Openness, competition, technology and FDI spillovers: Evidence from Romania

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February 10, 2009

Abstract

We study whether FDI spillovers depend on openness, competition and the level of technology in a sample of Romanian manufacturing firms. Spillovers depend on the level of technology in non-linear way and are more likely to be positive in open sectors than in closed sectors. Horizontal spillovers are especially beneficial export-oriented and competitive sectors. Backward spillovers are very positive for firms that face globalized competition on their home and export markets, in line with Rodriguez-Clare (1996). Forward spillovers are especially important for firms that face high levels of import penetration in their product markets

JEL Classification:
Keywords: foreign direct investment, spillovers, absorptive capability

1 Introduction

When a firm invests in a foreign country, it often brings with it proprietary technology to compete successfully with indigenous firms (Markusen, 1995). Believing that this transferred technology will be adopted by domestic firms, host country policymakers may try to implement policies to attract foreign direct investment (FDI). Unfortunately, such faith in the positive spillover effects of FDI contrasts starkly with the empirical evidence (Rodrik, 1999). The literature surveys of Görg and Greenaway (2004), Smarzynska Javorcik (2004), and Crespo and Fontoura (2007) conclude that there is no clear evidence of aggregate positive spillovers from FDI. The literature distinguishes spillovers to firms in the same industries (intra-industry or horizontal spillovers) and spillovers to firms in linked industries (inter-industry or vertical spillovers). Horizontal spillovers have received widespread attention, while the vertical spillover discussion launched by McAleese and McDonald (1978) and Lall (1980) languished for two decades until its recent revival by Schoors and van der Tol (2002) and Smarzynska Javorcik (2004). Schoors and van der Tol (2002) and Smarzynska Javorcik (2004) distinguish vertical spillovers that occur through contacts between foreign firms and their local suppliers in upstream industries (backward spillovers) from those that occur through contacts between foreign firms and their downstream customers (forward spillovers). Both studies suggest that spillovers between industries dominate spillovers within industries. Several papers in this line of research that aim at identifying vertical spillovers. Kugler (2006) finds evidence in a sample of Colombian manufacturing firms for the propagation of technology between industries, suggesting that MNCs outsourcing relationships with local upstream suppliers are the main channel of diffusion. Gorodnichenko et al. (2007) find for a sample of firms in 17 Central and Eastern European countries that backward spillovers (stemming from supplying a foreign firm in the host country or exporting to a foreign firm) are consistently positive.

Our contribution is threefold. First we consider non-linear inter-industry spillover effects that depend on the level of technology. Second, we classify sectors along three lines, -import penetration, export orientation and sectoral competition -, and verify whether FDI spillovers depend on this sector classification. Last, we consider the welfare impact of the spillovers implied by our model. We analyze the spillover effects of FDI in a sample of domestic Romanian manufacturing firms. Romania is a good testing ground for the spillover effects

Table 1: Overview of spillovers

from FDI, because it received hardly any FDI in the years before the first year of our data sample, 1998, while it received a considerable amount during the years of our sample. The fact that there is no important stock of FDI before the period of study allows a clean identification of the spillover effects of interest. We find that vertical spillovers are economically more important than horizontal spillovers. The spillovers are often found to be dependent on the original level of technology and on the characteristics of the sector. The welfare effects are found to be considerable, which underlines the economic significance of FDI spillovers. In section 2, we provide a short overview of the spillover literature. Section 3 lays out the data and the estimation strategy. Results and interpretation are provided in section 4. Section 5 concludes.

2 Spillovers of foreign investment to local firm productivity

2.1 Direct and indirect effects

Figure 1 illustrates how the spillovers from foreign direct investment run through the host economy's production chain.

Horizontal spillovers run from a foreign firm to a host country firm in the same industry. Teece (1977) suggests two main channels for horizontal spillovers: technology imitation (the demonstration effect) and mobility of workers trained by foreign firms (see Fosfuri et al., 2001, and Görg and Strobl, 2005). Marin and Bell (2006) find that training activities by foreign subsidiaries are related to higher horizontal spillovers. Foreign entry may also fuel competition in the domestic market. Fiercer competition urges host country firms to either use existing technologies and resources more efficiently or adopt new technologies and organizational practices, which provides another important channel of horizontal spillovers (see Aitken and Harrison, 1999, and Glass and Saggi, 2002). None of these effects is necessarily positive, however. Labor market dynamics may entail negative spillovers such as a brain drain of local talent to foreign firms to the detriment of local firm productivity (Blalock and Gertler, 2004) or an overall increase in wages irrespective of productivity improvements caused

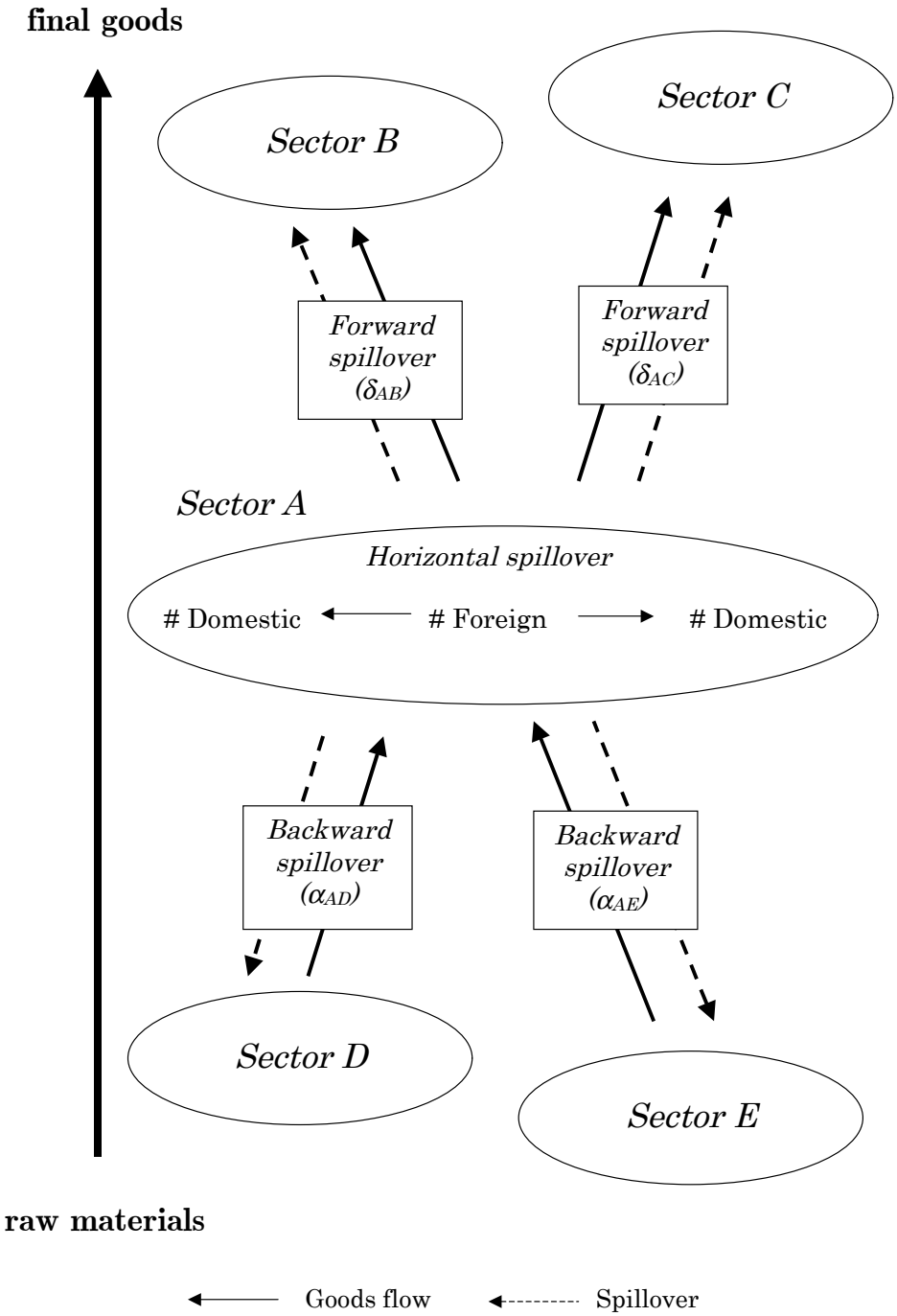

Figure 1: Spillovers through the host economy's production chain

by foreign firms paying higher wages (Aitken et al., 1996). Where foreign technology is easily copied, the foreign investor may choose to avoid leakage costs on state-of-the-art technology by restricting its technology transfer to technology that is only marginally superior to technology found in the host country (see Glass and Saggi, 1998). Such policies obviously limit the scope for horizontal spillovers via demonstration effects. The higher productivity of foreign affiliates may also lead to lower prices or less demand for the products of domestic competitors. If domestic firms fail to raise productivity in response to the increased competition, they will be pushed up their average cost curves. Ultimately, domestic producers may not merely fall behind, but fall by the wayside, driven out of business by the shock of foreign entry (see Aitken and Harrison, 1999, on this market-stealing effect). These partial effects are hard to disentangle empirically. We identify labor market spillovers by including a measure that accounts for labor market effects next to a measure that incorporates the net effect of all other spillovers.

