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FDI Spillovers and the Timing of Foreign Entry*

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Abstract

This study analyzes the dynamic effect of FDI on local firms' productivity by relaxing the standard implicit assumption that technological spillovers are immediate and permanent. We find that the entry of majority foreign owned firms has a short run negative effect on the productivity of local competitors, which is more than offset by a longer run positive effect. The entry of minority foreign owned firms has an immediate, though short-lived, positive effect on local suppliers through backward linkages. The entry of majority foreign owned firms also improves the productivity of local suppliers, but the effect materializes later and lasts longer.

JEL Classification: F2
Keywords: FDI, spillovers, dynamics, timing

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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 often try to implement policies to attract foreign direct investment (FDI). Unfortunately, the literature surveys of Görg and Greenaway (2004) and Crespo and Fontoura (2007) on FDI spillovers conclude that there is no clear evidence of aggregate positive FDI spillovers.

FDI spillovers are commonly analyzed in a production function framework where FDI spillover variables are introduced as additional 'input' variables to explain domestic firms' productivity. The size and significance of the resulting coefficients are then taken as evidence of FDI spillovers. The literature distinguishes between horizontal spillovers to firms in the same industries and vertical spillovers to firms in other industries linked to the foreign firm through the supply chain. These are illustrated in figure 1. Following new theoretical insights that stress the importance of firm level heterogeneity in the study of firms' participation in international markets (see e.g. Melitz, 2003 and Helpman et al., 2004), the spillover literature has analyzed firm- (or industry-) specific characteristics that may mediate any spillover effects. These characteristics most often concern domestic firms' characteristics such as measures for absorptive capability (see a.o. Merlevede and Schoors, 2007). The attention for foreign firms' characteristics has been more limited (Marin and Bell, 2006, and Javorcik and Spatareanu, 2008, are the exceptions).

This paper adds dynamic aspects to the analysis of FDI spillovers. Although the literature has acknowledged that FDI spillover effects may require time to materialize, the empirical literature has addressed this issue merely by using lagged values of spillover variables. This approach is unsatisfactory. Since spillover variables are typically based on foreign firms' share in total industry output (or employment), the spillover effect of all foreign investment, new and old, is lumped together in one variable. Lagging the spillover variables does not adequately address the dynamic nature of spillovers, since lagged variables still lump together the effect of all previous foreign investment in one variable. The root of the problem is that this aggregate approach implicitly assumes that the contemporaneous spillover effect of a foreign firm that entered in a given year t is identical to that of a foreign firm that entered in any other year $-t$. This does not correspond with our understanding of the theoretical transmission channels of spillover effects. Teece (1977) for example already suggests that technology imitation and worker mobility might be important channels of horizontal spillovers, but neither the mobility of workers trained by foreign firms, nor technology imitation are likely to materialize in the very short run. Likewise, vertical spillovers driven by

