spillovers as:

$$\begin{aligned} F_d^S &= \theta F_d + (1-\theta) F_{IJV} \\ \beta_d^S &= \theta \beta_d + (1-\theta) \beta_{IJV} \end{aligned} \tag{6}$$

where θ is a parameter capturing the strength of Intellectual Property Rights protection (IPP), with $\theta = 1$ denoting perfect protection and $\theta = 0$ no protection whatsoever. Hence, spillovers are maximized when $\theta = 0$, implying that the fixed and marginal cost structures of IJVs can be copied perfectly.

For intentional knowledge transfers from the IJV to local upstream firms we then have:

$$\begin{aligned} F_u^T &= (1-\theta) F_u + \theta F_{IJV} \\ \beta_u^T &= (1-\theta) \beta_u + \theta \beta_{IJV} \end{aligned} \tag{7}$$

Note that because knowledge transfer is intentional (as opposed to spillovers) the IJV is more willing to transfer its technology as the extent of IPP increases (θ increases), since the risk of expropriation is very small in that case (Branstetter et al., 2006).

The local upstream firm has the following formulation for profits:

$$\Pi_u = p_u x_u - (F_u^T + \beta_u^T x_u) w \tag{8}$$

We can derive the equilibrium price for the upstream firm by substituting equilibrium demand (2) into (8) and maximize profits, which yields:

$$p_u = \frac{\sigma \beta_u^T w}{(\sigma - 1)}$$

It directly follows from this expression that MNEs benefit from technology transfer to upstream firms, since this decreases β_u^T and hence decreases input prices p_u.

[3] Apart from the theoretical relevance of introducing IPP in this manner, its opposite effects on knowledge spillovers and transfers also allow us to test our hypothesized difference between horizontal and vertical knowledge diffusion empirically.

Local downstream firms have the following profit function:

$$\Pi_d = p_d x_d - (F_d^S + \beta_d^S x_d)(\alpha P_U + (1-\alpha)w) \tag{9}$$

the interpretation of which is similar to that of the IJV.[4] The equilibrium pricing condition is found by substituting x_d from (3) into (9) and maximizing profits:

$$p_d = \frac{\varepsilon \beta_d^S (\alpha P_U + (1-\alpha)w)}{(\varepsilon - 1)}$$

Note that on top of the knowledge spillovers through β_d^S, the backward demand linkage from MNEs to upstream firms poses an additional benefit to the local downstream firm as it serves to decrease P_U as well, which constitutes an (indirect) forward linkage.

Finally, for the IJV we obtain a similar pricing condition:

$$p_{IJV} = \frac{\varepsilon \beta_{IJV} (\alpha P_U + (1-\alpha)w)}{(\varepsilon - 1)}$$

We can now close the model by also writing down derived demand for the upstream firm's products, which is generated by the input demand from the IJV and the domestic firm in the downstream sector:[5]

$$I = \alpha n_{IJV}(F_{IJV} + \beta_{IJV} x_{IJV}) + \alpha n_d (F_d^S + \beta_d^S x_d) \tag{10}$$

So far, we have only considered part A of Figure 1, i.e. the situation in which the IJV is active in the downstream sector generating horizontal intra-industry effects as well as upstream or backward effects through inter-industry linkages. In order to analyze downstream or forward linkages, we also consider the situation in which the IJV is active in the upstream industry (together with local firms) and supplying local firms in the downstream industry. That is, part B of Figure 1.[6] Because the model remains largely the same, except

[4] Note that we assume (unlike Markusen and Venables, 1999) that $\alpha_{IJV} = \alpha_d = \alpha$. Although it has been argued that MNEs (or IJVs) will potentially source less of their inputs in the host-country, we have no way of distinguishing between α_{IJV} and α_d in the empirical part of the paper, so that we prefer the current specification. However, we will come back to the implied relationship between α and MNE ownership ρ when discussing the empirical results later on.

[5] Coming back to our earlier remark, we again note that we refrain from deriving free entry (i.e. zero profit) conditions, but instead assume that these are fulfilled in both sectors. A potential problem in this case is that the cost structure of the two firm types in the downstream sector (IJVs and ds) differ. Specifically, given that IJVs are more efficient than ds, imposing a zero-profit condition for ds would imply positive profits for IJVs. In order to prevent this situation from ocurring, we assume that any resulting positive profits from IJVs are absorbed by added co-ordination costs between the MNE and its local partner.

[6] We already noted above that in the model setup discussed so far, we do have *indirect* forward linkages to the downstream local firms which are contingent on the upstream linkage, since they will be affected by changes in P_U induced by changes in MNE ownership in the IJV (ρ). However, in the empirical section, we will also investigate the *direct* forward linkages, i.e. the linkage effects of an IJV directly supplying local firms, so that we also have to consider this case theoretically.

for the fact that the IJV switches industries, we will not fully write it down here (Appendix A). However, note that in this case it is the upstream firm that benefits from knowledge spillovers, whereas the downstream firm benefits from knowledge transfer. This also implies that the moderating effects of IPP change accordingly. In the next section we will analyze the comparative static effects of a change in MNE ownership in the IJV (ρ) on the profits of local firms for both situations A and B.

3 Intra and inter-industry effects of MNE ownership

3.1 IJVs in the downstream sector

Since our main interest in this paper concerns the effects of MNE ownership in the IJV (ρ) on local firms through demand linkages, competition effects and knowledge diffusion, we investigate the effect of ρ on local firms' profits. In order to do this, we compute total derivatives with respect to ρ while assuming that all other variables remain unchanged. First consider the effect of MNE ownership in the downstream industry on upstream firms' profits:

$$\frac{d\Pi_u}{d\rho} = \frac{p_u^{1-\sigma} P_U^{\sigma}}{\sigma} \underbrace{BL_1}_{\gtrless 0} + \frac{p_u}{\sigma} \underbrace{PE_1}_{<0} + \underbrace{KT_1}_{>0} \tag{11}$$

where BL_1, PE_1 and KT_1 are a backward linkage effect, a price effect and a knowledge transfer effect respectively, the full expressions of which are given in Appendix B1.

The knowledge transfer effect KT_1 is straightforward: An increase in MNE ownership in the IJV increases explicit knowledge transfer to the upstream firm by decreasing fixed and variable costs, increasing upstream firms' profits. Moreover, the larger the IPP (i.e the larger θ), the larger is this positive effect.

The negative upstream price effect $PE_1$is due to our assumption of homogeneity of firms and their interrelationships, so that all upstream firms are affected by an increase in ρ in the same way. Specifically, the decrease in β_u^T following an increase in ρ decreases upstream prices p_u. This effectively reduces the price index in the upstream industry P_U, i.e. it depresses per firm revenue in this sector. This effect is stronger the larger is θ due to increased knowledge transfer.

The effect of ρ through the backward demand linkage (BL_1) has three components in $d\Pi_u/d\rho$ (see Appendix). First, there is a negative indirect knowledge spillover effect, which occurs because of the increase in knowledge spillovers to the local downstream firm as a result of an increase in ρ, making downstream firms more efficient. This implies less demand for x_u since less inputs are needed to produce the same output. Also note that the negative effect of knowledge spillovers is moderated by the extent of IPP: The larger θ, the smaller knowledge spillovers to the local downstream firm and hence, the smaller its negative influence on demand for intermediate inputs. This adds to the positive *direct* effect of θ through KT_1.

Third, there are positive downstream demand effects, induced by the change in demand for downstream firm products after an increase in ρ. Since fixed and marginal costs of downstream firms are reduced, as well as the fact that input prices P_U go down, prices for downstream products fall, inducing an increase in demand for downstream products and accordingly also for upstream inputs. The impact of θ on this effect is twofold: On the one hand, an increase in θ decreases knowledge spillovers to local downstream firms, thus limiting the price decrease of these firms and limiting the increase in derived input demand. On the other hand, an increase in θ raises knowledge transfer to the upstream firm, lowering input prices and downstream prices, thus increasing derived demand for inputs again. However, this latter effect is a second order effect, so that in this case, IPP will most likely exert a negative effect on Π_u.

The third effect which takes place through the backward demand linkage (BL_1) is a downstream price effect. As we will see below as well (when analyzing $d\Pi_d/d\rho$) an increase in ρ decreases individual prices of all downstream firms, and thereby also the price index P_D. That is to say, an increase in ρ eventually decreases per firm revenue in the downstream sector. This in turn has a negative impact on derived demand for upstream inputs and accordingly on upstream profits.

We now turn to the national firm in the downstream industry (i.e. the competitor of the IJV). Recall that two clear differences with the upstream firm are that (i) the downstream firm is not vertically linked with the IJV and (ii) knowledge diffusion occurs through knowledge spillovers rather than knowledge transfer. Computing the total derivative of Π_d with respect to ρ yields:

$$\frac{d\Pi_d}{d\rho} = (\varepsilon - \eta)\frac{p_d}{\varepsilon}\frac{x_d}{P_D}\underbrace{PE_2}_{<0} + \underbrace{KS_1}_{>0} + \underbrace{IDL_1}_{>0} \tag{12}$$

where PE_2, KS_1 and IDL_1 are a price effect, a knowledge spillover effect, and an indirect demand linkage effect respectively (the explicit expressions are relegated to Appendix B2).

First, the price effect (PE_2) works through the price index P_D. Due to the increase in ρ, IJV cost structures improve because of increased intra-firm knowledge transfer, making IJVs more competitive. Moreover, since the increase in ρ also increases horizontal knowledge spillovers, contingent on the lack of IPP $(1-\theta)$, each individual national firm in the downstream industry is confronted with a decrease in P_D, a decrease in per firm revenue, and hence a decrease in profits.

Second, there is the direct knowledge spillover effect (KS_1), occurring through the fixed and marginal cost structure and again contingent on the absence of IPP protection $(1-\theta)$. This effect is obviously positive.

Finally, the downstream national firm also profits from the vertical linkage between the IJVs and the upstream firms, albeit in an indirect way via P_U (IDL_1). Indeed, since backward knowledge transfer from the IJV to the upstream firm increases with ρ (see above), national downstream firms are confronted with lower input prices P_U. The extent of this positive indirect linkage is contingent on the input share α as well as on the extent of IPP θ. Regarding the latter, this poses a counter-acting force to the direct knowledge spillovers from the IJV to the downstream firm: To benefit more from these spillovers, the downstream firm requires a lower θ (first-order), but to benefit from lower input prices, it requires a higher θ (second-order).

3.2 IJVs in the upstream sector

Now we will consider the situation in which the IJVs (and local firms) are active in the upstream sector, hence supplying local firms in the downstream sector (situation B in Figure 1). The analysis is similar to the one before, but recall that in this situation the local upstream firms benefit from knowledge diffusion through knowledge spillovers, whereas the downstream firms receive MNE knowledge through knowledge transfer. First consider the effect of an increase in ρ on local upstream firms' profits (the explicit formulations are relegated to Appendix B3):

$$\frac{d\Pi_u}{d\rho} = \frac{p_u}{\sigma}(\underbrace{IDL_2}_{<0} + \underbrace{PE_3}_{<0}) + \underbrace{KS_2}_{>0} \tag{13}$$

As before, there are three effects: An indirect demand linkage effect (IDL_2), a price effect (PE_3) and a knowledge spillover effect (KS_2). First, the indirect demand linkage takes effect as a result of an increase in knowledge transfer from the IJV to the local downstream firms. As they become more efficient, the derived input demand decreases, lowering upstream firms' profits. Moreover, the higher IPP (i.e. the higher θ), the more knowledge is transferred downstream and the larger the negative effect on Π_u. Second, as similar as before, the price effect occurs because knowledge spillovers to local upstream firms and knowledge transfer by the MNE to the IJV affect all firms in the upstream sector simultaneously. This lowers the price index P_U and thus also per firm revenue. Moreover, the extent to which knowledge spillovers add to this effect is larger the lower θ. Third, the knowledge spillover effect obviously increases upstream profits, and this effect becomes stronger the lower is θ.