As seen from the top panel in Figure 1, backward spillovers go from the foreign firm to its upstream local suppliers. Thus, even if foreign firms attempt to minimize their technology leakage to direct competitors (horizontal effect), they may still want to assist their local suppliers in providing inputs of sufficient quality in order to realize the full benefits of their investment. In other words, they want the inputs from the host country to be lower cost yet similar in quality to inputs in the home country. If the foreign firm decides to source locally, it may transfer technology to more than one domestic supplier and encourage upstream technology diffusion to circumvent a hold-up problem. Rodriguez-Clare (1996) shows that the backward linkage effect is more likely to be favorable when the good produced by the foreign firm uses intermediate goods intensively and when the home and host countries are similar in terms of the variety of intermediate goods produced. Under reversed conditions, the backward linkage effect could even damage the host country's economy. Figure 1 also suggests how a forward spillover goes from the foreign firm to its downstream local buyer of inputs. The availability of better inputs due to foreign investment enhances the productivity of firms that use these inputs. However, there is also a danger that inputs produced locally by foreign firms are more expensive and less adapted to local requirements. In this case there would be a negative forward spillover.

2.2 The level of technology and non-linear spillovers

The existence, direction, and magnitude of spillovers may depend on the firm-specific level of technology. Findlay (1978) constructs a dynamic model of technology transfer through FDI from developed to developing countries. He argues that there is a positive connection between the distance to the world's technological frontier and economic growth. Findlay's model implies that productivity spillovers are an increasing function of the technology gap between foreign and domestic firms. Acemoglu et al. (2002) and Aghion et al. (2005) on the other hand use a Schumpeterian model to predict that firms that are close to the efficiency frontier benefit more from foreign presence than firms that are far from the frontier. This is the absorptive capability hypothesis. Kokko et al. (1996) find a positive spillover effect in a subsample of firms with high absorptive capability and no effect in a subsample of firms with low absorptive capability. While Findlay suggests that spillovers are a negative function of the level of technology, the absorptive capability interpretation suggests a positive relation. Figure 2 suggests roughly how these competing hypotheses might give rise to non-linear relationships. In line with these competing hypotheses, Girma and Görg (2005) offer a U-shaped relationship between productivity growth and their horizontal spillover variable interacted with the level of technology. Girma (2005) observes that horizontal spillovers increase with absorptive capability up to a threshold level, beyond which the increase is much less pronounced.

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2.3 Characteristics of the sector

The existence, direction, and magnitude of spillovers may also depend on sectoral characteristics like openness or competition. Domestic firms in export-oriented sectors are more likely to be already exposed to contacts with foreign firms, new technologies and high competition on their export markets, prior to the entry of the MNC. This implies that domestic firms have less to learn from foreign entrants, but also that they have a greater capacity to absorb the foreign technology that remains to be learned, as suggested by the results of Barrios and Strobl (2002) and Schoors and van der Tol (2002) and Sisani and Meyer (2004). As regards import penetration, Sjöholm (1999) finds for Indonesian firms that domestic competition rather than competition from imported goods affects FDI spillovers. The theoretical literature is inconclusive as to the impact of competition on productivity. Stephen J. Nickell (1996) finds a posi-

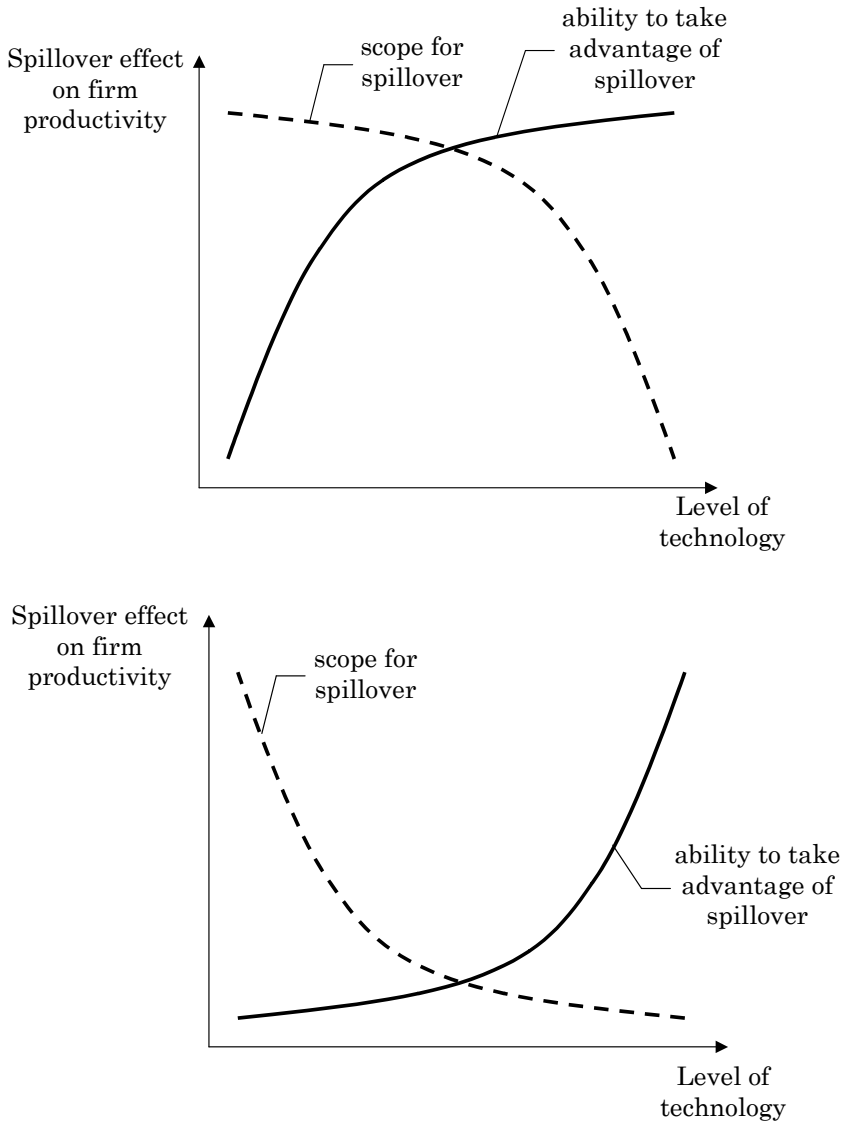

Figure 2: Spillovers as a non-linear function of the level of technology

tive impact of competition on firm performance. Wang and Blomström (1992) are the first to stress the importance of competition for FDI spillovers. Higher levels of competition force foreign subsidiaries to bring relatively new and sophisticated technologies from the parent company, which magnifies the potential for spillovers. The reverse reasoning also applies and reinforces the argument. Kokko (1994, 1996) examined the effect of FDI on productivity in different manufacturing sectors. A high technology gap in combination with a low degree of competition was found to prevent spillovers. There is however a serious identification problem in examining productivity levels, as foreign firms may locate in highly productive sectors. Nickell (1996) finds evidence of a generally positive impact of competition on productivity growth in his empirical analysis. Sjöholm (1999) finds in an Indonesian dataset that high sectoral competition (measured by a Herfindahl index) raises the magnitude of FDI spillovers, suggesting that the degree of competition affects the choice of technology transferred to the MNC's affiliate, and the potential for spillovers size. The literature also considers other conditionalities like the degree of foreign ownership (Blomström and Sjöholm, 1999; Smarzynska and Spatareanu, 2008) or firm size, (Sisani and Meyer, 2004; Merlevede and Schoors, 2008), but these fall beyond the scope of this contribution.

3 Empirical approach, data, and variables

3.1 Empirical approach

We use a two-step procedure. The first step consists in the estimation of a standard production function. The second step relates the estimated total factor productivity to measures of FDI spillovers and several control variables.