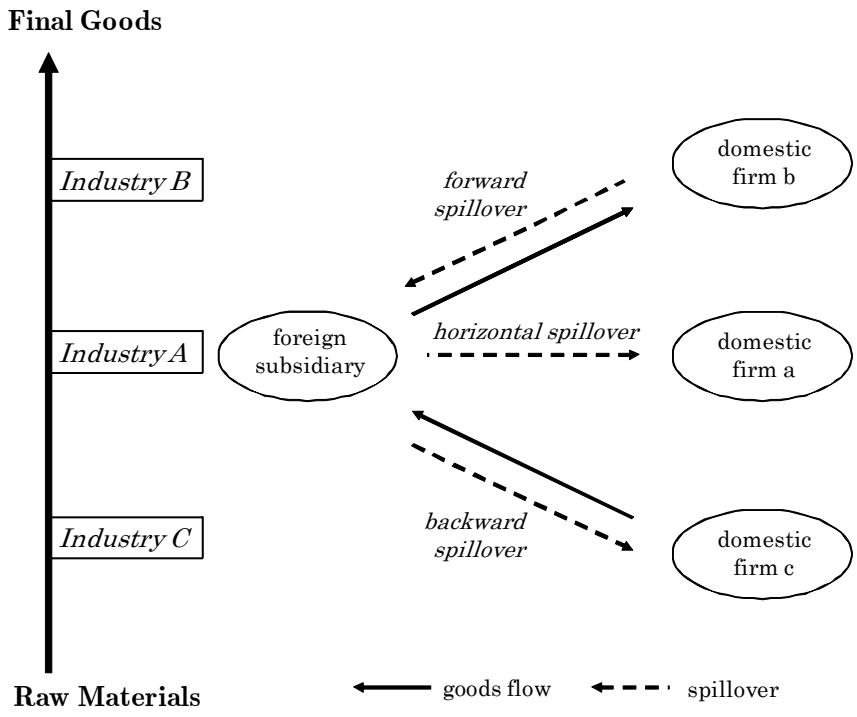

Figure 1: Horizontal, forward and backward spillovers through the supply chain

access to better inputs produced by foreign firms or by supplying inputs to multinational companies are not necessarily instantaneous nor permanent. There is some circumstantial evidence that timing may be important for spillover effects. For a long panel (1982-95) of firms in the Irish electronics sector Görg and Ruane (2001) find indications that foreign firms start off with a relatively low extent of local linkages, but as they get accustomed, they proceed to develop more local input linkages. Giroud (2007) confirms this by comparing foreign firms' perceived impact on local suppliers in Malaysia and Vietnam. Local suppliers benefit significantly less form foreign presence in Vietnam than in Malaysia, where multinationals have been present for a longer period. Based on their AB Volvo case study Ivarsson and Alvstam (2005) conclude that technology transfer to suppliers seems to be more efficient in Volvo's older plants. Technology is also not necessarily easily or rapidly transferred within multinationals (see e.g. Urata and Kawai, 2000) which may also give rise to specific time patterns in the transfer of technology to foreign affiliates and the ensuing spillovers.

Given the above, the current 'static' empirical approach may be inadequate to identify spillovers accurately. In addition to providing a better link between theory and test, understanding the dynamic nature of spillovers also has clear policy relevance for e.g. the fiscal treatment of foreign investment. If foreign entry spills over in a positive level shift of domestic

firms' productivity, a temporary tax holiday seems appropriate (left aside e.g. employment considerations in the foreign firms), while a more permanent tax incentive scheme may be warranted if foreign firms are a source of a more continuous flow of positive spillover effects.

Our results indicate that spillover effects of foreign investment on domestic firm productivity are dynamic indeed. Domestic firms' productivity seems to benefit from the presence of majority foreign owned firms in their industry, although the majority foreign owned firm needs to be present for at least four years in the host country before domestic firms experience a positive contribution to their productivity growth. This may result from the fact that it takes time for domestic firms to familiarize themselves with the advanced technology introduced by majority owned foreign firms, or alternatively from the fact that worker mobility can only improve domestic firm productivity if workers trained (long enough) by the foreign entrant later join a domestic firm. The impact of majority foreign owned firms that entered the domestic economy more recently is negative, pointing to a short run negative competition effect. The impact of the entry of minority foreign owned firms on their local competitors' productivity is more moderate.

Minority foreign owned firms do however generate immediate and strong positive backward spillover effects to their local suppliers. The first two years after foreign entry, domestic suppliers enjoy a substantial contribution to productivity growth when supplying the minority foreign owned entrant. If minority foreign owned firms have entered the domestic economy longer ago, the positive backward spillover effect fades away. Backward spillovers from majority foreign owned firms are also positive and significant but not immediate. Foreign firms need to be present for at least a full year before domestic firms are able to grasp positive backward spillover effects. Although the effect lasts longer than for minority foreign owned firms, it also fades out in the longer run. Domestic firms may have closer ties with minority than majority foreign owned firms (because of the majority domestic participation in the former), which ensures that positive spillovers of minority foreign investment materialize quicker. But since the minority foreign owner has to share profits with a local partner and has more reasons to fear technology leakage, he may bring in less advanced technology, which makes the spillover effect of foreign minority investment smaller and fade out faster. We do not find evidence for the existence of forward spillovers, a finding that is in line with most of the literature (see e.g. Smarzynska Javorcik, 2004, and Smarzynska Javorcik and Spatareanu, 2008).

This paper continues as follows. In section 2, we provide a description of our dynamic approach to FDI spillovers. Section 3 lays out the data and estimation strategy. Results and interpretation are provided in section 4. Section 5 concludes.

2 A dynamic approach to spillovers

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 also Fosfuri et al., 2001, and Görg and Strobl, 2005). Marin and Bell (2006) find that training activities by foreign subsidiaries are related to stronger 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. 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 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 transferring 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 and a general measure for horizontal spillovers will identify the net effect of all these channels.

Figure 1 shows how backward spillovers run 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.

The current empirical literature implicitly assumes the spillover intensity, i.e. the coefficients of the spillover variables in the regression, to be constant[1]. This is shown as the bold line in figure 2. At best spillover effects are allowed to kick in with a time lag, which would shift the bold line to the right. One can easily infer that whether a firm has been present in the host country for one, 10 or 20 years is assumed irrelevant for the spillover effect. In the introduction however, we discussed that most spillovers, horizontal or vertical, are probably dynamic. Workers need to receive training and absorb technologies before they can move to a domestic firm to improve the latter's productivity. Enhanced foreign competition may initially hurt domestic companies before it makes them better. If foreign affiliates tend to increase their local sourcing over time, backward spillovers will not rise to their full effect immediately. The presence of better foreign inputs probably requires an adaptation effort, before domestic firms can reap the full benefits of it. The dashed line in figure 2 shows a hypothetical dynamic pattern where the spillover effect is negative at first, say there is an adjustment cost, then becomes positive and finally fades out.