Finally, for local downstream firms we now have (the explicit formulations are relegated to Appendix B4):

$$\frac{d\Pi_d}{d\rho} = \underbrace{PE_4}_{<0} + \underbrace{KT_2}_{>0} + \underbrace{FL_1}_{>0} \tag{14}$$

We can distinguish a price effect (PE_4), a knowledge transfer effect (KT_2) and a forward linkage effect (FL_1). The negative price effect occurs because all downstream firms are similarly affected by knowledge transfer and decreased input prices. That is, they all become more productive and charge lower prices, thus decreasing per firm revenue. Note that θ has an ambiguous effect on this mechanism: On the one hand, it magnifies the negative effect through increased knowledge transfer, but on the other hand it reduces it through decreased knowledge spillovers to upstream firms (and hence, a smaller decrease in input prices). The knowledge transfer effect obviously increases downstream firm profits, and the more so the higher is θ. Finally, the forward linkage effect occurs because knowledge spillovers from the IJV to local upstream firms, as well as knowledge transfer from the MNE to the IJV, decrease input prices for downstream firms, thus increasing their profits. In this case, an increase in θ has an unambiguously negative effect, as it serves to decrease knowledge spillovers.

3.3 Signing the effects

All total derivatives derived contain effects that are opposite in sign. Moreover, as can be seen from the expressions in the Appendix, deriving conditions under which their sign is unambiguous is not straightforward for most of these derivatives. A lot of this ambiguity is caused by the often opposing effects of IPP (θ). Indeed, as it turns out, many of the expressions simplify substantially when considering the extreme cases, i.e. when $\theta = 0$ or $\theta = 1$. In Table 1 below we summarize the signs of the total derivatives, also considering the cases in which $\theta = \{0, 1\}$. The derivations can be found in the Appendix.

<< INSERT TABLE 1 ABOUT HERE >>

First consider the effects through backward linkages, i.e. $d\Pi_u/d\rho$ with MNEs downstream. When θ is variable or when $\theta = 0$, the effect of a change in ρ on upstream profits is indeterminate in (11). However, given that the conditions in Table 1 are met, the effect is unambiguously positive for $\theta = 1$. Obviously, $\theta = 1$ indicates perfect IPP and upstream knowledge transfer by the MNE is at its maximum, *ceteris paribus* maximizing the positive effect of KT_1 in (11). Moreover, the condition implies that the positive effect is more likely (i) the smaller are total variable costs relative tot total fixed costs in the downstream industry (the LHS of the condition), (ii) the larger is α and (iii) the larger is η. The latter effect is caused by the fact that a higher η - implying a more price-sensitive downstream demand - translates the downstream price decrease (due to a decrease in P_U following increased knowledge transfer) into higher downstream demand, and thus also higher derived demand for upstream intermediates. This effect in turn is larger, the larger is the intermediate input share of downstream firms α. The first effect occurs through the backward demand linkage BL_1: Since downstream fixed costs are only affected through knowledge spillovers, whereas marginal costs both through knowledge spillovers and price effects, the total negative effect on upstream firms of these combined effects will be lower, the smaller are variable costs relative to fixed costs.

Next consider the effects through forward linkages, i.e. $d\Pi_d/d\rho$ with MNEs upstream. The table shows that in all cases, $\varepsilon > 2$ is a sufficient condition for this derivative to be positive. The reason for this is that although the negative price effect PE_4 in (14) becomes more severe when downstream products become better substitutes (i.e. when ε is higher), at the same time also the positive impact of both KT_2 and FL_1 are more pronounced; the resulting downstream price decreases that follow from them have a larger impact on firm profits when ε is higher. These two positive effects consistently outweigh the negative effect of PE_4 when $\varepsilon > 2$.

Finally, in order to consider the intra-industry effects of a change in ρ, we have to consider both $d\Pi_d/d\rho$ with MNEs downstream, as well as $d\Pi_u/d\rho$ with MNEs upstream, for in practice MNEs will simultaneously serve as downstream (customer) firms for some local companies, and as upstream (supplier) firms for others. First consider $d\Pi_d/d\rho$ with MNEs downstream: We see that in both the extreme cases ($\theta = 0, 1$) its sign is unambiguously positive. The reason is that in both cases, one of either two positive effects in (12) is maximized, which more then compensates the remaining negative effect of PE_2. Specifically, when $\theta = 0$, KS_1 is maximized and when $\theta = 1$, IDL_1 is maximized. For $d\Pi_u/d\rho$ with MNEs upstream, we see a conditional positive effect when $\theta = 0$ and an unconditional negative effect when $\theta = 1$. The latter is obvious: If $\theta = 1$, KS_2 in (13) is zero, so that only the negative effects of IDL_2 and PE_3 remain. When $\theta = 0$, the negative effect of IDL_2 disappears and the effect of KS_2 is maximized. The condition states that the larger fixed costs are relative to marginal costs (or more precisely: the more important the effect of knowledge diffusion on fixed rather than marginal costs) the more likely it is that $d\Pi_u/d\rho > 0$. The reason is that the negative price effect PE_1 only works through marginal costs, whereas the positive knowledge spillover effect KS_2 works both through fixed and marginal costs. Taken together, these effects imply that horizontal (intra-industry) effects of increasing ρ are positive if $\theta = 0$ and fixed costs are large relative to marginal costs, whereas they are ambiguous if $\theta = 1$.

In the remainder of this paper we will empirically explore these insights regarding the horizontal and vertical effects of MNE ownership on local firms. Moreover, the cross-country nature of our firm panel also allows us the empirically investigate the derived effects of differences in IPP.

4 Data and methodology

4.1 Methodology

Although our theoretical model derives predictions regarding the relationship between firm profits and MNE ownership, the extant literature on knowledge diffusion from FDI usually considers the effect of MNE presence on local firms' productivity. In order to enhance comparability of our results, we also follow this approach in the empirical section of the paper. Moreover, from the profit functions in Section 2 it is clear that there exists a positive and proportional relationship between firm productivity and firm profits.

The empirical model that we will estimate takes the following generic form:

$$\begin{aligned} \omega_{ijkt} &= \beta_0 + \beta_1 Horizontal_{jkt} + \beta_2 Backward_{jkt} + \beta_3 Forward_{jkt} \\ &\quad + \boldsymbol{\beta}_4 \mathbf{X}_{it} + D_j + D_k + \varepsilon_{ijkt} \end{aligned} \tag{15}$$

where i, j, k and t index firm, industry, country and time (year) respectively, ω is firm level productivity, $Horizontal$ is a measure of intra-industry MNE presence, $Backward$ ($Forward$) is a measure of MNE presence in customer or downstream (supplier or upstream) industries, $\mathbf{X}$ is a vector of firm level control variables, D_j and D_k are two sets of industry and country dummies, ε is an error term which is clustered at the industry level and assumed to be normally distributed, and the β's are the parameters to be estimated. The precise measurement of these variables is explained below.

A well-known problem with empirical models such as the one in (15) is the measurement of the dependent variable. Productivity is usually computed as the error term of a production function. However, to the extent that (expected) changes in productivity are observed or anticipated by firms' managers, the requirement of independence between the error term and the independent variables is violated, since managers may adjust variable inputs and production factors (such as labor) in anticipation of productivity changes.

Olley and Pakes (1996) suggest a robust estimator to tackle this issue. The underlying idea is that there exists a relationship between unobserved productivity on the one hand, and observable investment and capital on the other hand. Using this relationship, one can control for productivity in the production function estimation, by adding the function of investment and capital in addition to labor and capital (and material) inputs.[7] Levinsohn and Petrin (2003) extend this approach to situations in which there are a lot of zero observations on firm level investment, in which case it is not possible to invert the investment function, and hence to derive the productivity function. Since virtually all of our firms have positive observations on investment, we will use the Olley and Pakes (1996) procedure to estimate productivity.[8]

One important additional issue we need to tackle is the fact that our theoretical model does not suggest a clear functional form regarding the relationship between MNE ownership in its subsidiary and local firm profits (and productivity). This can be noted from the expressions of the total derivatives (cf. Appendix), which themselves are polynomial functions of MNE ownership ρ. Moreover, the degree of the polynomial in ρ depends on the elasticities of substitution and demand. A second issue in this regard is that some parameters in our model may be functions of ρ themselves, such as the different elasticities of substitution or the input and output shares, which further induces the different total derivatives to be (polynomial) functions of ρ. Hence it would be inappropriate to specify a functional form empirically *ex ante.* Fortunately, we can use (semiparametric) partial linear regression analysis to get a clue regarding the proper empirical specification.

Specifically, the generic partial linear regression model in our case takes the

[7] Since the appropriate functional form of the function of investment and capital is not known, Olley and Pakes (1996) use a third-order polynomial expansion in both variables to proxy the function. We follow this procedure in our production function estimation.

[8] In order to empirically implement the estimator, we use a programme developed by Arnold (2003).

following form:

$$y_i = g(z_j) + \gamma \mathbf{X}_i + \eta_{ij} \tag{16}$$

where i and j again index firm and industry respectively, $g(z)$ is the nonparametric component of the model for which the functional form is determined using a Kernel estimator, $\mathbf{X}$ is a vector of (firm level) variables that enter the model in the usual parametric fashion, and η is an error term. In the context of the present paper, the variables measuring MNE presence would enter the non-parametric component, whereas the control variables enter the parametric component.

The model in (16) can be estimated by using a difference estimator (Robinson, 1988). Lokshin (2006) proposes the following estimator of the model, based on Yatchew (1997):

$$\sum_{j-1}^{m} d_j y_{i-j} = \sum_{j-1}^{m} d_j g(z_{i-j}) + \gamma \left(\sum_{j-1}^{m} d_j \mathbf{x}_{i-j} \right) + \sum_{j-1}^{m} d_j \eta_{i-j} \tag{17}$$

where m is the order of differencing and the d's are the differencing weights.[9] When optimal weights d are chosen, OLS estimation can be consistently applied to (17) in order to obtain estimates for the parametric part of the model. If we denote the resulting estimator by $\hat{\gamma}_{diff}$ we can retrieve the nonparametric component in (16) as follows:

$$y_i - \hat{\gamma}_{diff} x_i = g\left(z_j\right) + (\gamma - \hat{\gamma}_{diff}) \mathbf{X}_i + \varepsilon_i \simeq g(z_j) + \eta_i$$

We can then use a nonparametric estimator to estimate the nonparametric component $g(z_j)$. Here we again follow Lokshin (2006) who proposes the use of a Locally Weighted Scatterplot Smoother (lowess). Lowess belongs to the class of Nearest Neighbours Estimators: It estimates local polynomials to derive a functional form for $g(.)$, based on the distribution of the observations in a zy-scatterplot. The local polynomial estimation is repeated over small parts of the distribution, where the partitioning (in so-called bandwidths) is variable. This results in a smoothed fit of the relationship between z and y, which can be depicted in zy space.

Finally, we need a way to determine whether or not the nonparametric component in (16) makes a significant contribution to the model. Obviously, since we are not estimating any parameter values, we cannot use regular test statistics to determine significance. Instead, Lokshin (2006) proposed the following test statistic:

$$V = \sqrt{mN}(s_{res}^2 - s_{diff}^2)/s_{diff}^2 \quad \sim \mathrm{N}(0,1) \tag{18}$$

where s_{res}^2 is the mean square residual of the parametric regression and s_{diff}^2 the squared residual of the semi-parametric regression. Hence, if this test statistic

[9] These weights have to satisfy two conditions: (i) $\sum_{j-1}^{m} d_j = 0$, which assusres that the nonparametric component in (16) is removed, and (ii) $\sum_{j-1}^{m} d_j^2 = 1$ which assures that the residuals in (16) have variance σ_η^2.

surpasses the standard normal critical values at usual significance levels, we can conclude that the nonparametric component contributes significantly to the model in (16).