Our initial problem is that researchers cannot directly observe how firms react to firm-specific productivity shocks. For example, a firm confronted with a large positive productivity shock might respond by using more inputs. Griliches and Mairesse (1995) provide a detailed account of this problem and make the case that inputs should be treated as endogenous variables since they are chosen on the basis of the firm's, rather than an econometrician's, assessment of its productivity. OLS estimates of production functions therefore yield biased estimates of factor shares and biased estimates of productivity.[1] We thus em-

[1] Specifically, the coefficient of labor is biased upwards, while the capital coefficient is biased downwards.

ploy the semi-parametric approach suggested by Olley and Pakes (1996) and subsequently modified by James Levinsohn and Amil Petrin (2003).that incorporates idiosyncratic shocks to firm-specific productivity differences.± We estimate domestic industry production functions for each industry j in the period 1998–2001, excluding foreign firms from the estimation. A measure of total factor productivity tfp_{it} is obtained as the difference between value added and capital and labor inputs, multiplied by their estimated coefficients:

$$\forall j : tfp_{it} = va_{it} - \widehat{\beta}_l l_{it} - \widehat{\beta}_k k_{it} \tag{1}$$

In the second step, we relate tfp_{ijrt} to a vector of spillover variables, FDI, a concentration index, H, and industry, region, and time dummies (α_j, α_r, and α_t). Note that we pool industries for the estimation of (2), whereas (1) is an industry-specific estimation.

$$tfp_{ijrt} = \alpha_i + \Psi_1 f\left(FDI_{jt}, T_{ijrt}\right)' + \alpha_j + \alpha_r + \alpha_t + \varepsilon_{ijrt} \tag{2}$$

The vector of spillover variables (FDI_{jt}) covers different transformations of the horizontal and vertical spillovers. We interact our three spillover variables (horizontal, backward, forward) with the firm-specific level of technology (T_{ijrt}) in a non-linear way. Specification (2) is first differenced and estimated as a fixed effects model:

$$\Delta tfp_{ijrt} = \beta_i + \Omega_1 \Delta f\left(FDI_{jt}, T_{ijrt}\right)' + \beta_t + \varepsilon_{ijrt} \tag{3}$$

The fixed effects control for all time-invariant firm-specific unobservables driving productivity growth, including region and industry effects. The first-differenced time dummies still control for the business cycle. Because FDI_{jt} and H_{jt} are defined at the industry level, while estimations are performed at the firm level, standard errors need to be adjusted (see Brent R. Moulton, 1990). Standard errors are clustered for all observations in the same industry and year. The effects of openness and competition are considered by estimating (3) for different subsamples. First we consider the characteristics separately (high versus low export share, high versus low import penetration, high versus low competition). In a second phase we consider these characteristics jointly, by running (3) for 8 exclusive subsamples that cover all possible combinations of the three characteristics of interest.

3.2 Data description and variable definitions

Romanian firm-level data for 1996–2001 are drawn from the Amadeus database published on DVD and CD by Bureau Van Dijk. Given our interest in import penetration and export orientation we limit our sample to manufacturing firms. Other sectors are largely producing non-tradables and their inclusion would obfuscate the distinction between closed sectors and service sectors. The sample is unbalanced due to firms entering in later years. There is no firm exit. Industry price level data at Nace 2-digit level[2] are taken from the Industrial Database for Eastern Europe from the Vienna Institute for International Economic Studies and from the Statistical Yearbook of the Romanian National Statistical Office (RNSO). Our industry classification follows the classification used in the Romanian input-output (IO) tables. This classification is then linked to the Nace classification scheme. The entire Amadeus series is used to construct a database of time-specific foreign entry in local Romanian firms.[3] IO tables for the period 1995–2001 were obtained from the RNSO.

The matrix FDI in (3) contains measures of foreign presence to capture the different spillovers described above. We classify a firm as foreign ($Foreign = 1$) when foreign participation exceeds 10%.[4] The horizontal spillover variable $Horizontal_{jt}$ captures the degree of foreign presence in sector j at time t and is measured as industry j's share of output produced by foreign-owned firms:

$$Horizontal_{jt} = \frac{\sum_{i \in j} Foreign_{it} * Y_{it}}{\sum_{i \in j} X_{it}} \tag{4}$$

For the measurement of the backward spillover variable $Backward_{jt}$, one possibility might be to employ the share of firm output sold to foreign firms. However, this information is unavailable from our dataset. Moreover, the share of firm output sold to foreign-owned domestic firms may cause endogeneity problems if the latter prefer to buy inputs from more productive domestic firms.

[2] *Nomenclature générale des activités économiques dans les Communautés européennes.*

[3] Amadeus DVDs are released each year. They provide a pan-European database of financial information on public and private companies. Specific entries, however, only indicate the most recent ownership information. Since ownership information is gathered at irregular intervals, we do not have ownership information for all years and firms. Ownership changes tend to show up *ex post* in the database. Therefore, if a given firm has any gaps in its ownership series, we fill the gaps with the information from the following year.

[4] This threshold level is commonly applied (e.g. by the OECD) in FDI definitions.

We thus measure $Backward_{jt}$ as :

$$Backward_{jt} = \sum_{k \ if \ k \neq j} \gamma_{jkt} * Horizontal_{kt} \tag{5}$$

where γ_{jkt} is the proportion of industry j's output supplied to sourcing industry k at time t. The γs are calculated from the time-varying IO tables for intermediate consumption. $Horizontal_{kt}$ is a measure for foreign presence in industry k at time t. In the calculation of γ, we explicitly exclude inputs sold within the firm's industry ($k \neq j$) because this is captured by $Horizontal_{jt}$.[5] Since firms cannot easily switch between industries for their inputs, we can avoid the problem of endogeneity by using the share of industry output sold to downstream domestic markets with some foreign presence. In the same spirit, we define the forward spillover variable $Forward_{jt}$ as:

$$Forward_{jt} = \sum_{l \ if \ l \neq j} \delta_{jlt} * Horizontal_{lt} \tag{6}$$

where the IO tables reveal the proportion δ_{jlt} of industry j's inputs purchased from upstream industries l. Inputs purchased within the industry ($l \neq j$) are again excluded, since this is already captured by $Horizontal$.[6]

A measure of the level of technology needs to reflect the relative technical capabilities of a domestic firm vis-à-vis the foreign firms in the same industry. In constructing measure T_{it}, we apply the Levinsohn-Petrin technique on earlier years of the full sample of both domestic and foreign firms to avoid endogeneity. The estimated relation is then used to derive total factor productivity measures φ_{it} for all firms. T_{it} is defined in (7) as the distance between firm i's lagged productivity level, φ_{it-1}, and the lagged "foreign frontier" in its industry. The latter is defined as the mean productive efficiency of the 25% most productive foreign firms in industry j ($\overline{\varphi}_{jt-1,FOR}$). More productive firms have higher

[5] To clarify, we offer the following example. Consider three sectors: j, k_1, and k_2. Suppose that half of the output of j is purchased by k_1 and the other half by k_2. Further suppose that no foreign firms are active in k_1, but half of the output of k_2 is produced by foreign firms. The backward variable for sector j would be $(0.5 * 0.0) + (0.5 * 0.5) = 0.25$. From this, it can be easily seen that the value of *Backward* increases with foreign presence in the sectors k that source inputs from j and with the share of output of sector j supplied to industries with foreign presence.

[6] Consider three sectors: j, l_1, and l_2. Suppose j buys 75% of its inputs with l_1 and the remaining 25% with l_2. Further suppose that 10% of l_1's output is produced by foreign firms, and half of the output of l_2 is produced by foreign firms. The backward variable for sector j would be $(0.75 * 0.10) + (0.25 * 0.50) = 0.20$.