Our dynamic approach requires that we employ a measure of spillover variables that differs from the current literature. Typically, the horizontal spillover variable $Horizontal_{jt}$ captures the degree of foreign presence in sector j at time t and is measured as:

$$Horizontal_{jt} = \frac{\sum_{i \in j} F_{it} * Y_{it}}{\sum_{i \in j} Y_{it}} \tag{1}$$

where Y_{it} is the output produced by firm i in year t. $Horizontal_{jt}$ is industry j's share of output that is produced by foreign firms. Foreign firms are identified by F_{it}. In the literature F_{it} either is the exact share of foreign participation in firm i in year t, or alternatively, F_{it} is a dummy variable that takes the value 1 if firm i is foreign in year t and 0 otherwise. To be classified as foreign a foreign participation of at least 10% is required.[2]

For the measurement of the backward spillover variable $Backward_{jt}$, the literature em-

[1] The value of the spillover variables itself varies through time, generating a small variation in the eventual effect on firms' productivity.

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

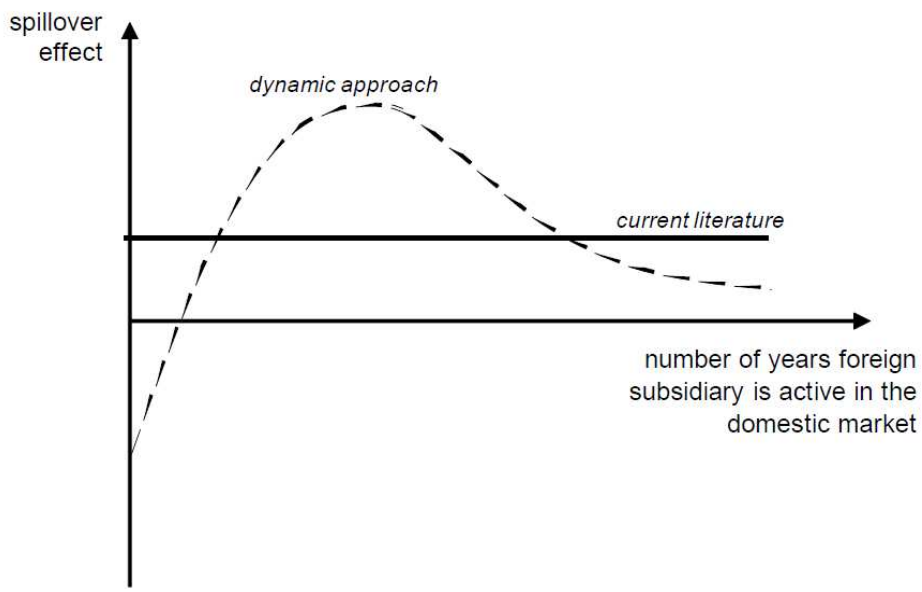

Figure 2: Intensity of the spillover effect to domestic firms' productivity as a function of the number of years of activity in the domestic market by the foreign firm: current literature versus dynamic approach

ploys:

$$Backward_{jt} = \sum_{k \ if \ k \neq j} \gamma_{jkt} * Horizontal_{kt} \tag{2}$$

where γ_{jkt} is the proportion of industry j's output supplied to sourcing industry k at time t. The γs are calculated from (possibly time-varying) IO-tables for intermediate consumption. Inputs sold within the firm's industry are excluded ($k \neq j$) because this is captured by $Horizontal_{jt}$. Since firms cannot easily or quickly switch industries to buy inputs, this approach avoids the problem of endogeneity by using the share of industry output sold to downstream domestic markets k with some level of foreign presence $Horizontal_{kt}$. Employing the share of firm output sold to foreign firms in different industries would cause endogeneity problems if the latter prefer to buy inputs from more productive domestic firms. In the same spirit, the forward spillover variable $Forward_{jt}$ is defined as:

$$Forward_{jt} = \sum_{l \ if \ l \neq j} \delta_{jlt} * Horizontal_{lt} \tag{3}$$

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 $Horizontal$. $Horizontal_{jt}$, $Backward_{jt}$, and $Forward_{jt}$ are then related

to domestic firms' productivity to infer the direction, magnitude and significance of spillovers.