Despite the attractive property of not having to specify an explicit functional form between productivity effects and MNE ownership, there are some other caveats of partial linear regression analysis. The most important of these is that the method of Lokshin (2006) is only applicable to cross-section samples, so that we loose a lot of information contained in the time-series dimension of the data. The second drawback is that this method does not allow for clustering of the error term, which is problematic when estimating firm-level productivity effects while using firm and sector level explanatory variables. Third, because of the need for a fairly large sample to consistently estimate the partial linear model (the so-called *curse of dimensionality* in semiparametric and non-parametric regression analysis), it is unwarranted to split up the sample according to IPP levels, as this would heavily reduce the size of the resulting subsamples. Because of these drawbacks, we use the semiparametric approach mainly for exploratory purposes, and revert to a more standard parametric specification to tackle these three issues.

Summarizing, in order to obtain a proper estimate of our dependent variable in model (15) we use the Olley and Pakes (1996) procedure. Moreover, since we have no clear theoretical indications regarding the proper functional form of the relationship between firm productivity and MNE ownership, we use semiparametric regression analysis to find the best parametric specification for this relationship. We will then take the functional forms suggested by the partial linear regression models and impose it in a standard parametric regression model like the one in (15).

4.2 Data

Our sample contains a short panel of 1549 large, publicly traded firms that are active in 20 countries and 18 sectors during the period 2000-2005. Of these firms, 327 are partly owned by an MNE. In order to obtain the production function parameters with the Olley and Pakes (1996) procedure, we estimated production functions at the two-digit ISIC Rev. 3 level. A full list of countries and sectors is included in the Appendix.

Our main variable of interest, i.e. the extent of intra-industry MNE presence, is computed as follows (cf. Javorcik, 2004):

$$Horizontal_{jt} = \frac{\sum_{i=1}^{n_j}(\rho_i \times Sales_{it})}{\sum_{i=1}^{N_j} Sales_{it}} \quad \text{s.t. } 0 \leq \rho_i < 1 \tag{19}$$

where n_j is the number of foreign-owned subsidiaries present in sector j, N_j is the total number of firms in sector j, ρ_i is the share of MNE ownership in the subsidiaries, and $Sales_i$ are the amount of firm-level sales. As with most empirical studies using MNE ownership, we only have observations for ρ in one year (2004), which we also use to compute $Horizontal$ in the other years.

In line with Javorcik (2004), we use input and output shares (constructed from OECD I-O tables) to compute forward and backward linkages.[10] Specifically, if α_{jk} denotes the output share of sector j flowing to sector k (with $j \neq k$) backward linkages are computed as:

$$Backward_{jt} = \sum_{k \neq j} (\alpha_{jk} \times Horizontal_{kt}) \tag{20}$$

where $Horizontal_k$ is defined as in (19). Hence, in line with the theoretical model developed in Section 2, the extent of backward linkages is proxied by the amount of inter-industry sales from industry j to k.

Forward linkages are computed in an analogous manner:

$$Forward_{jt} = \sum_{j \neq k} (\mu_{jk} \times Horizontal_{kt}) \tag{21}$$

where μ_{jk} is the share of inputs that sector j obtains from sector k. Javorcik (2004) nets out exports from the host country to other countries from $Hoirzontal_{kt}$ in this case,.since such exports are obviously not destined for local sector j. However, due to lack of data we are not able to follow this approach, and have to settle with the computation in (21).

As explained in the previous section, our dependent variable is the productivity of local firms, computed using the Olley and Pakes (1996) methodology, and using data on net sales and revenue, employment, net fixed capital stocks and total investment for the years 2000-2005.

We add two control variables: First, we use a measure of firm size, measured by (the log of) total assets of the firm. The expected sign of this variable is unclear: Some authors have argued that large firms are conducive to innovation and hence productivity, because of economies of scale (Cohen and Klepper, 1996). Yet others argue that resources are not easily and efficiently allocated in large firms, hence wasting productive resources and decreasing productivity (Acs and Audretsch, 1990). The sign of this variable is thus an empirical matter. Second, in order to also incorporate a relative measure of firm size, we use the share of firm-sales in total industry-sales (i.e. market share) as an additional control variable. Again, the sign of this variable is not clear *ex-ante*. Table 2 below presents some summary statistics and pairwise correlations between the variables.

<< INSERT TABLE 2 ABOUT HERE >>

We also have to construct variables that enable us to test the conditions in Table 1. For this purpose, we follow earlier research (Javorcik, 2004*b*; Allred and Park, 2007) and use the Ginarte and Park (1997) dataset containing data on the strength of national IPP systems .[11] The most recent set of observations

[10] Although our data pertain to the period 2000-2005, the most recent I-O tables available are from 2002, so that we use these data to compute input-output shares for the entire period.

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

relate to the year 2000, which are the ones we have used in the empirical part of the paper. The IPP index is made up out of five different components, all rated on a 0 to 1 scale (cf. Ginarte and Park, 1996 for a detailed description of this index). Taken together, the IPP index is measured along a 5 point scale, where a value of 0 indicates very weak IPP and 5 indicates very strong IPP.

Regarding the horizontal productivity effects, we noted that they are more likely to be positive under $\theta = 0$ when fixed costs make up a relative large share of total costs (i.e. fixed and variable costs). We use data on net fixed assets F (property, plant and equipment) to capture firm-level fixed costs, and data on salaries and benefit expenses L to capture variable costs. We then construct a variable $(F + L)/L$ which corresponds with the condition in Table 1.

For forward productivity effects ($d\Pi_d/d\rho$ with MNEs upstream) we established that if the elasticity of substitution ε between upstream products is large enough, this effect will be positive. If we interpret ε as a measure of upstream competition (with higher ε indicating more substitution and hence more competition) we can construct a Herfindahl index to measure the inverse of ε. Hence, for each country-industry-year combination in our sample, we construct a Herfindahl index which captures all our sample-firms which belong to a particular sector.

Finally, the condition regarding backward productivity effects ($d\Pi_u/d\rho$ with MNEs downstream) depends *inter alia* on α and η. α is already incorporated in the computation of (20). Since we do not have the data to compute proper estimates of η, we will just focus on α in the empirical part of the paper.

5 Empirical results

5.1 Semiparametric results

Before turning to the regression results, we first briefly consider the productivity difference between local firms and IJVs, since the presumed productivity superiority of MNEs and hence IJVs vis-à-vis local firms lies at the heart of our model, and as such at the hart of the knowledge diffusion process. Comparing the log of productivity levels of the 327 IJVs in our sample versus the 1222 local firms, the former have an average productivity of 5.80 and the latter 5.02. A paired t-test strongly rejects the equality of these two means ($t = 14.3$). Hence, the superiority of IJVs with respect to local firms on productivity as assumed in our theoretical model is confirmed in our sample.

First we consider the results of the semiparametric partial linear regression model. We will investigate the effect of the three different MNE presence variables separately, in order to obtain the empirical functional relationship between productivity and the relevant MNE ownership share. As explained in the previous section, the partial linear regression estimator we use is only applicable in cross-sections. Thus all results reported in this subsection pertain to the year 2004, which is the year in which the MNE ownership shares were observed. The results of the partial linear regression model are reported in Table 3 below. Figure 2 contains the resulting non-parametric relationship between productivity and each of the MNE presence variables.

The first column in Table 3 adds the horizontal variable from (19) to the non-parametric component of the model. As indicated by the test statistic V from (18), the non-parametric component enters the model highly significantly. Panel (a) in Figure 2 depicts the implied relationship. We find that an increase in MNE ownership in the IJV increases local firms' productivity. However, it is also clear that this relationship is not linear, but characterized by decreasing returns to MNE ownership at low levels of MNE ownership, and increasing returns to MNE ownership at high levels. Hence, the semiparametric model suggests a cubic relationship between intra-industry MNE ownership and local firms' productivity.

<< INSERT TABLE 3 ABOUT HERE >>
<< INSERT FIGURE 2 ABOUT HERE >>

In the second column we put the backward variable from (20) in the non-parametric component. The test statistic V again indicates that the non-parametric component enters the model highly significantly, and panel (b) in Figure 2 depicts the relationship between the downstream MNE ownership share and upstream local firms' productivity. The figure demonstrates a quadratic relationship, although the 95% confidence interval around this relationship is quite large.

Finally, in column three of Table 3 we put the forward variable from (21) in the non-parametric component of the model. Forward spillovers enter the model highly significantly and from panel (c) in Figure 2 we see that the relationship between upstream MNE ownership and downstream productivity of local customers is again characterized by a quadratic relationship. But also in this case, the 95% confidence interval is rather wide.

Both firm size and market share are significant and positive, indicating that both absolute firm size as well as firm size relative to the market are conducive to productivity. In terms of model fit, the models perform rather well, indicating that the industry and country fixed effects also absorb a lot of the variation in firm productivity. However, in order to tackle the three problems described in the previous section, we have to revert to parametric regression analysis. In doing so, we can use the outcomes of the semiparametric models as guide regarding the parametric model specification. Specifically, the semiparametric results suggest that we need quadratic and cubic specifications to capture the relationship between firm productivity and MNE ownership. Hence, we construct two new variables:

$$Horizontal^2_{jt} = \frac{\sum_{i=1}^{n_j}(\rho_i^2 \times Sales_{it})}{\sum_{i=1}^{N_j} Sales_{it}} \quad \text{s.t. } 0 \leq \rho_i < 1 \tag{22}$$

$$Horizontal^3_{jt} = \frac{\sum_{i=1}^{n_j}(\rho_i^3 \times Sales_{it})}{\sum_{i=1}^{N_j} Sales_{it}} \quad \text{s.t. } 0 \leq \rho_i < 1 \tag{23}$$

These two variables - in combination with $Horizontal$ from (19) - should be able to capture the intra-industry productivity effects in a parametric setup. Using these, we can also construct two additional variables to parametrically proxy the quadratic relationship between downstream (upstream) MNE ownership and upstream (downstream) productivity:

$$Backward^2_{jt} = \sum_{k \neq j} (\alpha_{jk} \times Horizontal^2_{kt}) \tag{24}$$

$$Forward^2_{jt} = \sum_{j \neq k} (\mu_{jk} \times Horizontal^2_{kt}) \tag{25}$$

5.2 Parametric results

Table 4 below specifies parametric regression models, including all three diffusion variables, as well as the two control variables, while exploiting both the cross-section and the time variation of the data and splitting up the sample in high and low IPP countries in columns (2) and (3). The standard errors are robust and have been allowed to cluster at the industry level.

The results for the total sample in the parametric model are reported in column (1) and are rather different from the semiparametric results. Regarding the horizontal productivity effects, instead of a cubic relationship we actually observe a squared relationship. Specifically, there appear to be decreasing returns to MNE ownership, as depicted in panel a of Figure 3:[12] After an initial increase in intra-industry productivity effects following an increase in ρ, the relationship becomes negative around 30% of MNE ownership. Regarding the backward and forward effects, none of them are significant.

<< INSERT TABLE 4 ABOUT HERE >>

We proceed by splitting up the sample in two groups: Those with a relatively high IPP index and those with a relatively low IPP index. We use the median IPP level in the total sample as the cutoff point: This level is 4.19.[13] Column 2 in Table 4 presents the result for the low-IPP sample. In contrast to the total sample results in column (1), we now observe a cubic relationship between MNE ownership and intra-industry productivity effects. As shown in panel b of Figure 3, between 0%-20% of MNE ownership there is a positive relationship

[12] All the panels in Figure 3 are constructed with generic formulas $y = (ax + bx^2 + cx^3) \cdot z$, where y is producitivity, x is MNE ownership (between 0 and 100) and z is the mean value of either $Horizontal$, $Backward$ or $Forward$, computed without correcting for MNE ownership shares (these are 0.1, 0.01 and 0.03 respectively). The coefficients a, b and (if applicable) c are the coefficient estimates from Table 4.

[13] Note that this median value pertains to the country-level rather than the industry or firm-level, so that the number of (firm-year) observations is not equally split between the two groups. Admittedly, a median value of 4.19 is rather high, which is caused by the fact that we have mainly high-developed countries in our sample. Also, it implies that the variation in IPP is much higer in the low-IPP sample (from 2.9 to 4.19)) than in the high-IPP sample (from 4.19 to 5).

with intra-industry productivity effects, but this becomes negative after 20%. The subsequent decline in total productivity is larger than in the total sample. The minimum in this relationship is beyond the relevant domain (0%-100%). As before, both the backward and forward effects are insignificant.