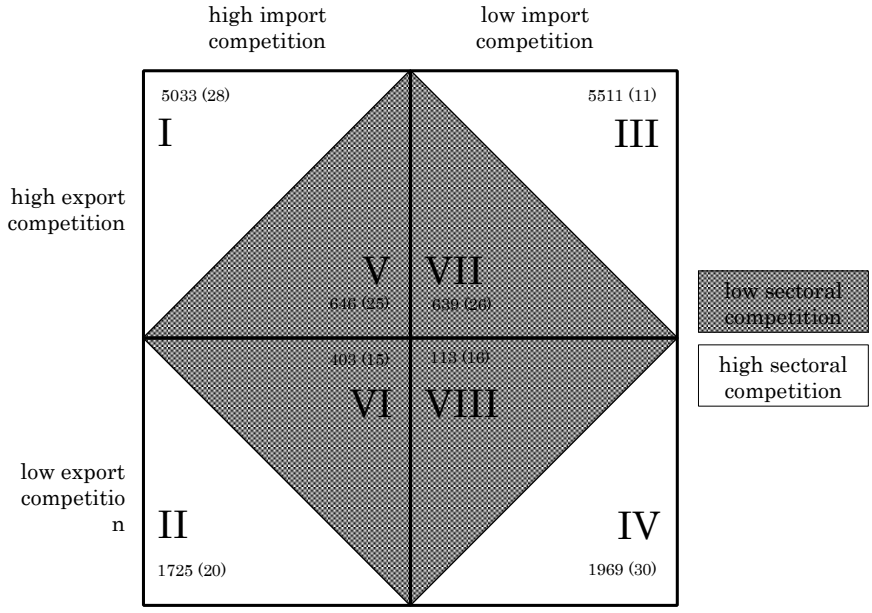

Figure 3: Classification of sectors according to three criteria

values of T.

$$T_{it} = \frac{\varphi_{it-1}}{\overline{\varphi}_{jt-1,FOR}} \tag{7}$$

3.3 Subamples and summary statistics

We first split the sample in subsamples according to levels of export orientation, import penetration and sectoral competition. Export orientation is measured by the share of sectoral exports in total sectoral output from the time varying IO tables. IImport penetration is measured by the share of imports of products, comparable to the produce of the sector, in total sectoral output from the time varying IO tables. Sectoral competition is proxied by the Herfindahl index. Then we combine these three criteria to classify firms and sectors into 8 classes

Figure **splitsample** shows precisely how we split the sample in 8 exclusive

subsamples and indicates the number of firms and sectors (between brackets) in each subsample. Subample I consists of high export, high import, high competition sectors (sectors that engage in globalized competition on all markets) . We have 5033 firms and 10364 observations in subsample I. Subample II consists of low export, high import, high competition sectors (sectors that face globalized competition on their home market). We have 1725 firms and 3618 observations in subsample II. Subsample III contains the high export, low import, high competition sectors (sectors with a competitive advantage). We have 5511 firms and 12310 observations in subsample III. Subsample IV contains the low export, low import, high competition sectors (closed but locally competitive sectors) We have 1969 firms and 4226 observations in subsample IV. Subsample V consists of high export, high import, low competition sectors (open sectors with high entry barriers). We have only 646 firms with 996 firms in subsample V. Subsample VI contains low export, high import, low competition sectors (sectors that are faced with devastating import competition). We have 403 firms with 602 observations in subsample VI. Subsample VII consists of high export, low import, low competition sectors (export-led growth of concentrated industries). We have 639 firms and 1327 observations in subsample VII. Subsample VIII contains low export, low import, low competition sectors (closed and unreformed sectors).

insert TABLE 1 around here

Table 1 gives summary statistics for the variables described above. The table shows data on real output, real materials, real capital, labor, the level of technology and the spillover variables of interest. Panel A provide the summary statistics for the sample splits according to import penetration, export orientation and sectoral competition. Panel B provides the summary statistics for the eight exclusive classes. The average values for the spillovers are surprisingly similar across sectors, which ensures that any found differences in spillover effects are not due to the fact that the level of foreign involvement is different in different types of sectors. This is less surprising in panel A, where the various columns are not exclusive, than in panel B, where the 8 subclasses are defined as exclusive classes.

4 Results and interpretation

INSERT Table 2 and around here

Table 2 shows how the estimates of (3) depend on import penetration, export

orientation and industry concentration. The first column shows results for all observations in the sample. Further columns show split sample results for low and high import penetration (columns 2 and 3), low and high export orientation (columns 4 and 5) and low and high competition (columns 6 and 7). Panel A of table 1 shows the estimates of the linear spillover effects. Only the horizontal spillovers are found to play a significant role. The significance of all vertical spillover effects is rejected, with the exception of a positive backward spillover in the export-oriented sectors, which are already used to supplying foreign firms. Panel B reveals that the insignificance of most vertical spillovers effects in panel A is explained by the inappropriate linearity assumed in panel A. Indeed, most vertical spillovers are now found to be significant. This is supported by the joint significance F-tests reported in panel C. These tests suggest that horizontal and backward spillovers are only insignificant in sectors that export a low share their total production. The other spillover effects can no longer be rejected, either in a linear or a non-linear form. The introduction on non-linear effects also raises the explanatory power of the regression by about 8% from around 2% in panel A to about 10%. This suggests by and large that the non-linear interactions with the level of technology are essential to a good understanding of the nature of productivity spillovers, as hypothesized.

In table 2 we observe that positive spillovers are more likely if import penetration is high, if export orientation is high and if competition is high than in the converse cases. Horizontal spillovers for example are consistently positive in open or competitive sectors (columns 3, 5 and 7), while this is not necessarily or less the case in closed or less competitive sectors. The found differences across subsamples suggest that the ambiguous results in the literature about the sign and the magnitude of horizontal spillovers may be explained by differences in openness and competition. Another result that catches the eye is that the relation between backward spillovers and the level of technology mostly shows an inverted U pattern, with backward spillovers turning less positive or negative at larger levels of technology,.while the relation between forward spillovers and the level of technology mostly shows a classical U-pattern, with forward spillovers more likely to be positive at fairly low levels of technology. For both vertical spillovers the sectors with low import penetration constitute an exception to this rule. The non-linear relation of horizontal spillovers with the level of technology also follows a classical U-shape, but is clearly less pronounced than in the case of forward spillovers.

INSERT Table 3 and figure 4 around here

Table 3 shows estimates of (3) for the exclusive subclasses defined in figure 3. Since we have only 113 firms and 199 observations in subsample 8, estimates are very unstable. Therefore table 3 reports estimates of (3) for the first 7 subsamples only. The implied non-linear productivity spillover are plotted in figure 4. With respect to horizontal spillovers Table 3 and Figure 4 reaffirm the earlier result that horizontal spillovers are particularly positive in sectors that are both export-oriented and competitive (subsamples I, III). If we remove the criterion of high export orientation (subsamples II, IV), horizontal spillovers turn insignificant, though still positive . If we remove the criterion of competition (subsamples V, VII) or both criteria (subsample VI) the horizontal spillovers turn largely negative, though not always significant. These findings are in line with Wang and Blomström (1992), who find low or negative horizontal spillovers in sectors with low competition, and with Barrios and Strobl (2002), Schoors and van der Tol (2002) and Sisani and Meyer (2004), who find more positive spillovers in export-oriented industries, but in contrast to Sjöholm (1999), who finds that horizontal spillovers are positive in competitive sectors especially if these sectors are still relatively closed (the so-called demonstration effect).

The results in Table 3 and Figure 4 also suggest that the backward spillover is very positive for sectors that are engaged in global competition in their home and export markets (subsample I). This is in line with the model of Rodriguez-Clare (1996) who shows that backward spillover effects should be positive if the inputs required are not too different from the ones already produced by the local firms. This condition is more likely to be fulfilled in export-oriented sectors. Firms in these sectors are already used to the required quality on export markets and will more easily adapt to the demand from foreign firms in downstream sectors. The impact on productivity will be especially pronounced if import penetration is high (the foreign firm has an option to buy imported components) and sectoral competition is high (there is competition between local firms to make the components for the foreign firm). In addition, the backward spillover is also significantly positive, though economically less important, in sectors with low competition and import penetration, but still a high degree of export orientation (subsample VII). Clearly, backward spillovers can be very positive in sectors that pursue a strategy of export-led growth. This is in line with anecdotal evidence of host country suppliers of foreign firms becoming more productive and turning into competitors of the home country suppliers, initially on the host country market and in the long run even on the home country market.

The results also suggest that forward spillovers are not very positive in man-

ufacturing sectors. Merlevede and Schoors (2008) find that forward spillovers are very positive if all sectors are considered. It is clear therefore that positive forward spillovers are mainly to be found in non-tradable and service sectors (financial services, business services, communication, trade, energy) . There is however one important exception to this general rule: Forward spillovers tend to be very positive economically and statistically in sectors faced with severe import competition (low export, low competition, high import, subsample VI). In these sectors access to better and cheaper inputs is a necessary condition to cope with import competition. Forward spillovers are self-evidently not very important for firms in export-oriented sectors, since these need to produce high quality anyhow and will have been forced already to buy better foreign inputs if local input quality were too low. So these firms can at best only benefit marginally from better local inputs.