As pointed out in the introduction, this typical definition of $Horizontal_{jt}$ in (1) lumps together all current and previous foreign investment in a single spillover variable and therefore implicitly assumes that the impact of a foreign firm on the domestic firm's productivity is constant over time. Since theory allows us to suspect that spillovers might be dynamic, rather than static, we define "y" different versions of the horizontal spillover variable instead of the single measure in (1) in order to capture these possible dynamic effects. Specifically we want to test whether the spillover effect is related to the time since entry. Therefore we define the variable $Horizontal^e_{jt}$ in (4) as industry j's share of output at time t produced by foreign firms that have been present in the host (domestic) economy for more than $y-1$, but less than y years (alternatively firms that entered between $t-y+1$ and $t-y$).

$$Horizontal^e_{jt} = \frac{\sum_i \widetilde{F}^y_{i,t} * Y_{it}}{\sum_i Y_{it}} \tag{4}$$

where $\widetilde{F}^y_{i,t}$ is set to one if

$$\left(\sum_{v=0}^{y-1} F_{i,t-v} = y\right) \wedge \left(\sum_{w=y}^{\infty} F_{i,t-w} = 0\right)$$

and to zero otherwise.

$Horizontal^2_{jt}$, for example, is industry j's share of output that is produced by foreign firms that have entered the domestic market more then one, but less than two years before t. Time varying definitions for $Backward^y_{jt}$, and $Forward^y_{jt}$ follow from (2) and (3) above

$$Backward^y_{jt} = \sum_{k \ if \ k \neq j} \gamma_{jkt} * Horizontal^y_{kt} \tag{5}$$

$$Forward^y_{jt} = \sum_{l \ if \ l \neq j} \delta_{jlt} * Horizontal^y_{lt} \tag{6}$$

3 Empirical approach and Data

3.1 Empirical approach

FDI spillovers are commonly analyzed in a production function framework. Total factor productivity at the firm level is obtained in a first step estimation and in a second step the FDI spillover variables $Horizontal$, $Backward$, and $Forward$, together with some further controls are treated as additional 'input' explaining domestic firms' productivity. The resulting coefficients are then taken as evidence of FDI spillover effects. The careful estimation of pro-

duction functions is thus an important building block in the analysis. The basic problem in estimating productivity is that firms react to firm-specific productivity shocks that are often not observed by the researcher. 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 unobservable assessment of its productivity. OLS estimates of production functions therefore yield biased estimates of factor shares and biased estimates of productivity. The semi-parametric approaches by Olley and Pakes (1996) (OP) and a more recent modification of it by Levinsohn and Petrin (2003) (LP), and the dynamic panel data approach by Blundell and Bond (1998) (DPD) are alternative methodologies to overcome the endogeneity bias in estimating production functions. Both types of methodologies have been widely used in the recent literature on firm level heterogeneity for derivation of total factor productivity measures. More recently, Ackerberg et al. (2008) (ACF) argue that, while there are some solid and intuitive identification ideas in the paper by Levinsohn and Petrin (2003), their semi-parametric techniques suffer from collinearity problems casting doubt on the methodology. They suggest an alternative methodology that make use of the ideas in these papers, but do not suffer from these collinearity problems. We will use ACF tfp as our base case, but we will check the robustness of our results with respect to other tfp-measures.

We estimate domestic industry production functions for each Nace 2-digit manufacturing industry j in the period 1996–2005 separately, excluding firms that are foreign at some point in time from the estimation. Capital, labor, and material inputs elasticities are thus industry-specific. A measure of total factor productivity tfp_{ijt} for firm i in industry j at time t is obtained as the difference between output and capital, labor, and material inputs, multiplied by their estimated coefficients:

$$tfp_{ijt} = Y_{ijt} - \widehat{\beta}_{lj} l_{ijt} - \widehat{\beta}_{kj} k_{ijt} - \widehat{\beta}_{mj} m_{ijt} \tag{7}$$

In the second step, we relate tfp_{ijt} to a firm specific effect, a vector of spillover variables, $\mathbf{FDI}_{jt}$, a control for competition, and time dummies (α_t). Note that (8) now pools firms from all industries together in one large panel, whereas (7) is estimated by industry. This specification follows the standard in the literature (e.g. Smarzynska Javorcik, 2004)

$$tfp_{ijt} = \alpha_i + \Psi_1 f\left(\mathbf{FDI}_{jt-1}\right) + \Psi_2 \mathbf{Z}_{i(j)t} + \xi_{ijt} \tag{8}$$

The vector of spillover variables ($\mathbf{FDI}_{jt-1}$) covers the different horizontal and vertical spillover variables described in (1)-(6). Considering the time span of our dataset (1996-2005) we opt to include $Horizontal^1_{jt-1}$ to $Horizontal^4_{jt-1}$ and create a variable $Horizontal^{5+}_{jt-1}$

which aggregates all foreign firms that have been present for at least four years on the domestic market. The time span of our dataset is then reduced to 2001-2005 because of missing values for $Horizontal_{jt}^{2}$ to $Horizontal_{jt}^{5+}$. $\mathbf{Z}_{i(j)t}$ is a veactor of control variables. Specifically we control for competition within the industry, measured by the Herfindahl index, import competition in the industry, the share of intermediates supplied in total industry output, and firm age.