<< INSERT FIGURE 3 ABOUT HERE >>

Column (3) in the table repeats this model for the high-IPP countries. The horizontal productivity effects change back to a quadratic form, with the turning point from a positive to a negative relationship at 55% (panel *c* of Figure 3). We now also observe significant backward productivity effects, for which there appear to be decreasing returns to MNE ownership as well. As shown in panel *d* of Figure 3, the turning point of the relationship lies around 50%. Also note that the backward effect is similar in magnitude as the horizontal effect.

Both control variables are significant as in the semiparametric regressions. Firm size is consistently positive, indicating that larger firms are more productive, and market share is consistently positive as well, indicating that large firm size *relative to market size* is generally also conducive to firm productivity. Regarding model fit, all three models perform rather well with R^2s around 80%.

In Table 5 we repeat these regressions, now taking into account the conditions derived in Table 1. Specifically, for all three regressions we interact the forward variable with a Herfindahl index. Additionally, in the low IPP sample we interact the horizontal variable with our $(F+L)/L$ variable. As mentioned before, the effect of α on the backward variable is already included by construction.

Column (1) shows that the horizontal productivity effects are virtually similar as in column (1) of Table 4. However, we now also observe significant effects of our forward variable, interacted with the Herfindahl index. Panel *a* of Figure 4 shows the individual forward productivity effect: The relationship is positive up to 50% of MNE ownership and then becomes negative. Panel *b* depicts the interacted relationship, where we have taken the extreme case (i.e. a Herfindahl index of 1). As can be seen, the effects are almost reversed now, with a negative relationship up to 40% of MNE ownership.

<< INSERT TABLE 5 ABOUT HERE >>

In column (2) we also interact the horizontal variable with $(F+L)/L$. Both the individual and interacted effects are highly significant. Panel *c* in Figure 4 shows the individual effects, which differ heavily from those in panel *b* of Figure 3. In this case, the relationship is positive for MNE ownership below 30% and above 60%, and negative in between. In stark contrast, the interacted effects shown in panel *d* of Figure 4 demonstrate a consistently negative relationship between MNE ownership and intra-industry productivity.[14] Regarding the forward effects, we now only observe a significant effect of the interaction terms. The effects are similar to those in panel *b* of Figure 4, although the turning point now lies around 50%.

[14] The variable $(F+L)/L$ was evaluated at its mean of 14 when constructing the graph.

<< INSERT FIGURE 4 ABOUT HERE >>

Finally, column (3) repeats the model in column (1) for the high IPP sample. In contrast to Table 4, there now is a cubic relationship between MNE ownership and intra-industry productivity, shown in panel *e* of Figure 4. The relationship is now positive over the entire domain, with decreasing returns to ρ up until 70%, after which there are increasing returns. As before, backward productivity effects are significant, showing a similar pattern as in panel *c* of Figure 3. The individual forward productivity effect is now linear and positive, whereas the interaction effect shows a effect similar to panel *b* in Figure 4, with the turning point at 20%.

As before, the control variables are both positive and significant throughout all the regressions, and with R^2s of around 80% the models perform well.

6 Discussion and conclusion

In this paper we have theoretically and empirically investigated the relationship between horizontal and vertical productivity effects from MNEs with varying degrees of foreign ownership to local (host-country) firms. Theoretically, we have established the ambiguity in this relationship due to the simultaneous interplay of (sometimes) opposing knowledge diffusion, price and direct and indirect demand and supply linkage effects, and the mediating effect of intellectual property right protection (IPP). We have also distinguished between unintentional knowledge spillovers and intentional knowledge transfers, where we argue the former mainly occur intra-industry, whereas the latter dominate inter-industry knowledge diffusion. Eventually we derived a number of conditions under which some of the ambiguous productivity effects are more likely to be positive or negative.

We then empirically investigate the relationship between horizontal and vertical MNE ownership in foreign affiliates and local firms' productivity, using a panel of 1904 local firms and 327 MNEs in 20 countries and 18 industries during the period 2000-2005. We utilize both semiparametric partial linear regression analysis for exploratory purposes, as well as standard parametric panel data techniques.

Regarding horizontal (intra-industry) productivity effects, we initially find that there are decreasing returns to MNE ownership. I.e. although productivity effects first increase with MNE ownership, at some point the relationship becomes negative. From our theoretical model, we can derive that for low degrees of MNE ownership, the positive knowledge spillover and indirect upstream demand linkages dominate, whereas for increased degrees of MNE ownership, the negative price effect and indirect downstream demand linkages dominate. One implication is that increased MNE ownership affects input and output shares asymmetrically: It appears that local input demand decreases faster with increased MNE ownership than local output supply, which may cause the shift from positive upstream to negative downstream linkages. Moreover, we observe that the relationship between firm productivity and MNE ownership occurs at higher degrees of MNE ownership in high-IPP systems relative to low-IPP systems. This may be a reflection of the fact that MNE owners feel more secure in transferring knowledge upstream in high-IPP systems than in low-IPP systems, as we already conjectured in our theoretical setup.

However, these results change quite a bit when we consider the interaction effect between our measure of horizontal foreign presence and the inverse share of variable costs in total costs of local firms. Our theoretical model predicts that in low-IPP systems, an increase in this inverse share should increase the likelihood of positive productivity effects. The reason for this is that the negative price effect in our model only works through marginal costs, whereas the positive knowledge spillover effect works both through fixed and marginal costs. However, our empirical results reach exactly the opposite conclusion: For higher inverse shares (indicating a larger share of fixed costs in total costs), the productivity effects from increased MNE ownership are actually negative, whereas for lower inverse shares they are largely positive. The implication is that positive knowledge spillover (and upstream indirect demand linkage) effects work more through marginal or variables costs than through fixed costs. The fact that our model predicts exactly the opposite is due both to an assumption (i.e. that both fixed and marginal costs are affected equally by knowledge spillovers and transfers) as well as the Dixit-Stiglitz monopolistic competition setup (which makes prices a function of marginal costs only). Our empirical results indicate that these modelling artifacts may be at odds with reality.

Regarding backward productivity effects, our theoretical model demonstrates opposing positive effects of upstream knowledge transfer, and negative effects of upstream price effects. Additionally, there is an ambiguous effect of backward linkages. We also find that at least in high-IPP countries, an increase in the input share will increase the likelihood of a positive effect, as it serves to make the backward linkages positive and hence tilt the balance in favor of the positive effects. Our empirical results are very consistent with this prediction. Indeed, in none of the total sample or low-IPP sample results do we find significant backward productivity effects, indicating the theoretical ambiguity. However, in the high-IPP samples we find a consistently significant effect. Moreover, we again find decreasing returns to MNE ownership, with a positive relationship only for relatively low degrees of MNE ownership. If we link this result with the literature on international input sourcing by MNEs (Taveres and Young, 2006), this result is very consistent with our theoretical predictions: According to this literature, increased MNE ownership increases the extent to which a subsidiary sources its inputs internationally instead of locally, hence decreasing the (local) input share. According to our model, this would eventually induce a negative relationship between MNE ownership and backward productivity effects for larger degrees of MNE ownership, which is exactly what we observe.

Finally, our model indicates that in all cases, forward productivity effects will only take effect if there is a sufficient degree of downstream competition, the reason being that in that case positive forward linkages and knowledge transfer effects outweigh negative demand effects. Indeed, when we just consider forward productivity effects separately (i.e. without simultaneously considering downstream competition) we find no effects whatsoever. Only after interacting this effect with a Herfindahl index of downstream competition do we find consistently significant effects. The positive relationship between MNE ownership and forward productivity effects in a highly competitive context is most pronounced in the high-IPP sample, where the effect is positive and linear. In the low-IPP sample there essentially is no effect in this case, whereas the relationship in the total sample is quadratic, reaching an optimum around 50%. These results are thus partly in accordance with our theory. Regarding the effects in low-competitive environments, we indeed find a negative relationship between MNE ownership and forward productivity effects for low degrees of MNE ownership. Nonetheless, for a large range of MNE ownership degrees, the relationship is positive, contrary to what our model predicts. There are two possible explanations for this: The first is that there exists a relationship between upstream MNE ownership and downstream competition, which we have not modelled, but which does not seem unlikely. Second, the derived conditions are sufficient conditions, but not necessary, so that the empirical results may be picking up something else.

So what does all of this imply for the effectiveness and usefulness of well-developed IPP policy? One thing that both our model and our empirical results suggest, is that a strong IPP system stimulates the intentional inter-industry transfer of knowledge from MNEs to local firms, the extent of which depends on the amount of MNE ownership. Indeed, only in the high IPP samples do we find significant and positive effects of backward productivity effects for low degrees of MNE ownership. Also for forward productivity effects, we find a positive relationship with MNE ownership in the high-IPP sample, given that downstream competition is sufficient. Even for horizontal productivity effects, we find an unconditional positive relationship with MNE ownership in high-IPP countries, which is again probably due to the increased willingness of intentional inter-industry knowledge transfer, inducing positive indirect demand linkage effects (although we cannot separate these empirically). In sum, it seems that developing well-functioning IPP regulations is only to the benefit of the country involved: Even though firms (with a relatively large share of variable costs in total costs) in low-IPP countries may also benefit from positive horizontal productivity effects, the positive inter-industry effects are largely absent.

Finally, this study is characterized by some limitations, the most important of which is the fact that our sample only consists of large and publicly traded firms. As such, the results of this study cannot be readily generalized beyond the specific characteristics of our sample, and moreover, a direct comparison to most of the earlier empirical one-country studies is not possible either. However, a trade-off exists between encompassing multiple countries in the analysis, versus increasing the firm-sample beyond only the largest firms, which inhibits investigating country-level effects on the knowledge spillover or transfer process. Another limitation is the fact that our sample mainly contains developed countries, which mainly translates into a limited variation on our IPP variable. Increasing the sample to include also (large and traded) firms from less developed countries and emerging markets would be a valuable extension of this study, again specifically with regard to investigating country-level determinants or moderators of the knowledge diffusion process.

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Appendix A

Here we consider the case in which the IJV (and its local competitors) are active in the upstream industries, supplying other local firms in downstream industries. That is, we now consider part B of Figure 1. This allows us to investigate the direct effect of demand and supply effects and knowledge diffusion through forward linkages (rather than indirectly, via backward linkages).