The analysis above portrays the contribution of the spillovers to TFP as a function of the firm's level of technology at the average values of the spillover variables. This neither reveals what actually happened to Romanian firms, nor provides a sound basis for FDI policy. Since firms are subject to all spillover effects at the same time, the correlations between the spillover variables will matter to determine their eventual economic impact. Moreover, the spillover variables, their correlation structure, and the firm's level of technology change over the time period considered. To analyze the economic significance of spillover effects for the domestic Romanian firms in the period 1998-2001 we use the results of Table 3, panel B, to calculate the total net effect of foreign presence on domestic firms. We predict the contribution to total factor productivity of the different spillovers at the firm level by multiplying the estimated coefficients with the actual values of the variables concerned.

Figure 5 show the spillovers' contribution to total factor productivity growth during the period 1998–2001, averaged over all firms in the subclass. H shows the accumulated 1998-2001 productivity impact for horizontal spillovers, B for backward spillovers, F for forward spillovers and $\sum$ indicates the sum of all three spillovers. The results suggest that the eventual economic impact of FDI spillovers on local firm productivity is potentially large, but strongly depends on the characteristics of the sector. The net productivity impact of the spillovers ranges from 0.626 in subsample I (the high competition, high openness sectors) to -0.367 in subsample II (sectors that face globalized competition on their home market). Net spillovers seem to be especially beneficial in highly competitive, export-oriented sectors (sector I and III). These are also the only sectors were

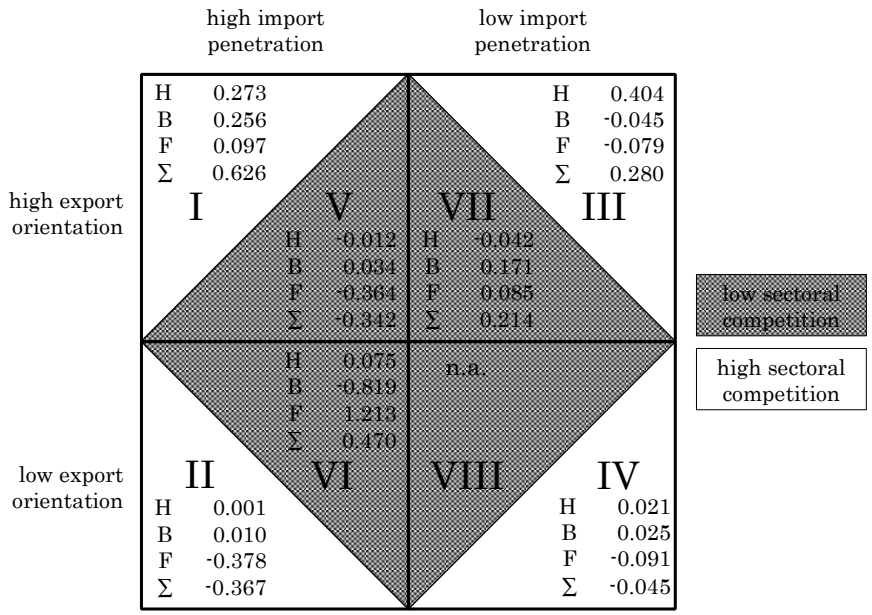

Figure 4: The spillovers' implied impact on firm level productivity

the horizontal spillover is large and positive. The forward spillover is especially beneficial to local firms of subsample VI. These are the sectors that face stiff import competition, without the benefit of either experience on export markets or local competition. Apparently the access to better inputs through foreign investment in these firms' local supplier sectors, greatly enhances their ability to face down the import competition. In most other subsamples however, the forward spillover is either small or negative. The backward spillover on the other hand is especially detrimental to local firm productivity in the same subsample VI. This seems logical: In sectors where imported goods dominate the local market and threaten to wipe out local firms, foreign firms in user sectors will simply buy imported goods rather then sourcing locally. In the other subsamples, the backward spillovers have either a negligible or a positive effect on local firm productivity. In Annex we provide the average contribution of spillovers to total factor productivity growth during the period 1998–2001 for different ranges of the initial level of technology. The breakdown in technology ranges is based on the 1998 level of technology percentiles.

5 Conclusions

This paper investigates whether productivity spillovers from foreign firms to domestic manufacturing firms depend on the sectoral levels of import penetration, export orientation and competition. We test this on a comprehensive set of Romanian manufacturing firms. In the estimation of the production function we allow unobserved productivity shocks. In the final regressions, productivity differences are explained by horizontal, backward and forward productivity spillovers from foreign investment. Here we allow non-linear interactions between the spillover variables and the firm-specific level of technology.

Spillovers affect productivity in a highly non-linear way. Both horizontal and vertical spillovers are more likely to be positive in open sectors than in closed sectors. Horizontal spillovers are most positive in sectors that are both export-oriented and competitive. They turn insignificant or even negative if these conditions are not met. This result may explain the lack of consensus in the literature about the direction and magnitude of the effect of horizontal spillovers on local form productivity. Highly positive backward spillovers are found in highly competitive and open sectors. The positive backward spillovers in these sectors characterized by "globalized competition" are in line with Rodriguez-

Clare (1996) who shows that backward spillover effects are beneficial if the inputs required are not too different from the ones already produced by the local firms. In addition the backward spillover is significantly positive, though economically less important, in sectors with low competition and import penetration, but still a high degree of export orientation. This is in line with the narrative that new local suppliers of foreign firms may grow to compete with and even outperform the home-country suppliers of the foreign firm. Forward spillovers are, as in most of the literature, not very important for manufacturing firms, except for sectors that struggle to cope with very high levels of import penetration in their product markets. In the latter sectors the access to better and cheaper inputs through foreign investment in supply sectors helps firms to compete with imported produce. The debate in the literature on the direction and magnitude of spillovers from foreign firms to local firms has a fair answer: it all depends on technology, openness and competition.

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Table 1 Summary Statistics

Panel A Summary statistics for the three sample splits

	All firms	Low import penetration	High import penetration	Low export orientation	High export orientation	Low competition	High competition
Ln(real output)	9.56	9.41	9.74	9.73	9.50	9.89	9.52
	(1.99)	(1.92)	(2.05)	(1.93)	(2.00)	(2.16)	(1.96)
Ln(labour)	2.15	2.09	2.22	2.01	2.20	2.38	2.13
	(1.58)	(1.51)	(1.66)	(1.50)	(1.61)	(1.84)	(1.55)
Ln(real capital)	7.63	7.51	7.77	7.80	7.57	8.00	7.59
	(2.51)	(2.41)	(2.61)	(2.43)	(2.54)	(2.76)	(2.48)
Ln(real materials)	8.80	8.63	9.00	9.01	8.74	9.12	8.77
	(2.17)	(2.10)	(2.23)	(2.14)	(2.18)	(2.35)	(2.15)
T	0.19	0.18	0.21	0.21	0.18	0.22	0.19
	(0.19)	(0.18)	(0.20)	(0.21)	(0.19)	(0.22)	(0.19)
Horizontal	0.24	0.24	0.25	0.24	0.25	0.24	0.24
	(0.10)	(0.09)	(0.12)	(0.11)	(0.10)	(0.19)	(0.09)
Backward	0.23	0.22	0.24	0.24	0.23	0.22	0.23
	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)
Forward	0.26	0.26	0.27	0.28	0.26	0.24	0.27
	(0.07)	(0.05)	(0.08)	(0.06)	(0.07)	(0.05)	(0.07)
# of observations	33642	18062	15580	8645	24997	3124	30518

Panel B Summary statistics for the sector classifications

	All firms	I	II	III	IV	V	VI	VII	VIII
Ln(real output)	9.56	9.65	9.84	9.30	9.59	10.16	9.79	9.65	10.41
	(1.99)	(2.03)	(2.06)	(1.92)	(1.78)	(2.14)	(2.03)	(2.21)	(1.95)
Ln(labour)	2.15	2.25	2.07	2.11	1.93	2.53	2.04	2.43	2.25
	(1.58)	(1.64)	(1.64)	(1.49)	(1.37)	(1.95)	(1.51)	(1.94)	(1.38)
Ln(real capital)	7.63	7.67	7.89	7.40	7.70	8.32	7.82	7.78	8.47
	(2.51)	(2.57)	(2.62)	(2.43)	(2.22)	(2.83)	(2.67)	(2.80)	(2.17)
Ln(real materials)	8.80	8.90	9.18	8.54	8.79	9.36	9.18	8.80	9.94
	(2.17)	(2.21)	(2.25)	(2.09)	(2.00)	(2.29)	(2.21)	(2.44)	(2.10)
T	0.19	0.19	0.24	0.17	0.19	0.25	0.17	0.22	0.17
	(0.19)	(0.19)	(0.22)	(0.17)	(0.20)	(0.24)	(0.20)	(0.22)	(0.20)
Horizontal	0.24	0.25	0.24	0.25	0.21	0.20	0.36	0.21	0.22
	(0.10)	(0.10)	(0.12)	(0.08)	(0.06)	(0.15)	(0.23)	(0.17)	(0.06)
Backward	0.23	0.24	0.24	0.22	0.24	0.21	0.24	0.22	0.23
	(0.05)	(0.04)	(0.05)	(0.05)	(0.06)	(0.04)	(0.04)	(0.06)	(0.03)
Forward	0.26	0.27	0.27	0.25	0.29	0.25	0.24	0.24	0.23
	(0.07)	(0.09)	(0.05)	(0.04)	(0.06)	(0.04)	(0.05)	(0.05)	(0.05)
# of observations	33642	10364	3618	12310	4226	996	602	1327	199

Table 2

Panel A Are simple spillovers dependent on sector characteristics?