Specification (8) is first-differenced and then estimated by OLS, including industry (α_j), region (α_r), and time dummies (α_t). Because $\mathbf{FDI}_{jt}$ and some control variables are defined at the industry level, and estimations are performed at the firm level, standard errors need to be adjusted (Moulton, 1990). Standard errors are therefore clustered for all observations in the same industry and year (cf. Smarzynska Javorcik, 2004). This results in (9) as final specification to be estimated.

$$\Delta tfp_{ijrt} = \Psi_1 \Delta f\left(\mathbf{FDI}_{jt-1}\right) + \Psi_2 \Delta \mathbf{Z}_{i(j)t} + \alpha_t + \alpha_j + \alpha_r + \varepsilon_{ijrt} \tag{9}$$

3.2 Data

We use firm-level data for a panel of Romanian manufacturing firms during 1996–2005. Because most foreign investment entered Romania after 1996, Romania makes a very good candidate to study the dynamic impact of recent foreign investment on domestic firm productivity. As can be seen from figure 3 Romania started attracting large FDI inflows only late in transition. The slow pace in the early 1990s of both privatization efforts and market-oriented reform in general made Romania an unattractive place to invest relative to the other transition countries in Central and Eastern Europe. It was only in 1997 that Romania really embarked on privatization. In 2004 FDI inflows took off on a larger scale. Early 2008 Austria (21.4%), The Netherlands (16.3%), Germany (11.7%), and France (8.8%) were the most import home countries of foreign firms in Romania. Manufacturing accounted for about 40% of total foreign investment, metal (7.5%) and food and tobacco (5.2%) are the most important subsectors. Banking and insurance (23.3%) , wholesale and retail (14%), and telecommunication (6,5%) are the other important industries in terms of FDI.

Our firm-level data are taken from the Amadeus database by Bureau Van Dijk. Amadeus is a pan-European database of financial information on public and private companies. Every month Bureau Van Dijk issues a new DVD with updated information. A single issue contains unfortunately only the latest information on ownership and firms that go out of business are dropped from the database fairly rapidly. Furthermore, because Bureau Van Dijk updates individual ownership links between legal entities rather than the full ownership structure of a given firm, the ownership information on a specific DVD-issue often consists of a number

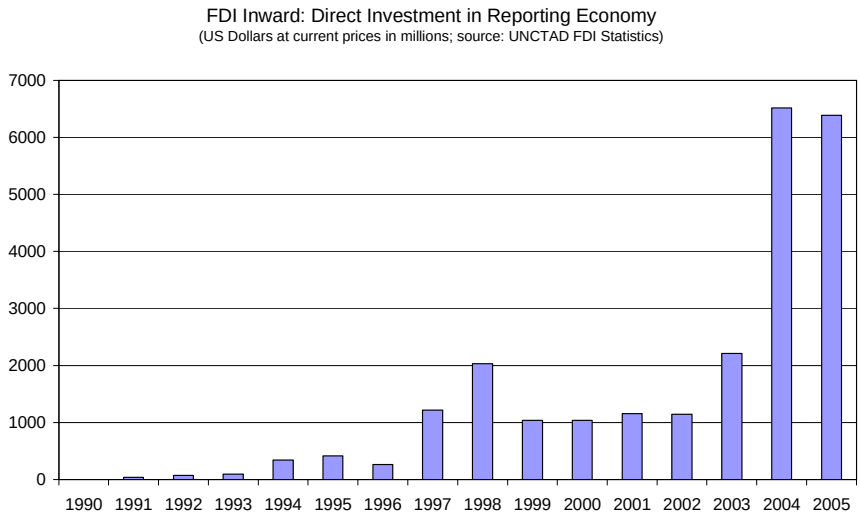

Figure 3: Foreign Direct Investment in Romania 1990-2005

of ownership links with different dates, referring to the last verification of a specific link. To construct our dataset with entry, exit, and time-specific foreign entry in local Romanian firms, we therefore employed a series of different issues of the database. However, since ownership information is gathered at irregular intervals, we do not have ownership information for all firm-owner-year combinations.[3] Given these specificities of Amadeus, we first created a dataset at the firm-owner-year-level with the available information from Amadeus. We then filled out missing firm-owner-year-entries under restriction that the full ownership structure cannot exceed 100%. In case of time gaps between entries for the same owner-firm combination but with a different share-size we assume that changes show up immediately in the database. We then fill out the gaps with the older information.[4]

Data are deflated using industry price level data at Nace rev.1.1 2-digit level[5]. These 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). Real output Y is measured as operating revenues deflated by producer price indices of the appropriate Nace industry; real material inputs M, are deflated

[3] Identifying the same owner in different issues is not always straightforward since an ID is only listed in case the owner is a firm that is listed in Amadeus itself. For all other owners matching is done on the basis of the name. Differences in spacings, plurals, addition to the name of a company-type, the use of characters specific to Romanian versus standard Roman characters, ... in different issues are corrected for.