The analysis is very similar to the one in the main text considering part A of Figure 1. The upstream industry price index is now given by:

$$P_U = (n_u p_u^{1-\sigma} + n_{IJV} p_{IJV}^{1-\sigma})^{1/(1-\sigma)}$$

As before, demand for intermediate products (which will be derived below) is denoted by I so that applying Sheppard's lemma yields demand for individual upstream firms' products:

$$\begin{aligned} x_u &= p_u^{-\sigma} I P_U^{\sigma} \\ x_{IJV} &= p_{IJV}^{-\sigma} I P_U^{\sigma} \end{aligned}$$

Profit functions for upstream firms are given by:

$$\begin{aligned} \Pi_u &= p_u x_u - (F_u^S + \beta_u^S x_u) w \\ \Pi_{IJV} &= p_{IJV} x_{IJV} - (F_{IJV} + \beta_{IJV} x_{IJV}) w \end{aligned}$$

In this case, the *upstream* firm benefits from MNE knowledge diffusion through spillovers rather than transfers, since it is a direct competitor of the IJV. Substituting the individual demands and maximizing profits yields the equilibrium pricing conditions:

$$\begin{aligned} p_u &= \frac{\sigma \beta_u^S w}{(\sigma - 1)} \\ p_{IJV} &= \frac{\sigma \beta_{IJV} w}{(\sigma - 1)} \end{aligned}$$

In the downstream, the price index is given by:

$$P_D = (n_d p_d^{1-\varepsilon})^{1/(1-\varepsilon)}$$

As before, total demand for downstream products is denoted by $YP_D^{-\eta}$ so that we can derive demand for individual downstream products:

$$x_d = p_d^{-\varepsilon} Y P_D^{\varepsilon - \eta}$$

Downstream firm profits are expressed as:

$$\Pi_d = p_d x_d - (F_d^T + \beta_d^T x_d)(\mu P_u + (1 - \mu) w)$$

where μ is the share of inputs that the downstream firm obtains from the upstream firms. Again note that in this case, the *downstream* firm benefits from knowledge diffusion through knowledge transfer rather than knowledge spillovers. Substituting demand into the profit function we can once more derive profit maximizing equilibrium prices:

$$p_d = \frac{\varepsilon \beta_d^T (\mu P_u + (1 - \mu) w)}{(\varepsilon - 1)}$$

We can now also write down an explicit function for derived demand for intermediate inputs:

$$I = \mu n_d (F_d^T + \beta_d^T x_d)$$

Appendix B

B1 IJVs in the downstream sector - $d\Pi_u / d\rho$

First consider the elements of $d\Pi_u / d\rho$:

$$
\begin{aligned}
BL_1 \quad \equiv \quad & \underbrace{\left(\frac{\partial I}{\partial F_{IJV}} + (1-\theta)\frac{\partial I}{\partial F_d^S}\right)(F_m - F_n) + \left(\frac{\partial I}{\partial \beta_{IJV}} + (1-\theta)\frac{\partial I}{\partial \beta_d^S}\right)(\beta_m - \beta_n)}_{\text{indirect knowledge spillover } <0} \\
& \underbrace{+\frac{\partial I}{\partial x_{IJV}}\frac{\partial x_{IJV}}{\partial p_{IJV}}\left[\frac{\partial p_{IJV}}{\partial \beta_{IJV}}(\beta_m - \beta_n) + \frac{\partial p_{IJV}}{\partial P_u}\frac{\partial P_u}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_n)\right]}_{\text{downstream demand linkage } >0} \\
& \underbrace{+\frac{\partial I}{\partial x_d}\frac{\partial x_d}{\partial p_d}\left[\frac{\partial p_d}{\partial \beta_d^S}(1-\theta)(\beta_m - \beta_n) + \frac{\partial p_d}{\partial P_U}\frac{\partial P_u}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_n)\right]}_{\text{downstream demand linkage } >0} \\
& \underbrace{+\left(\frac{\partial I}{\partial x_{IJV}}\frac{\partial x_{IJV}}{\partial P_D} + \frac{\partial I}{\partial x_d}\frac{\partial x_d}{\partial P_D}\right)\left(\begin{array}{c} \frac{\partial P_D}{\partial p_d}\left[\begin{array}{c} \frac{\partial p_d}{\partial \beta_d^S}(1-\theta)(\beta_m - \beta_n) \\ +\frac{\partial p_d}{\partial P_U}\frac{\partial P_u}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_n) \end{array}\right] \\ +\frac{\partial P_D}{\partial p_{IJV}}\left[\begin{array}{c} \frac{\partial p_{IJV}}{\partial \beta_{IJV}}(\beta_m - \beta_n) \\ +\frac{\partial p_{IJV}}{\partial P_U}\frac{\partial P_u}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_n) \end{array}\right] \end{array}\right)}_{\text{downstream price effect } <0}
\end{aligned}
$$

$$
PE_1 \equiv \frac{\partial x_U}{dP_U}\frac{\partial P_u}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_n)
$$

$$
KT_1 \equiv -w\theta\left[(F_m - F_u) + x_u(\beta_m - \beta_n)\right]
$$

Using the explicit expressions for the partial derivatives and collecting terms yields the following expression for $d\Pi_u/d\rho$:

$$
\begin{aligned}
\frac{d\Pi_u}{d\rho} \quad = \quad & \underbrace{\left[\frac{w\beta_u^T x_u}{\sigma - 1} \cdot \frac{\alpha\left(n_{IJV} + (1-\theta)n_d\right)}{I} - w\theta\right]}_{\text{Term 1}}(F_m - F_n) \\
& + \frac{w\beta_u^T x_u}{\sigma - 1}\underbrace{\left[\begin{array}{c} \frac{\alpha A_1}{\beta_{IJV}} + \frac{\alpha}{\beta_u^T}\left(A_1 + A_2\right)\frac{\alpha P_U \theta}{\alpha P_U + (1-\alpha)w} + \frac{\alpha A_2}{\beta_d^S}(1-\theta) \\ +\alpha(n_{IJV}x_{IV} + (1-\theta)n_d x_d) + \frac{\theta I}{\beta_u^T} \end{array}\right]}_{\text{Term 2}}(\beta_m - \beta_n)
\end{aligned}
$$

where

$$
A_1 \equiv (n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d)n_{IJV}(\varepsilon - \eta)\left(\frac{p_{IJV}}{P_D}\right)^{1-\varepsilon} - \varepsilon(n_{IJV}\beta_{IJV}x_{IJV})
$$

$$
A_2 \equiv (n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d)n_d(\varepsilon - \eta)\left(\frac{p_d}{P_D}\right)^{1-\varepsilon} - \varepsilon(n_d\beta_d^S x_d)
$$

In order to sign the derivative, note that the first term in Term 1 is positive and the second negative, so that Term 1 has an ambiguous sign. It can be shown that $A_1 < 0$ as follows:

$$\begin{aligned}
A_1 &< 0 \Longleftrightarrow X n_{IJV}(\varepsilon-\eta)\left(\frac{p_{IJV}}{P_D}\right)^{1-\varepsilon} < \varepsilon(n_{IJV}\beta_{IJV}x_{IJV}) \\
&\Leftrightarrow \frac{\varepsilon-\eta}{\varepsilon} < \frac{n_{IJV}\beta_{IJV}x_{IJV}P_D^{1-\varepsilon}}{X n_{IJV}p_{IJV}^{1-\varepsilon}} \\
&= \frac{n_{IJV}\beta_{IJV}p_{IJV}^{-\varepsilon}YP_D^{\varepsilon-\eta}P_D^{1-\varepsilon}}{X n_{IJV}p_{IJV}^{1-\varepsilon}} \\
&= \frac{\beta_{IJV}YP_D^{1-\eta}}{Xp_{IJV}} = \frac{\beta_{IJV}YP_D^{1-\eta}}{p_{IJV}(n_{IJV}\beta_{IJV}x_{IJV}+n_d\beta_d^S x_d)} \\
&= \frac{\beta_{IJV}YP_D^{1-\eta}}{p_{IJV}YP_D^{\varepsilon-\eta}(n_{IJV}\beta_{IJV}p_{IJV}^{-\varepsilon}+n_d\beta_d^S p_d^{-\varepsilon})} \\
&= \frac{\beta_{IJV}P_D^{1-\varepsilon}}{p_{IJV}(n_{IJV}\beta_{IJV}p_{IJV}^{-\varepsilon}+n_d\beta_d^S p_d^{-\varepsilon})} = 1
\end{aligned}$$

since $p_{IJV} = (\beta_{IJV}/\beta_d^S)p_d$. Since $\varepsilon > \eta$, this condition will always hold, and similarly for A_2. Moreover, this also implies that $A_1 + A_2 < 0$. Indeed, we have that:

$$A_1 + A_2 = -\eta(n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d) < 0$$

Note that we can rewrite Term 2 as follows:

$$\begin{aligned}
&\left[\begin{array}{c} \frac{\alpha A_1}{\beta_{IJV}} + \frac{\alpha}{\beta_u^T}(A_1+A_2)\frac{\alpha P_U\theta}{\alpha P_U+(1-\alpha)w} + \frac{\alpha A_2}{\beta_d^S}(1-\theta) \\ +\alpha(n_{IJV}x_{IV}+(1-\theta)n_d x_d) + \frac{\theta I}{\beta_u^T} \end{array}\right] \\
=\;& \underbrace{\frac{\alpha(A_1+n_{IJV}\beta_{IJV}x_{IJV})}{\beta_{IJV}}}_{<0} + \frac{\theta\left[\alpha^2(A_1+A_2)P_U + I(\alpha P_U+(1-\alpha)w)\right]}{\beta_u^T(\alpha P_U+(1-\alpha)w)} \\
&\underbrace{+(1-\theta)\frac{\alpha\left(A_2+n_d\beta_d^S x_d\right)}{\beta_d^S}}_{<0}
\end{aligned}$$

where the sign of the first and last term follow from the fact that $A_1, A_2 < 0$.[15] The sign of the second term is ambiguous however. We can derive a condition under which this term (and hence the entire Term 2) is negative, which obviously is the case if the numerator is negative:

$$\begin{aligned}
&\left[\alpha^2(A_1+A_2)P_U + I(\alpha P_U+(1-\alpha)w)\right] \\
=\;& \alpha\left\{\begin{array}{c} (n_{IJV}\beta_{IJV}x_{IJV}+n_d\beta_d^S x_d)\left[\alpha(1-\eta)P_U+(1-\alpha)w\right] \\ +(\alpha P_U+(1-\alpha)w)(n_{IJV}F_{IJV}+n_dF_d^S) \end{array}\right\} < 0
\end{aligned}$$

[15]Note that the condition in this case changes to $(\varepsilon-\eta)/(\varepsilon-1) < 1$ which still holds since $\varepsilon > \eta > 1$.

For this condition to hold it is necessary to have:

$$\frac{(n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d)}{(n_{IJV}F_{IJV} + n_d F_d^S)} < -\frac{\alpha(1-\eta)P_U + (1-\alpha)w}{\alpha P_U + (1-\alpha)w}$$

$d\Pi_u/d\rho$ **if** $\theta = 1$

If $\theta = 1$, Term 1 reduces to $-w(F_m - F_n) > 0$. Hence, a sufficient condition for $d\Pi_u/d\rho > 0$ then is:

$$\frac{(n_{IJV}\beta_{IJV}x_{IJV} + n_d\beta_d^S x_d)}{(n_{IJV}F_{IJV} + n_d F_d^S)} < -\frac{\alpha(1-\eta)P_U + (1-\alpha)w}{\alpha P_U + (1-\alpha)w}$$

$d\Pi_u/d\rho$ **if** $\theta = 0$

If $\theta = 0$, Term 1 is unambiguously positive and Term 2 unambiguously negative.

$$\frac{d\Pi_u}{d\rho} = \frac{\alpha w \beta_u^T x_u}{\sigma - 1}\left\{\begin{array}{c} \underbrace{\frac{(n_{IJV}+n_d)}{I}(F_m - F_n)}_{<0} \\ +\underbrace{\left[\frac{A_1 + n_{IJV}\beta_{IJV}x_{IJV}}{\beta_{IJV}} + \frac{A_2 + n_d\beta_d^S x_d}{\beta_d^S}\right](\beta_m - \beta_n)}_{>0} \end{array}\right\}$$

There is no concise sufficient or necessary condition which ensures $d\Pi_u/d\rho$ is either positive or negative in this case.

B2 IJVs in the downstream sector - $d\Pi_d/d\rho$

The elements of $d\Pi_d/d\rho$ are:

$$\begin{aligned} PE_2 \quad \equiv \quad & \frac{\beta_d^S(\alpha P_U + (1-\alpha)w)}{(\varepsilon - 1)}\frac{\partial x_d}{\partial P_D} \\ & \left[\begin{array}{c} \frac{\partial P_D}{\partial p_d}\left[\frac{\partial p_d}{\partial \beta_d^S}\left[(1-\theta)(\beta_m - \beta_d)\right] + \frac{\partial p_d}{\partial P_U}\left[\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_d)\right]\right] \\ +\frac{\partial P_D}{\partial p_{IJV}}\left[\frac{\partial p_{IJV}}{\partial \beta_{IJV}}(\beta_m - \beta_d) + \frac{\partial p_{IJV}}{\partial P_U}\left[\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_d)\right]\right] \end{array}\right] \end{aligned}$$

$$KS_1 \equiv -(\alpha P_u + (1-\alpha)w)(1-\theta)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right]$$

$$IDL_1 \equiv -\alpha(F_d^S + \beta_d^S x_d)\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^T}\theta(\beta_m - \beta_d)$$

Using the explicit expressions for the partial derivatives and collecting terms yields the following expression for $d\Pi_d/d\rho$:

$$\begin{aligned} \frac{d\Pi_d}{d\rho} \quad = \quad & (\varepsilon - \eta)\frac{p_d}{\varepsilon}x_d P_D^{\varepsilon-1}\left[p_d^{-\varepsilon}n_d A_3 + p_{IJV}^{-\varepsilon}n_{IJV}A_4\right](\beta_m - \beta_n) \\ & -(\alpha P_U + (1-\alpha)w)(1-\theta)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right] \\ & -\alpha(F_d^S + \beta_d^S x_d)\frac{P_U}{\beta_u^T}\theta(\beta_m - \beta_n) \end{aligned}$$

with

$$A_3 \equiv \frac{p_d}{\beta_d^S}(1-\theta) + \alpha\beta_d^S\theta\frac{\varepsilon}{\varepsilon-1}\frac{P_U}{\beta_u^T}$$

$$A_4 \equiv \frac{p_{IJV}}{\beta_{IJV}}(1-\theta) + \alpha\beta_d^S\theta\frac{\varepsilon}{\varepsilon-1}\frac{P_U}{\beta_u^T}$$

Signing this derivate is not straightforward. Therefore, we consider its sign under $\theta = 1$ and $\theta = 0$.