	All firms	Low import penetration	High import penetration	Low export orientation	High export orientation	Low competition	High competition
ΔHorizontal	1.385***	1.414***	4.113***	1.986**	1.341***	0.336*	5.198***
	[0.471]	[0.357]	[1.019]	[0.931]	[0.507]	[0.197]	[1.132]
ΔBackward	1.114**	0.612	1.297	0.575	2.255**	0.790	0.515
	[0.492]	[0.647]	[0.850]	[0.370]	[1.140]	[0.621]	[0.537]
ΔForward	-0.544	-0.815	-0.066	-2.144	-0.308	-0.290	0.108
	[0.514]	[1.476]	[0.561]	[1.362]	[0.492]	[0.851]	[0.551]
# observations	33642	18062	15580	8645	24997	3124	30518
# firms	15011	8220	7326	3898	11418	1409	13817
R-squared	0.02	0.02	0.04	0.04	0.02	0.07	0.03

Panel B: Are non-linear spillovers dependent on sector characteristics?

	All firms	Low import penetration	High import penetration	Low export orientation	High export orientation	Low competition	High competition
ΔHorizontal	1.464***	1.600***	3.899***	1.701*	1.590***	0.881**	5.040***
	[0.449]	[0.499]	[1.104]	[0.979]	[0.462]	[0.367]	[1.264]
*ΔHorizontal*T*	-0.902	-2.718	0.247	0.465	-2.085	-3.928***	0.425
	[1.065]	[1.858]	[1.096]	[1.346]	[1.450]	[1.356]	[1.503]
*ΔHorizontal*T²*	1.127**	0.608	1.269***	0.033	1.639**	1.953*	0.902
	[0.558]	[1.176]	[0.423]	[0.897]	[0.813]	[1.129]	[0.616]
ΔBackward	0.963	3.779***	0.662	0.623	2.158*	2.250*	0.302
	[0.684]	[0.951]	[1.114]	[0.728]	[1.299]	[1.203]	[0.789]
*ΔBackward*T*	3.724**	-11.869***	5.213**	-0.281	5.106*	-1.684	3.212*
	[1.738]	[3.014]	[2.086]	[2.415]	[2.615]	[3.725]	[1.932]
*ΔBackward*T²*	-4.679***	6.032***	-5.534***	-0.557	-6.049***	-0.461	-4.258***
	[1.015]	[1.852]	[1.131]	[1.607]	[1.612]	[2.695]	[1.020]
ΔForward	0.894	-3.660***	2.072***	-0.344	1.093*	0.451	1.708***
	[0.587]	[1.373]	[0.646]	[1.371]	[0.657]	[0.903]	[0.623]
*ΔForward*T*	-10.238***	2.651	-12.391***	-8.293***	-10.811***	-4.708	-11.129***
	[1.699]	[2.933]	[2.195]	[2.339]	[2.658]	[3.062]	[1.867]
*ΔForward*T²*	5.952***	-1.422	6.569***	3.325**	7.143***	4.272**	5.681***
	[0.917]	[2.119]	[1.129]	[1.335]	[1.684]	[1.939]	[0.916]
# observations	33642	18062	15580	8645	24997	3124	30518
# firms	15011	8220	7326	3898	11418	1409	13817
R-squared	0.10	0.12	0.12	0.14	0.10	0.15	0.11

Panel C F-tests for the joint existence of non-linear spillovers

	All firms	Low import penetration	High import penetration	Low export orientation	High export orientation	Low competition	High competition
F: No *T-Horizontal*	2.72*	1.92	8.10***	0.18	2.47*	5.25***	4.06**
F: No *Horizontal*	4.66***	4.48***	7.27***	1.32	5.19***	3.64**	7.85***
F: No *T-Backward*	12.99***	7.79***	14.16***	0.29	8.49***	1.07	11.94***
F: No *Backward*	9.11***	6.12***	10.15***	0.97	6.35***	2.26*	7.98***
F: No *T-Forward*	21.52***	0.42	17.07***	6.50***	9.20***	3.01*	19.89***
F: No *Forward*	14.64***	2.49*	11.61***	4.53***	6.18***	2.03	13.27***

Table 4 spillovers according to firm classification

Panel A Simple spillovers according to firm classification

	All firms	I	II	III	IV	V	VI	VII
ΔHorizontal	1.385***	6.909***	0.845	19.576**	2.467*	-1.272*	4.283***	0.214
	[0.471]	[1.590]	[1.145]	[7.529]	[1.345]	[0.714]	[0.090]	[0.343]
ΔBackward	1.114**	7.109***	-0.077	3.741	0.280	-2.199	-5.613***	2.092***
	[0.492]	[1.502]	[0.505]	[5.787]	[0.993]	[1.724]	[0.236]	[0.653]
ΔForward	-0.544	0.704	-8.130***	0.070	-1.526	-2.889	15.136***	2.333
	[0.514]	[0.576]	[2.207]	[3.192]	[2.477]	[2.614]	[0.310]	[2.725]
# observations	33642	10364	3618	12310	4226	996	602	1327
# firms	15011	5033	1725	5511	1969	646	403	639
R-squared	0.02	0.10	0.09	0.03	0.05	0.06	0.05	0.13

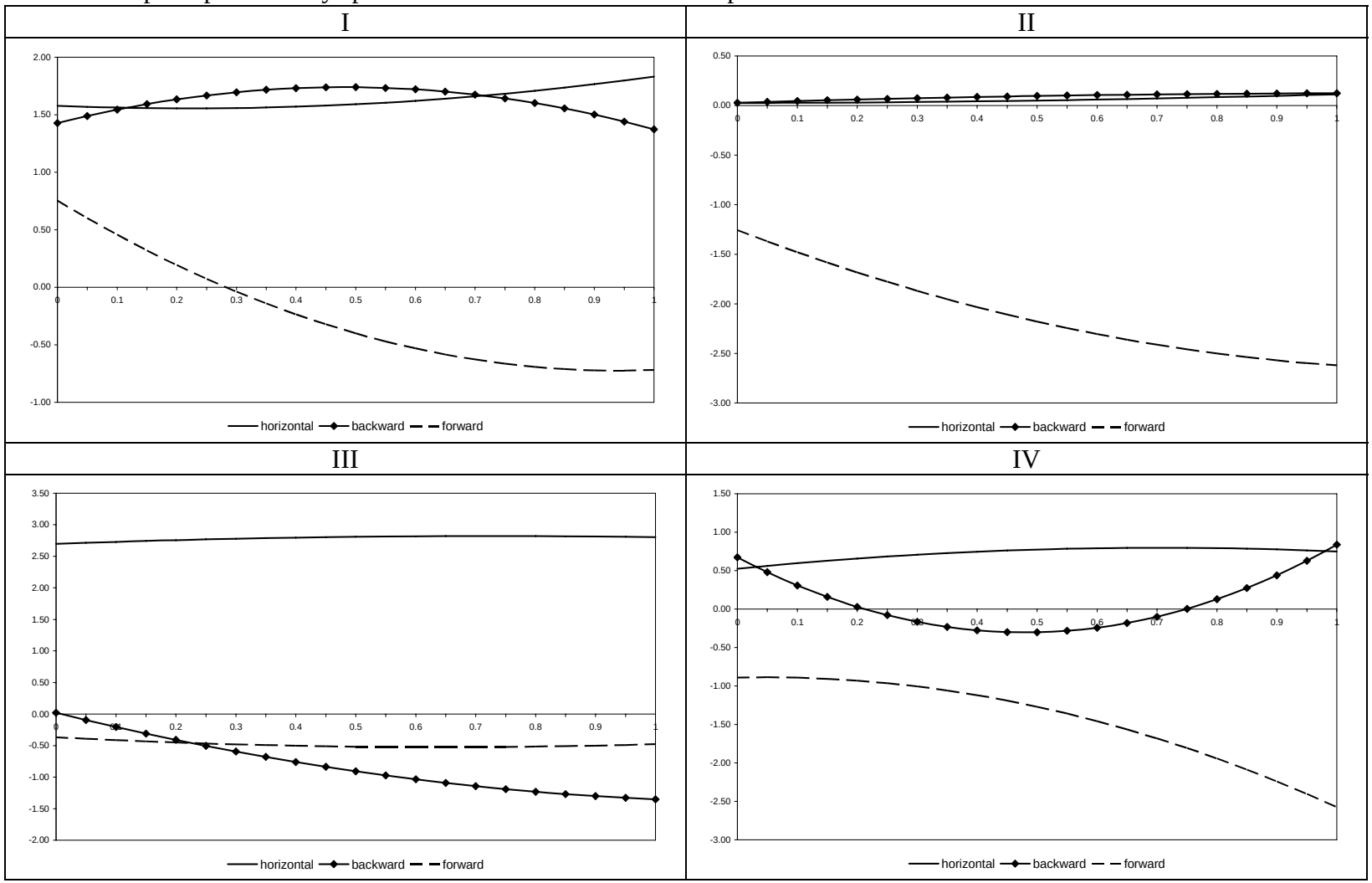
Panel B Non-linear spillovers according to firm classification