[4] e.g.

	Amadeus	immediate
2000	40	40
2001	.	40
2002	50	50

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

by a weighted intermediate input deflator where the industry-specific weighting scheme is drawn from the IO tables. Labor L is expressed as the number of employees. Real capital K is measured as fixed assets, deflated by the average of the deflators for the following five Nace industries: machinery and equipment (29); office machinery and computing (30); electrical machinery and apparatus (31); motor vehicles, trailers, and semi-trailers (34); and other transport equipment (35) (see Smarzynska Javorcik, 2004). IO tables for the period 1996–2005 were obtained from the RNSO. The tables are in national industry classification, but the RNSO provided a mapping into Nace rev. 1.1. The RNSO tables are fairly detailed and identify 59 manufacturing sectors. This provides us with richer detail in vertical relationships than the more common IO-tables at Nace 2-digit that only have 22 manufacturing sectors.

We restrict the dataset to firms with on average 5 employees over the sample period. The dataset is further trimmed for outliers by removing the top and bottom percentiles of the annual growth rates of real operating revenues, real capital, labour, and real material inputs.[6] Table 1 lists the annual number of firms, and the entry and exit rate of all firms and for the subsample of foreign firms. The share of foreign firms in the total number of sample firms steadily increased from 16% to 22% (10 to 15% if small firms are not excluded). The 2003 exit rate is high, but this pattern is confirmed by the pattern in the Romanian Trade Register (Trade Register data also include agriculture and services though). Table 2 lists summary statistics both for domestic and foreign firms. The stylized facts commonly found in the literature are confirmed in our dataset. Foreign firms are larger in terms of employment and capital, produce more output and are more productive. The latter holds across different estimation techniques. The productivity bonus of foreign over domestic firms ranges between 14% in case of the Olley-Pakes methodology[7] (OP) and 36% in case of the Levinsohn-Petrin methodology (LP). Table 3 indicates a fairly high correlation between the tfp-measures resulting from different estimation techniques. For our empirical results we will mainly rely on the tfp measure obtained by the methodology proposed by Ackerberg et al. (2008). Finally, table 4 shows the sector breakdown of the spillover variables for the first and last year of our sample. Left aside the highly concentrated tobacco industry (Nace 16)[8], on average (over industries) some 15% of industry output was produced by foreign firms in 1996. The share of foreign firms varies between 7% and 30%. In 2005 on average 39% of industry output was produced by foreign firms, while shares varied between 15% and 57% across industries. The correlation across years and spillovers is limited.

[6] If the 'outlier' is the first or last observation for a specific firm and other datapoints are normal, the other firm-year data are kept. If not all observations for this firm are dropped from the dataset.

[7] We apply the procedure from Amiti and Konings (2007) to calculate investment from our data.

[8] Including or excluding the tobacco industry does not affect our results.

4 Results

This section presents results of different sets of estimations. For the sake of clarity and in order to keep the tables manageable we do not report control variables. If not mentioned otherwise results include age, industry competition, competition from imports in the industry, the share of intermediates supplied in total industry ouput, and time, industry and region dummies. We consider horizontal, backward and forward spillovers. Forward spillovers turn out to be unimportant and to reduce table size results on forward spillovers are not presented. We think of them as additional control variables. In the robustness section we show that our main results are qualitatively unaffected by dropping the forward spillover variables from the regressions altogether.

As a starting point, table 5 presents the estimation results for the standard non-dynamic specification found in the literature. The estimates in table 5 are based on our 'long' sample running from 1996 to 2005. The first five columns all use the sample of firms with at least five employees on average and the share definition of the spillover variables (cf. section 2). The first five columns differ in the estimation technique used to construct a measure of total factor productivity. Column 6 uses a dummy version of the spillover variable and column 7 uses all firms without employment threshold. Results suggest that Romanian manufacturing firms have benefited from supplying foreign firms. The backward effect is large and significant. Horizontal spillovers are also positive and significant, but coefficients are smaller in size. The presence of foreign competitors therefore seems to have contributed positively to domestic firms' productivity growth. These results are consistent throughout the different columns of table 5. The unreported forward spillover is negatively signed, implying that firm-level productivity is lower for firms in industries that source inputs from industries with a larger foreign presence. The forward spillover loses significance either when the dummy version is used, or when the time period is restricted to 2001-2005 (our sample for the entry timing regressions).