6.0.1 $d\Pi_u/d\rho$ if $\theta = 1$

If $\theta = 1$, $d\Pi_d/d\rho$ reduces to:

$$\begin{aligned}
\frac{d\Pi_d}{d\rho} &= \alpha\frac{P_U}{\beta_u^T}(\beta_m - \beta_n)\left[p_d x_d P_D^{\varepsilon-1}\beta_d^S\frac{(\varepsilon-\eta)}{\varepsilon-1}\left[p_d^{-\varepsilon}n_d + p_{IJV}^{-\varepsilon}n_{IJV}\right] - (F_d^S + \beta_d^S x_d)\right] \\
&= \alpha\frac{P_U}{\beta_u^T}(\beta_m - \beta_n)\left[\beta_d^S x_d\left\{p_d P_D^{\varepsilon-1}\frac{(\varepsilon-\eta)}{\varepsilon-1}\left[p_d^{-\varepsilon}n_d + p_{IJV}^{-\varepsilon}n_{IJV}\right] - 1\right\} - F_d^S\right]
\end{aligned}$$

Note that a sufficient condition for $d\Pi_d/d\rho$ to be positive is thus:

$$\begin{aligned}
p_d P_D^{\varepsilon-1}\frac{(\varepsilon-\eta)}{\varepsilon-1}\left[p_d^{-\varepsilon}n_d + p_{IJV}^{-\varepsilon}n_{IJV}\right] &< 1 \\
\frac{\varepsilon-\eta}{\varepsilon-1} &< \frac{P_D^{1-\varepsilon}}{p_d\left[p_d^{-\varepsilon}n_d + p_{IJV}^{-\varepsilon}n_{IJV}\right]} \\
\frac{\varepsilon-\eta}{\varepsilon-1} &< \frac{\left[p_d^{1-\varepsilon}n_d + p_{IJV}^{1-\varepsilon}n_{IJV}\right]}{\left[p_d^{1-\varepsilon}n_d + p_d p_{IJV}^{-\varepsilon}n_{IJV}\right]}
\end{aligned}$$

Given that $\varepsilon > \eta > 1$ the LHS of this condition < 1. Hence, if the RHS ≥ 1 the condition is always met. It can be shown that RHS ≥ 1 by noting that we in this case we need that $p_d \geq p_{IJV}$:

$$\begin{aligned}
p_d &\geq p_{IJV} \\
&\iff \frac{\varepsilon\beta_d^S(\alpha P_U + (1-\alpha)w)}{(\varepsilon-1)} \geq \frac{\varepsilon\beta_{IJV}(\alpha P_U + (1-\alpha)w)}{(\varepsilon-1)} \\
&\iff \beta_d^S \geq \beta_{IJV} \\
&\iff \theta\beta_d + (1-\theta)\beta_{IJV} \geq \beta_{IJV} \\
&\iff \beta_d \equiv \beta_n \geq \beta_{IJV} \text{ (since } \theta = 1) \\
&\iff \beta_n \geq \rho\beta_m + (1-\rho)\beta_n
\end{aligned}$$

Since we have assumed that $\beta_m < \beta_n$ this condition is always met for for all $\rho \in [0,1]$.

$d\Pi_u/d\rho$ **if** $\theta = 0$

If $\theta = 0$, $d\Pi_d/d\rho$ reduces to:

$$
\begin{aligned}
\frac{d\Pi_d}{d\rho} &= (\varepsilon-\eta)\frac{p_d}{\varepsilon}x_d P_D^{\varepsilon-1}\left[\frac{n_d p_d^{1-\varepsilon}}{\beta_d^S}+\frac{n_{IJV}p_{IJV}^{1-\varepsilon}}{\beta_{IJV}}\right](\beta_m-\beta_n) \\
&\quad -(\alpha P_U+(1-\alpha)w)\left[(F_m-F_d)+x_d(\beta_m-\beta_n)\right] \\
&= \left\{(\varepsilon-\eta)\frac{p_d}{\varepsilon}P_D^{\varepsilon-1}\left[\frac{n_d p_d^{1-\varepsilon}}{\beta_d^S}+\frac{n_{IJV}p_{IJV}^{1-\varepsilon}}{\beta_{IJV}}\right]-(\alpha P_U+(1-\alpha)w)\right\}x_d(\beta_m-\beta_n) \\
&\quad -(\alpha P_U+(1-\alpha)w)(F_m-F_d) \\
&= \left\{(\varepsilon-\eta)\frac{p_d}{\varepsilon}P_D^{\varepsilon-1}\left[\frac{n_d p_d^{1-\varepsilon}}{\beta_d^S}+\frac{n_{IJV}p_{IJV}^{1-\varepsilon}}{\beta_{IJV}}\right]-(\varepsilon-1)\frac{p_d}{\varepsilon\beta_d^S}\right\}x_d(\beta_m-\beta_n) \\
&\quad -(\alpha P_U+(1-\alpha)w)(F_m-F_d)
\end{aligned}
$$

Note that a sufficient condition for $d\Pi_d/d\rho > 0$ is:

$$\frac{(\varepsilon-\eta)}{(\varepsilon-1)}\left[\frac{n_d p_d^{1-\varepsilon}}{\beta_d^S}+\frac{n_{IJV}p_{IJV}^{1-\varepsilon}}{\beta_{IJV}}\right] < \frac{P_D^{1-\varepsilon}}{\beta_d^S}$$

If $\beta_d^S = \beta_{IJV}$ this condition reduces to:

$$
\begin{aligned}
\frac{(\varepsilon-\eta)}{(\varepsilon-1)}\left[\frac{n_d p_d^{1-\varepsilon}+n_{IJV}p_{IJV}^{1-\varepsilon}}{\beta_d^S}\right] &< \frac{P_D^{1-\varepsilon}}{\beta_d^S} \\
\frac{(\varepsilon-\eta)}{(\varepsilon-1)}\left[\frac{P_D^{1-\varepsilon}}{\beta_d^S}\right] &< \frac{P_D^{1-\varepsilon}}{\beta_d^S} \\
\frac{(\varepsilon-\eta)}{(\varepsilon-1)} &< 1
\end{aligned}
$$

which as we saw above is always the case. Given that $\beta_d^S = \theta\beta_d + (1-\theta)\beta_{IJV}$ and the fact that $\theta = 0$, we indeed have that $\beta_d^S = \beta_{IJV}$ so that this condition always holds.

B3 IJVs in upstream sector - $d\Pi_u/d\rho$

First consider the elements of $d\Pi_u/d\rho$:

$$IDL_2 = \theta\frac{w\beta_u^S}{(\sigma-1)}\frac{\partial x_u}{\partial I}\left(\frac{\partial I}{\partial F_d^T}(F_m-F_d)+\frac{\partial I}{\partial\beta_d^T}(\beta_m-\beta_d)\right)$$

$$PE_3 = \frac{w\beta_u^S}{(\sigma-1)}\frac{\partial x_u}{\partial P_U}(\beta_m-\beta_d)\left(\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial\beta_u^S}(1-\theta)+\frac{\partial P_U}{\partial p_{IJV}}\frac{\partial p_{IJV}}{\partial\beta_{IJV}}\right)$$

$$KS_2 = -w(1-\theta)\left[(F_m-F_d)+x_u(\beta_m-\beta_n)\right]$$

Using the explicit expressions for the partial derivatives and collecting terms yields the following expression for $d\Pi_u/d\rho$:

$$\begin{aligned}\frac{d\Pi_u}{d\rho} &= \theta\mu n_d \frac{p_u}{\sigma}\frac{x_u}{I}\left[(F_m - F_n) + x_d(\beta_m - \beta_n)\right] \\ &\quad + x_u p_u P_U^{\sigma-1}(\beta_m - \beta_n)\frac{\sigma w}{\sigma - 1}\left(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma}\right) \\ &\quad - w(1-\theta)\left[(F_m - F_d) + x_u(\beta_m - \beta_n)\right]\end{aligned}$$

The elements of $d\Pi_d/d\rho$ are:

$$PE_4 = \frac{p_d}{\varepsilon}\frac{\partial x_d}{\partial P_D}\frac{\partial P_D}{\partial p_d}(\beta_m - \beta_n)\left[\begin{array}{c} \frac{\partial p_d}{\partial \beta_d^T}\theta \\ +\frac{\partial p_d}{\partial P_U}\left(\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^S}(1-\theta) + \frac{\partial P_U}{\partial p_{IJV}}\frac{\partial p_{IJV}}{\partial \beta_{IJV}}\right)\end{array}\right]$$

$$KT_2 = -\theta(\mu P_U + (1-\mu)w)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right]$$

$$FL_1 = -\mu\left(\beta_d^T x_d + F_d^T\right)\left((1-\theta)\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^S} + \frac{\partial P_U}{\partial p_{IJV}}\frac{\partial p_{IJV}}{\partial \beta_{IJV}}\right)(\beta_m - \beta_n)$$

Using the explicit expressions for the partial derivatives and collecting terms yields the following expression for $d\Pi_d/d\rho$:

$$\begin{aligned}\frac{d\Pi_d}{d\rho} &= \frac{x_d}{\varepsilon}(\beta_m - \beta_n)\left[\begin{array}{c} \theta\frac{p_d}{\beta_d^T} \\ +P_U^{\sigma}\frac{\varepsilon\mu\beta_d^T}{(\varepsilon-1)}\frac{\sigma w}{\sigma-1}((1-\theta)n_u p_u^{-\sigma} + n_{IJV}p_{IJV}^{-\sigma})\end{array}\right] \\ &\quad -\theta(\mu P_U + (1-\mu)w)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right] \\ &\quad -\mu\left(\beta_d^T x_d + F_d^T\right)(\beta_m - \beta_n)P_U^{\sigma}\frac{\sigma w}{\sigma - 1}((1-\theta)n_u p_u^{-\sigma} + n_{IJV}p_{IJV}^{-\sigma})\end{aligned}$$

It is clear that the firs two lines of this expression are positive, while the third line is negative.

$d\Pi_u/d\rho$ **if** $\theta = 1$

If $\theta = 1$ $d\Pi_u/d\rho$ reduces to:

$$\begin{aligned}\frac{d\Pi_u}{d\rho} &= \mu n_d \frac{p_u}{\sigma}\frac{x_u}{I}\left[(F_m - F_n) + x_d(\beta_m - \beta_n)\right] \\ &\quad + x_u p_u P_U^{\sigma-1}(\beta_m - \beta_n)\frac{\sigma w}{\sigma - 1}\left(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma}\right)\end{aligned}$$

which is clearly negative. Hence if $\theta = 1$, $d\Pi_u/d\rho < 0$.