	All firms	I	II	III	IV	V	VI	VII
ΔHorizontal	1.464***	6.928***	0.093	11.705*	2.220	-0.721	2.276**	0.414
	[0.449]	[1.701]	[1.367]	[5.763]	[1.655]	[1.065]	[0.871]	[0.550]
*ΔHorizontal*T*	-0.902	-0.891	0.047	1.471	3.266	0.277	-12.388***	-5.400**
	[1.065]	[1.927]	[2.770]	[3.318]	[2.888]	[2.713]	[2.903]	[1.950]
*ΔHorizontal*T²*	1.127**	2.006***	0.274	-1.011	-2.320	-0.383	8.011***	1.830
	[0.558]	[0.707]	[1.213]	[2.374]	[1.460]	[1.883]	[1.856]	[1.672]
ΔBackward	0.963	6.147***	0.123	0.113	2.443	1.319	-17.375***	4.901***
	[0.684]	[1.857]	[0.654]	[4.746]	[2.007]	[2.143]	[4.667]	[0.692]
*ΔBackward*T*	3.724**	5.614*	0.769	-12.808**	-14.760**	-3.052	-31.499**	-5.685
	[1.738]	[3.213]	[2.858]	[5.523]	[5.986]	[7.622]	[13.516]	[4.712]
*ΔBackward*T²*	-4.679***	-5.843***	-0.356	5.307	15.357***	-0.141	33.790**	1.599
	[1.015]	[1.639]	[1.771]	[3.371]	[3.764]	[6.089]	[15.298]	[4.161]
ΔForward	0.894	2.881***	-5.036**	-1.486	-3.535	-3.387	35.477***	2.013
	[0.587]	[0.743]	[2.410]	[3.529]	[3.099]	[3.636]	[7.918]	[2.680]
*ΔForward*T*	-10.238***	-12.026***	-9.275***	-1.949	0.682	-13.136	20.605*	-1.129
	[1.699]	[3.323]	[3.339]	[5.988]	[4.633]	[8.324]	[10.932]	[3.612]
*ΔForward*T²*	5.952***	6.394***	3.820*	1.511	-7.380***	10.142	-27.159**	3.000
	[0.917]	[1.912]	[1.929]	[4.394]	[2.293]	[6.661]	[11.381]	[2.790]
# observations	33642	10364	3618	12310	4226	996	602	1327
# firms	15011	5033	1725	5511	1969	646	403	639
R-squared	0.10	0.17	0.20	0.15	0.15	0.24	0.32	0.24

Panel C: F-test of joint significance of non-linear spillovers

	All firms	I	II	III	IV	V	VI	VII
F: No *T-Horizontal*	2.72*	10.01***	0.16	0.10	1.36	0.03	10.26***	10.48***
F: No *Horizontal*	4.66***	8.38***	0.13	1.67	2.19	0.29	6.96***	11.33***
F: No *T-Backward*	12.99***	7.51***	0.04	3.14*	22.38***	0.62	2.81*	2.29
F: No *Backward*	9.11***	10.81***	0.10	2.67*	14.92***	0.53	34.18***	20.33***
F: No *T-Forward*	21.52***	6.55***	4.54**	0.06	22.69***	1.27	2.86*	1.46
F: No *Forward*	14.64***	6.41***	6.54***	0.27	15.81***	1.62	22.15***	1.09

Figure 4: The implied productivity spillovers for the 8 exclusive subamples



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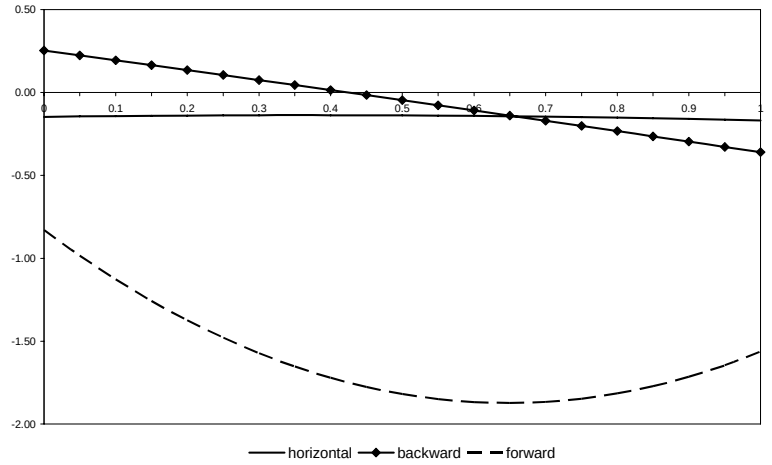
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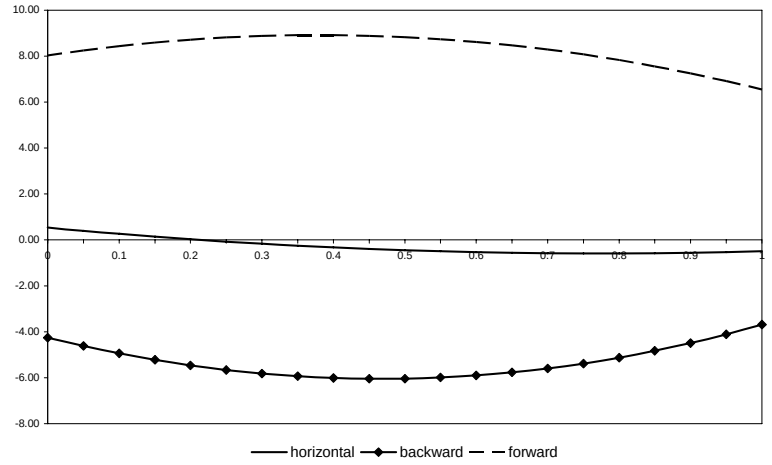
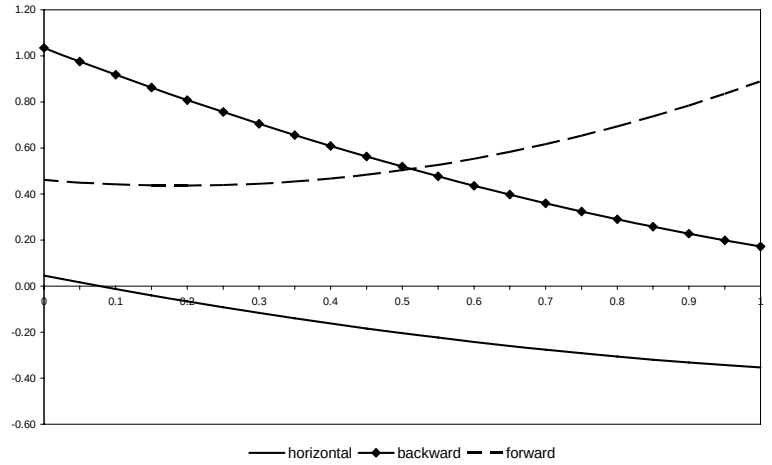
forward

VI


10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
horizontal
backward
forward

VII


1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
horizontal
backward
forward