< insert table 5>

4.1 The impact of entry timing

< insert table 6 >

In table 6 we allow FDI spillovers to differ according to the timing of entry of the foreign firm. Column headings are the same as those in table 5. In order not to reduce the time

dimension of our panel too much[9], we created for each spillover a 4+ variable that brings together all foreign firms that have been present for at least four full years on the domestic market. One could think of the coefficient of this variable as an aggregated longer term effect. Further note that the average values of these 4+ variables are considerably larger than the variables capturing entry in a more recent specific year. This needs to be taken into account when interpreting coefficients and the variables' contribution to firm-level productivity growth. Gauging across the different columns in table 6, the results generally suggest a positive horizontal spillover effect on a longer horizon. Firms that recently entered the host economy have no impact on domestic firms' tfp, whereas firms that have been present for more than four full years generate strong positive spillovers that are significant in all 7 columns of table 6. This is a clear indication that it takes time for domestic firms to grasp benefits from foreign entry in their industry. But longer established foreign firms do affect domestic firm productivity positively. The backward spillover presents a different story. Here the impact on domestic firm productivity is faster than for the horizontal spillover, although positive effects are not immediate either. The strongest positive backward spillovers are found for foreign firms that entered between one and two years ago. There is a smaller, but still positive effect for firms entering between two and four years earlier, but the evidence is more mixed across columns. A longer term effect is absent. This suggest that domestic firms that supply new foreign entrants enjoy higher productivity growth for a couple of years after a short adjustment period. With respect to the forward spillover no significant impact remains.

4.2 The impact of ownership structure

The literature on FDI spillovers has already acknowledged that the level of local participation may play an important role in determining spillover effects. On the one hand, local participation in a foreign investment project reveals the foreign firm's proprietary technology, which facilitates spillovers (Blomström and Sjöholm, 1999). On the other hand, the fear of technology leakage on behalf of the foreign firm will induce foreign firms to bring in less advanced technology or to shy away from shared ownership when bringing in their more sophisticated technologies. Desai *et al.* (2004) for example find evidence that majority subsidiaries receive more intangible property from their parent companies than do minority subsidiaries. Furthermore, advanced technologies offer a larger scope for spillovers, but may impede knowledge diffusion to local firms operating in the same sector if the latter lack sufficient absorptive capacity. With respect to backward spillovers Smarzynska Javorcik and

[9] E.g. in case of $Horizontal_{jt}^{6}$ we observe firms that have been present between 5 and 6 years on the domestic market only from 2002 onwards, prior to 2002 this variable only contains missing values.

Spatareanu (2008) find positive effects mainly for spillovers from joint ventures. They argue that due to greater technological sophistication majority foreign owned firms may require more complex inputs that may be more difficult for local firms to provide. Therefore, they may be less likely to engage in local sourcing than affiliates with shared ownership. These lines of reasoning may also be subject to entry timing issues. The effects of supplying majority foreign owned firms may take time to show up, either because majority foreign owned firms initially do not source locally or because the domestic suppliers need to get acquainted with the majority foreign owned firms' requirments.

Therefore we allow the timing of entry effects to be different for majority and minority foreign owned firms in table 7. This is done by considering two versions of (1) where our single foreign ownership variable $\widetilde{F}_{i,t}^{y}$ is now broken down in two versions $\widetilde{F}_{i,t}^{yM}$ and $\widetilde{F}_{i,t}^{ym}$. $\widetilde{F}_{i,t}^{yM}$ is the share of majority foreign participation (50% or more) taken between $y-1$ and y years ago in firm i in year t, and is set to zero if foreign participation is smaller than 50%. Likewise $\widetilde{F}_{i,t}^{ym}$ is then the share of minority foreign participation (less than 50%, but more than 10%) taken between $y-1$ and y years ago in firm i in year t, and is set to zero if foreign participation exceeds 50% or is smaller than 10%. (10) and (11) are then used to generate both majority and minority foreign owned versions of all our previously defined spillover variables along the lines of (4)-(6).

$$Horizontal_{jt}^{yM} = \frac{\sum_{i\in j} \widetilde{F}_{i,t}^{yM} * Y_{it}}{\sum_{i\in j} Y_{it}} \tag{10}$$

$$Horizontal_{jt}^{ym} = \frac{\sum_{i\in j} \widetilde{F}_{i,t}^{ym} * Y_{it}}{\sum_{i\in j} Y_{it}} \tag{11}$$