$d\Pi_u/d\rho$ **if** $\theta = 0$

If $\theta = 0$ $d\Pi_u/d\rho$ reduces to:

$$\begin{aligned}\frac{d\Pi_u}{d\rho} &= x_u p_u P_U^{\sigma-1}(\beta_m - \beta_n)\frac{\sigma w}{\sigma - 1}\left(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma}\right) \\ &\quad - w\left[(F_m - F_d) + x_u(\beta_m - \beta_n)\right]\end{aligned}$$

Hence, a sufficient and necessary condition to have that $d\Pi_u/d\rho > 0$ in this case is that:

$$\begin{aligned} p_u P_U^{\sigma-1}\frac{\sigma}{\sigma-1}\left(n_u p_u^{-\sigma} + n_{IJV}p_{IJV}^{-\sigma}\right) &< \frac{[(F_m - F_d) + x_u(\beta_m - \beta_n)]}{x_u(\beta_m - \beta_n)} \\ \frac{\sigma}{\sigma-1}\frac{\left(n_u p_u^{1-\sigma} + n_{IJV}p_u p_{IJV}^{-\sigma}\right)}{\left(n_u p_u^{1-\sigma} + n_{IJV}p_{IJV}^{1-\sigma}\right)} &< \frac{[(F_m - F_d) + x_u(\beta_m - \beta_n)]}{x_u(\beta_m - \beta_n)} \end{aligned}$$

Given that $\theta = 0$ we have that $\beta_{IJV} = \beta_u^S$ and hence that $p_u = p_{IJV}$ i.e:

$$\frac{\sigma}{\sigma-1} < \frac{[(F_m - F_d) + x_u(\beta_m - \beta_n)]}{x_u(\beta_m - \beta_n)}$$

Hence, the larger fixed costs relative to marginal costs (or more precisely: The more important the effect of knowledge diffusion on fixed rather than marginal costs), the more likely this condition is to hold, and hence, the more likely it is that $d\Pi_u/d\rho > 0$

B4 IJVs in the upstream sector - $d\Pi_d/d\rho$

The elements of $d\Pi_d/d\rho$ are:

$$PE_4 = \frac{\beta_d^T(\mu P_U + (1-\mu)w)}{(\varepsilon-1)}\frac{\partial x_d}{\partial P_D}\frac{\partial P_D}{\partial p_d}\left[\begin{array}{c} \frac{\partial p_d}{\partial \beta_d^T}\theta(\beta_m - \beta_n) \\ +\frac{\partial p_d}{\partial P_U}\left(\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^S}(1-\theta) + \frac{\partial P_U}{\partial p_{IJV}}\frac{\partial p_{IJV}}{\partial \beta_{IJV}}\right)(\beta_m - \beta_n) \end{array}\right]$$

$$KT_2 = -\theta(\mu P_U + (1-\mu)w)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right]$$

$$FL_1 = -\mu\left(\beta_d^T x_d + F_d^T\right)\left((1-\theta)\frac{\partial P_U}{\partial p_u}\frac{\partial p_u}{\partial \beta_u^S} + \frac{\partial P_U}{\partial p_{IJV}}\frac{\partial p_{IJV}}{\partial \beta_{IJV}}\right)(\beta_m - \beta_u)$$

Using the explicit expressions for the partial derivatives and collecting terms yields the following expression for $d\Pi_d/d\rho$:

$$\begin{aligned} \frac{d\Pi_d}{d\rho} = {} & \frac{x_d}{\varepsilon}(\beta_m - \beta_n)\left[\begin{array}{c} \theta\frac{p_d}{\beta_d^T} \\ +P_U^{\sigma}\frac{\varepsilon\mu\beta_d^T}{(\varepsilon-1)}\frac{\sigma w}{\sigma-1}((1-\theta)n_u p_u^{-\sigma} + n_{IJV}p_{IJV}^{-\sigma}) \end{array}\right] \\ & -\theta(\mu P_U + (1-\mu)w)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right] \\ & -\mu\left(\beta_d^T x_d + F_d^T\right)(\beta_m - \beta_n)P_U^{\sigma}\frac{\sigma w}{\sigma-1}((1-\theta)n_u p_u^{-\sigma} + n_{IJV}p_{IJV}^{-\sigma}) \end{aligned}$$

Clearly, the term in the first line is negative whereas the terms in the second and third lines are negative. From the analyses below it follows that $\varepsilon > 2$ is a sufficient condition for $d\Pi_u/d\rho$ to be positive.

$d\Pi_u/d\rho$ **if** $\theta = 1$

If $\theta = 1$ $d\Pi_d/d\rho$ reduces to:

$$\begin{aligned}
\frac{d\Pi_d}{d\rho} &= \frac{x_d p_d}{\varepsilon}(\beta_m - \beta_n)\left[\begin{array}{c} \frac{p_d}{\beta_d^T} \\ +P_U^\sigma \frac{\varepsilon\mu\beta_d^T}{(\varepsilon-1)}\frac{\sigma w}{\sigma-1}(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma}) \end{array}\right] \\
&\quad -(\mu P_U + (1-\mu)w)\left[(F_m - F_d) + x_d(\beta_m - \beta_n)\right] \\
&\quad -\mu\left(\beta_d^T x_d + F_d^T\right)(\beta_m - \beta_n)P_U^\sigma \frac{\sigma w}{\sigma - 1}(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma}) \\
&= \frac{x_d}{\varepsilon}(\beta_m - \beta_n)\left[\frac{p_d}{\beta_d^T} - \varepsilon(\mu P_U + (1-\mu)w)\right] \\
&\quad +\mu P_U^\sigma \frac{\sigma w}{\sigma - 1}(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma})(\beta_m - \beta_n)\cdot \\
&\quad \left[\frac{x_d \beta_d^T}{(\varepsilon - 1)} - \left(\beta_d^T x_d + F_d^T\right)\right] \\
&\quad -(\mu P_U + (1-\mu)w)(F_m - F_d) \\
&= \frac{x_d}{\varepsilon}(\beta_m - \beta_n)\left[\frac{p_d(2-\varepsilon)}{\beta_d^T}\right] \\
&\quad +\mu P_U^\sigma \frac{\sigma w}{\sigma - 1}(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma})(\beta_m - \beta_n)\cdot \\
&\quad \left[\frac{x_d \beta_d^T(2-\varepsilon)}{(\varepsilon - 1)} - F_d^T\right]
\end{aligned}$$

Hence, a sufficient condition for $d\Pi_d/d\rho > 0$ when $\theta = 1$ is $\varepsilon > 2$.

$d\Pi_u/d\rho$ **if** $\theta = 0$

If $\theta = 0$ $d\Pi_d/d\rho$ reduces to:

$$\begin{aligned}
&\frac{d\Pi_d}{d\rho} = \mu P_U^\sigma \frac{\sigma w}{\sigma - 1}(n_u p_u^{-\sigma} + n_{IJV} p_{IJV}^{-\sigma})(\beta_m - \beta_n)\cdot \\
&\left[\frac{x_d \beta_d^T(2-\varepsilon)}{(\varepsilon - 1)} - F_d^T\right]
\end{aligned}$$

Hence, a sufficient condition for $d\Pi_d/d\rho > 0$ when $\theta = 0$ is $\varepsilon > 2$.

Table 1: Signs of the total derivatives

		$0 \leq \theta \leq 1$	$\theta = 0$	$\theta = 1$
MNEs downstream	$\frac{d\Pi_u}{d\rho}$	$\gtreqless 0$	$\gtreqless 0$	> 0 if $\frac{(n_{IJV}\beta_{IJV}x_{IJV}+n_d\beta_d^S x_d)}{(n_{IJV}F_{IJV}+n_dF_d^S)} < -\frac{\alpha(1-\eta)P_U+(1-\alpha)w}{\alpha P_U+(1-\alpha)w}$
	$\frac{d\Pi_d}{d\rho}$	$\gtreqless 0$	> 0	> 0
MNEs upstream	$\frac{d\Pi_u}{d\rho}$	$\gtreqless 0$	> 0 if $\frac{\sigma}{\sigma-1} < \frac{[(F_m-F_d)+x_u(\beta_m-\beta_n)]}{x_u(\beta_m-\beta_n)}$	< 0
	$\frac{d\Pi_d}{d\rho}$	> 0 if $\varepsilon > 2$	> 0 if $\varepsilon > 2$	> 0 if $\varepsilon > 2$

Table 2: Pairwise correlations

	1	2	3	4	6	7
1. Productivity						
2. Horizontal	0.15					
3. Backward	0.16	0.16				
4. Forward	0.17	0.39	0.22			
6. (Log) Size	0.17	-0.04	0.08	-0.00		
7. Market share	0.18	0.07	0.11	0.04	0.52	
Mean	5.03	4.40	0.50	1.46	12.8	0.07
St. Dev.	1.88	8.66	0.77	3.65	1.87	0.14

Table 3: Semiparametric model esimates

	(1) Horizontal	(2) Backward	(3) Forward
(log) Size	0.124***	0.163***	0.162***
	(.042)	(.025)	(.023)
Market Share	0.634*	0.387**	0.280*
	(.397)	(.160)	(.156)
V	2.85***	2.61***	2.67***
Industry dummies	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes
Adj R^2	0.29	0.53	0.52
N	$1,195$	$2,462$	$2,462$

Dependent variable is log of firm productivity. Notes: (a) * p<0.1; ** p<0.05; *** p<0.01 (b) Estimator based on Lokshin (2006) with 1st-order differencing

Table 4: Parametric model esimates

	(1) Total Sample	(2) Low IPP	(3) High IPP
Horizontal	0.047**	0.100*	0.057**
	(.017)	(.053)	(.022)
Horizontal Squared	−0.001**	−0.004**	−0.001**
	(.001)	(.002)	(.001)
Horizontal Cubed (× 100)	0.000	0.002**	0.000
	(.000)	(.001)	(.000)
Backward	0.168	0.014	0.420**
	(.146)	(.340)	(.203)
Backward Squared	−0.003	0.001	−0.008***
	(.002)	(.004)	(.003)
Forward	0.004	−0.087	0.100
	(.073)	(.058)	(.220)
Forward Squared	0.000	0.001	−0.002
	(.001)	(.001)	(.004)
(log) Size	0.205***	0.183**	0.206***
	(.050)	(.076)	(.046)
Market Share	0.847***	1.24**	0.785**
	(.265)	(.492)	(.359)
Constant	0.138	−1.60	2.74***
	(.643)	(.847)	(.574)
Industry dummies	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes
R^2	0.79	0.78	0.79
N	6,579	1,855	4,724

Dependent variable is log of firm productivity. Notes: (a) * p<0.1; ** p<0.05; *** p<0.01 (b) Robust standard errors with industry-level clustering (c) Low IPP < 4.19 on Ginarte and Park (1996) index

Table 5: Parametric model esimates - Interactions

	(1) Total Sample	(2) Low IPP	(3) High IPP
Horizontal	0.046^{**}	0.145^{**}	0.061^{**}
	(.018)	(.062)	(.020)
Horizontal $\times$ $[(F+L)/L]$	-	-0.014^{***}	-
		(.004)	
Horizontal Squared	-0.001^{*}	-0.004^{**}	-0.001^{***}
	(.001)	(.002)	(.000)
Horizontal Squared $\times$ $[(F+L)/L]$	-	0.0004^{***}	-
		(.0001)	
Horizontal Cubed ($\times$ 100)	0.000	0.003^{**}	0.0006^{*}
	(.000)	(.001)	(.0003)
Horizontal Cubed $\times$ $[(F+L)/L]$ ($\times$ 100)	-	-0.0003^{***}	-
		(.0001)	
Backward	0.147	-0.183	0.437^{**}
	(.147)	(.375)	(.192)
Backward Squared	-0.003	0.011^{*}	-0.009^{***}
	(.002)	(.006)	(.003)
Forward	0.189^{*}	0.274	0.466^{*}
	(.102)	(.255)	(.263)
Forward $\times$ Herfindahl	-0.550^{***}	-1.15^{**}	-1.05^{***}
	(.146)	(.506)	(.326)
Forward Squared	-0.002^{*}	-0.003	-0.008
	(.001)	(.003)	(.005)
Forward Squared $\times$ Herfindahl	0.007^{***}	0.013^{**}	0.016^{**}
	(.002)	(.006)	(.006)
(log) Size	0.196^{***}	0.147^{**}	0.195^{***}
	(.050)	(.069)	(.044)
Market Share	1.03^{***}	1.92^{***}	1.00^{**}
	(.287)	(.567)	(.345)
Constant	0.208	-1.04	2.92^{***}
	(.654)	(1.45)	(.584)
Industry dummies	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes
R^2	0.79	0.80	0.79
N	6,579	1,404	4,724