VIII*

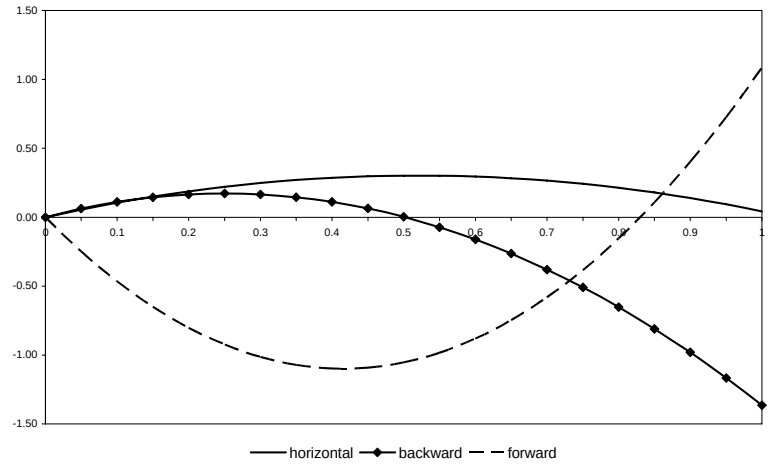

1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
horizontal
backward
forward

Table A.1 Welfare effects

	All firms							
				predicted				
	gaprelevant	prod level	prod growth	prod growth	horizontal	backward	forward	sum
all	0,211	5,056	0,021	-0,062	0,043	0,058	-0,017	*0,085*
p1-p99	0,208	5,058	0,019	-0,063	0,044	0,057	-0,015	*0,085*
p1-p10	0,015	4,418	0,201	0,036	0,041	0,059	-0,030	*0,070*
p10-p25	0,046	4,591	0,099	0,004	0,045	0,055	-0,021	*0,079*
p25-p50	0,101	4,835	0,016	-0,046	0,046	0,053	-0,017	*0,082*
p50-p75	0,204	5,162	-0,010	-0,088	0,046	0,051	-0,014	*0,084*
p75-p90	0,383	5,520	-0,034	-0,102	0,045	0,045	0,002	*0,092*
p90-p99	0,712	5,908	-0,074	-0,101	0,031	0,103	-0,031	*0,102*
	splitnum I							
				predicted				
	gaprelevant	prod level	prod growth	prod growth	horizontal	backward	forward	sum
all	0,218	4,932	0,022	0,014	0,273	0,256	0,097	*0,626*
p1-p99	0,215	4,933	0,022	0,013	0,274	0,255	0,097	*0,626*
p1-p10	0,024	4,416	0,174	0,146	0,249	0,252	0,089	*0,591*
p10-p25	0,059	4,559	0,039	0,017	0,280	0,252	0,086	*0,618*
p25-p50	0,113	4,824	0,003	0,007	0,271	0,252	0,095	*0,618*
p50-p75	0,213	5,034	0,000	-0,008	0,295	0,245	0,106	*0,645*
p75-p90	0,385	5,178	-0,011	-0,030	0,286	0,246	0,119	*0,651*
p90-p99	0,710	5,670	0,004	0,023	0,233	0,318	0,074	*0,625*

splitnum II

	predicted							
	gaprelevant	prod level	prod growth	prod growth	horizontal	backward	forward	sum
all	0,268	5,287	-0,068	-0,066	0,001	0,010	-0,378	*-0,367*
p1-p99	0,267	5,286	-0,069	-0,070	0,002	0,010	-0,378	*-0,366*
p1-p10	0,022	4,611	0,173	0,158	0,003	0,012	-0,393	*-0,378*
p10-p25	0,068	4,601	0,025	-0,063	0,003	0,011	-0,382	*-0,367*
p25-p50	0,142	5,071	-0,073	-0,054	0,003	0,010	-0,379	*-0,366*
p50-p75	0,279	5,379	-0,124	-0,114	0,003	0,010	-0,368	*-0,356*
p75-p90	0,487	5,911	-0,109	-0,111	0,003	0,010	-0,399	*-0,387*
p90-p99	0,782	6,088	-0,151	-0,079	-0,009	0,008	-0,352	*-0,353*

splitnum III

	predicted							
	gaprelevant	prod level	prod growth	prod growth	horizontal	backward	forward	sum
all	0,204	4,826	-0,109	-0,119	0,404	-0,045	-0,079	*0,280*
p1-p99	0,198	4,820	-0,107	-0,117	0,404	-0,046	-0,078	*0,280*
p1-p10	0,022	4,209	0,017	-0,025	0,393	-0,069	-0,080	*0,243*
p10-p25	0,054	4,348	-0,086	-0,076	0,407	-0,061	-0,081	*0,266*
p25-p50	0,105	4,601	-0,093	-0,083	0,402	-0,055	-0,079	*0,269*
p50-p75	0,197	4,978	-0,106	-0,129	0,403	-0,048	-0,078	*0,277*
p75-p90	0,352	5,258	-0,150	-0,174	0,408	-0,032	-0,073	*0,303*
p90-p99	0,658	5,569	-0,193	-0,199	0,408	0,010	-0,085	*0,332*

splitnum IV

	predicted							
	gaprelevant	prod level	prod growth	prod growth	horizontal	backward	forward	sum
all	0,194	5,112	0,166	-0,069	0,021	0,025	-0,091	*-0,045*
p1-p99	0,192	5,121	0,162	-0,068	0,020	0,030	-0,097	*-0,046*
p1-p10	0,008	4,375	0,332	0,077	0,059	-0,275	0,122	*-0,095*
p10-p25	0,029	4,645	0,281	0,064	0,038	0,027	-0,142	*-0,078*
p25-p50	0,075	4,926	0,194	-0,042	0,031	0,025	-0,122	*-0,066*
p50-p75	0,172	5,166	0,125	-0,063	0,022	0,046	-0,114	*-0,046*
p75-p90	0,346	5,567	0,091	-0,106	0,005	0,094	-0,128	*-0,029*
p90-p99	0,681	5,968	0,035	-0,121	0,013	-0,041	0,007	*-0,021*

splitnum V

	predicted							
	gaprelevant	prod level	prod growth	prod growth	horizontal	backward	forward	sum
all	0,273	5,674	-0,006	0,009	-0,012	0,034	-0,364	*-0,342*
p1-p99	0,267	5,659	-0,007	0,008	-0,012	0,034	-0,362	*-0,341*
p1-p10	0,022	4,163	-0,005	0,004	-0,013	0,032	-0,298	*-0,280*
p10-p25	0,057	5,047	-0,066	-0,071	-0,016	0,031	-0,296	*-0,281*
p25-p50	0,124	5,435	0,023	0,041	-0,012	0,021	-0,280	*-0,271*
p50-p75	0,254	5,873	0,019	0,017	-0,017	0,016	-0,351	*-0,351*
p75-p90	0,506	6,199	0,028	-0,008	-0,008	0,046	-0,417	*-0,380*
p90-p99	0,889	6,914	0,025	0,071	-0,004	0,093	-0,662	*-0,572*

	splitnum VI							
				predicted				
	gaprelevant	prod level	prod growth	prod growth	horizontal	backward	forward	sum
all	0,226	6,045	0,104	0,084	0,075	-0,819	1,213	*0,470*
p1-p99	0,227	6,045	0,104	0,084	0,075	-0,819	1,226	*0,483*
p1-p10	0,020	4,754	0,364	0,084	0,055	-0,962	1,551	*0,644*
p10-p25	0,048	5,340	0,218	0,230	0,059	-0,820	1,246	*0,485*
p25-p50	0,096	5,579	0,172	0,152	0,034	-0,907	1,374	*0,502*
p50-p75	0,216	6,337	0,027	0,035	0,099	-0,722	1,086	*0,463*
p75-p90	0,421	6,697	-0,005	-0,008	0,103	-0,829	1,203	*0,477*
p90-p99	0,734	6,915	0,057	0,032	0,084	-0,768	1,059	*0,375*

	splitnum VII							
				predicted				
	gaprelevant	prod level	prod growth	prod growth	horizontal	backward	forward	sum
all	0,251	5,376	-0,261	-0,270	-0,042	0,171	0,085	*0,214*
p1-p99	0,254	5,378	-0,260	-0,270	-0,042	0,171	0,085	*0,214*
p1-p10	0,021	4,333	-0,143	-0,171	0,015	0,191	0,092	*0,299*
p10-p25	0,064	4,924	-0,247	-0,268	-0,017	0,167	0,089	*0,238*
p25-p50	0,151	5,203	-0,315	-0,335	-0,035	0,164	0,093	*0,222*
p50-p75	0,318	5,722	-0,307	-0,303	-0,073	0,156	0,089	*0,172*
p75-p90	0,561	6,119	-0,185	-0,197	-0,036	0,191	0,097	*0,252*
p90-p99	0,899	6,214	-0,147	-0,106	-0,108	0,209	-0,018	*0,083*