Dependent variable is log of firm productivity. Notes: (a) * p<0.1; ** p<0.05; *** p<0.01 (b) Robust standard errors with industry-level clustering (c) Low IPP < 4.19 on Ginarte and Park (1997) index

Table A1: Sample countries and industries

Countries	**Industries**
Australia	Mining of coal
Austria	Mining of metal oares
Belgium	Food products and beverages
Canada	Textiles
Denmark	Wood and wood products
Finland	Paper and paper products
France	Coke, petroleum and fuel
Germany	Chemicals and chemical products
Hong Kong	Rubber and plastic products
Israel	Other non-metallic and mineral products
Italy	Basic metals
Japan	Fabricated metal products
South Korea	Machinery and equipment
Netherlands	Electrical machinery and apparatus
Singapore	Medical, precision and optical instruments
Spain	Motor vehicles
Sweden	Furniture
Switzerland	Construction
United Kingdom	
United States	

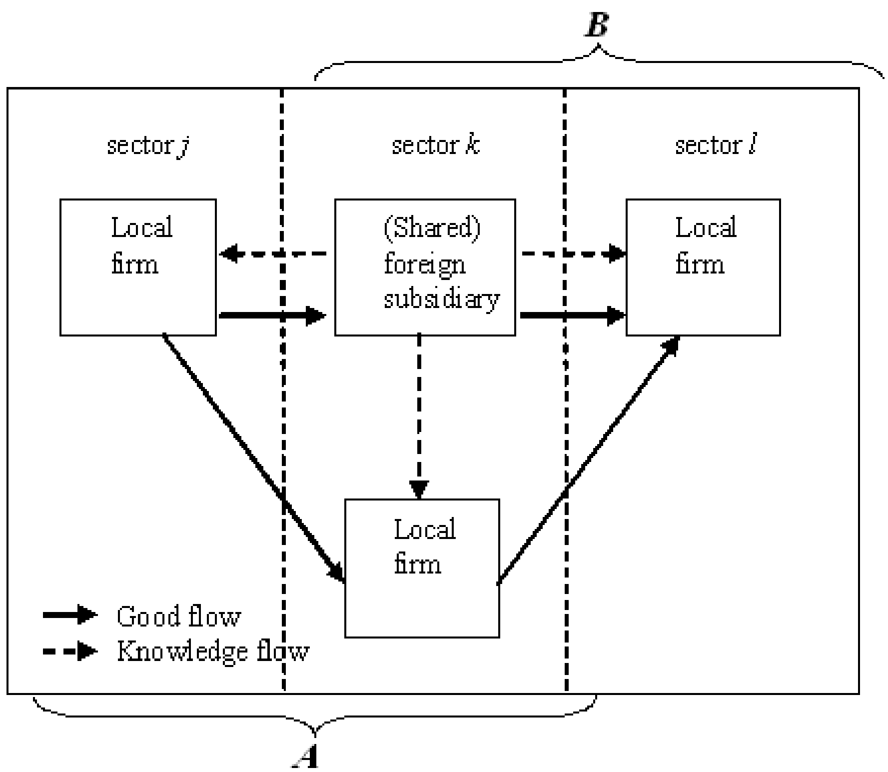

Figure 1: Schematic representation of horizontal and vertical linkages

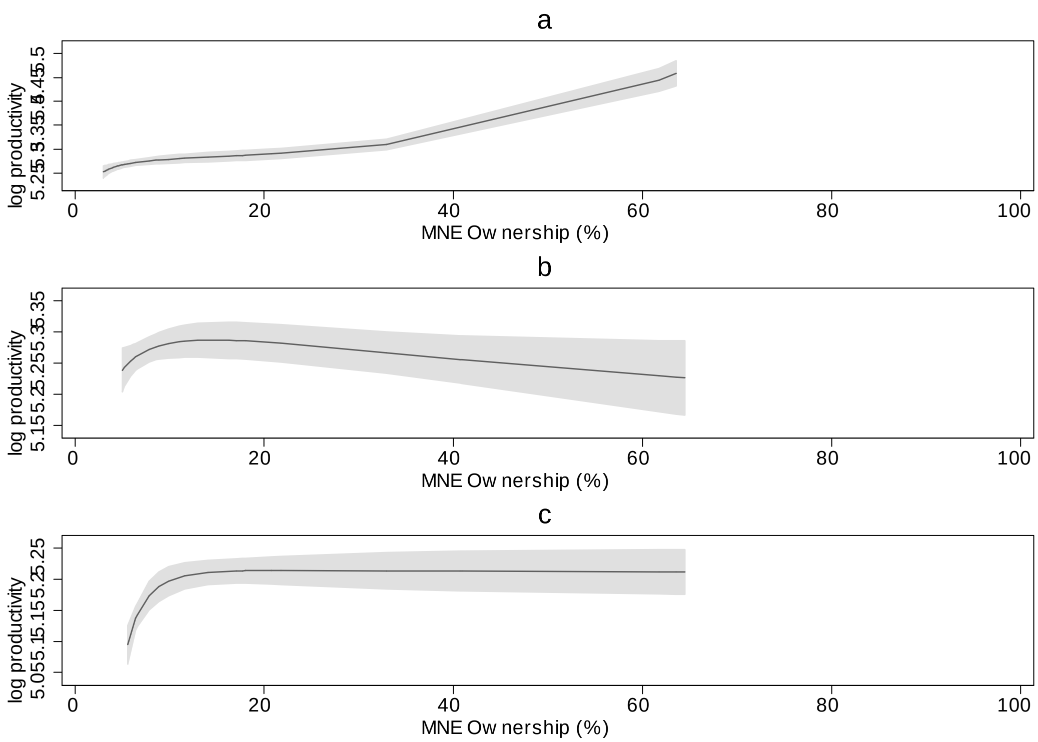

Figure 2: Semiparametric relationship between firm productivity and MNE ownership

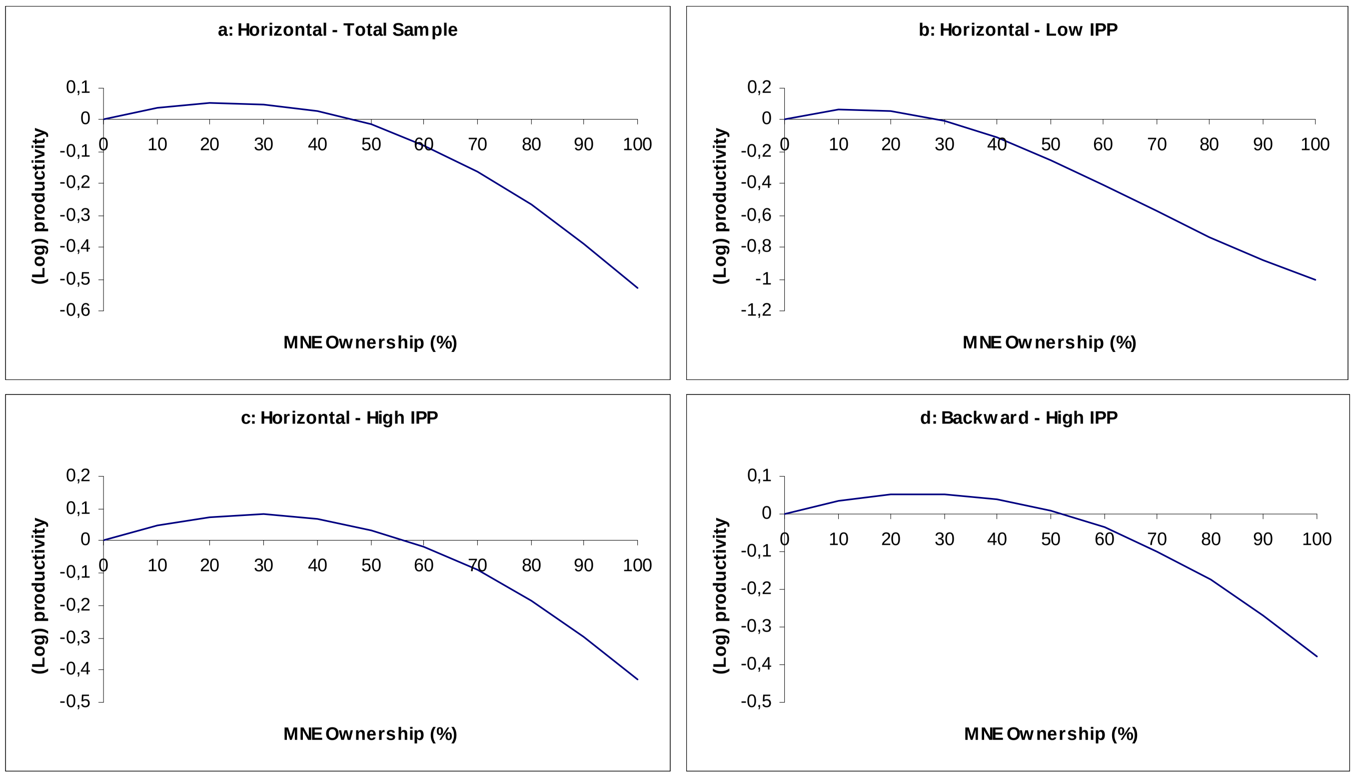

Figure 3: Parametric relationship between firm productivity and MNE ownership

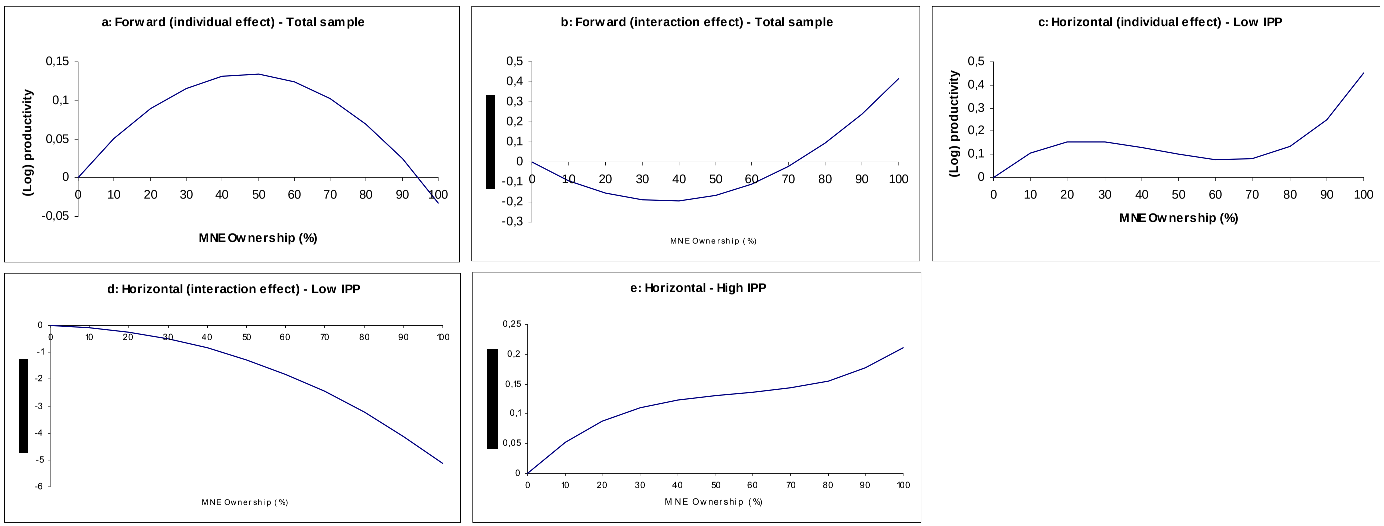

Figure 4: Parametric relationship between firm productivity and MNE ownership: Interaction effects