< insert table 7>

In table 7 we jointly consider ownership structure and timing of entry effects. The effects of minority and majority foreign entry on the productivity of their local competitors and suppliers that are implied by specification (1) in table 7 are visualised in figures 4 and 5. The positive time-invariant horizontal spillover effect from table 5 appears to be largely driven by a longer term positive spillover effect from majority foreign owned firms. This result is very robust across measures of tfp, samples and spillover definitions. The horizontal spillover from majority foreign owned firms (horizontal majority spillover henceforth) turns negative if they entered between t-1 and t-2 and significantly negative if they entered between t-2 and t-3. This is reversed in the longer run, where the spillover turns strongly positive. This

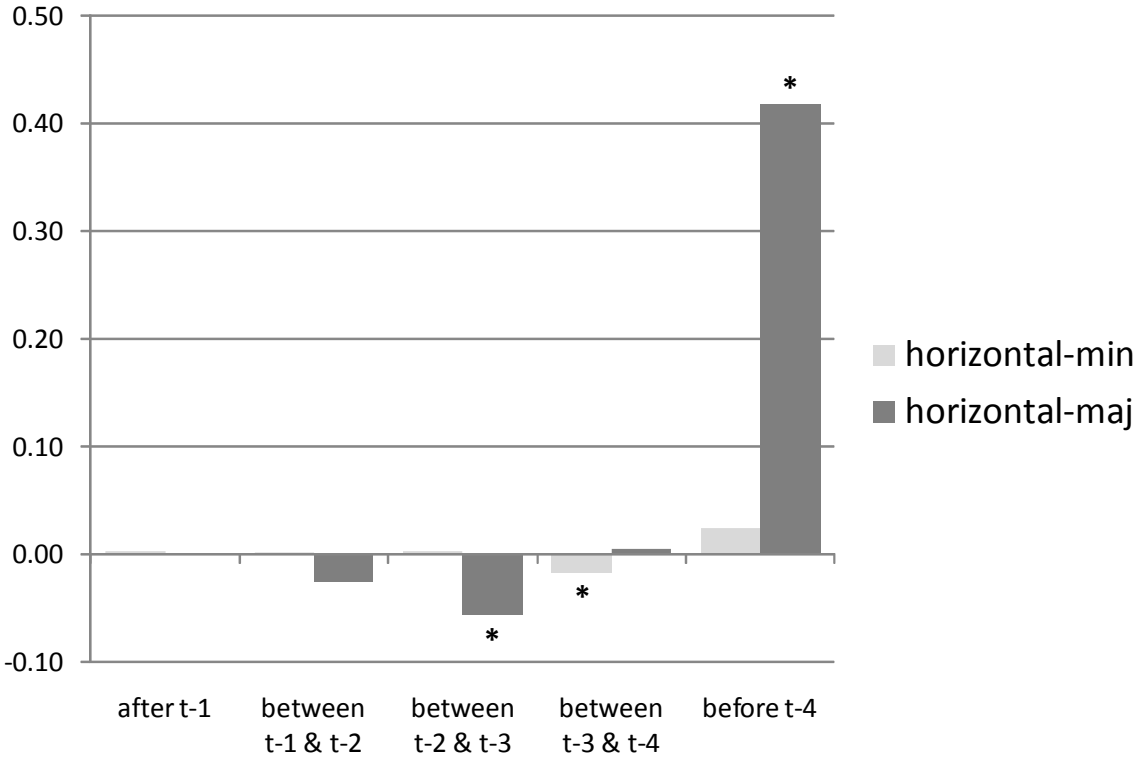

Figure 4: Contribution of 2001-05 mean horizontal spillovers to 2001-05 mean log tfp of domestic firms as implied by specification (1) of table 7 (stars indicate statistically significant coefficients; average log ACF tfp of domestic firms is 5.62)

is consistent with the thesis that the advanced technology of majority foreign owned firms drives the positive spillover, but that it takes time to absorb this advanced technology. It is also consistent with a labour market theory of spillovers. Majority foreign owned entrants may initially push up local wages and poach the best talents, yielding a negative spillover. But a few years later local employees that have received on the job training from the majority foreign owned firm may quit to join domestic firms or set up their own firm, reversing the effect. The productivity spillovers from minority foreign owned firms are much smaller (they also account for a substantially smaller share of industry output). The initial impact seems to be insignificant, but the spillover turns negative for firms that entered between t-3 and t-4. Taking into account average values of the variables concerned, we may conclude that the spillovers from minority foreign owned firms are fairly small relative to these from majority foreign owned firms (cf. figure 4).

Minority foreign owned firms, however, do generate immediate and strong positive backward spillover effects. The first two years after entry domestic firms enjoy a substantial contribution to productivity. As testified by figure 5, point estimates imply a considerable

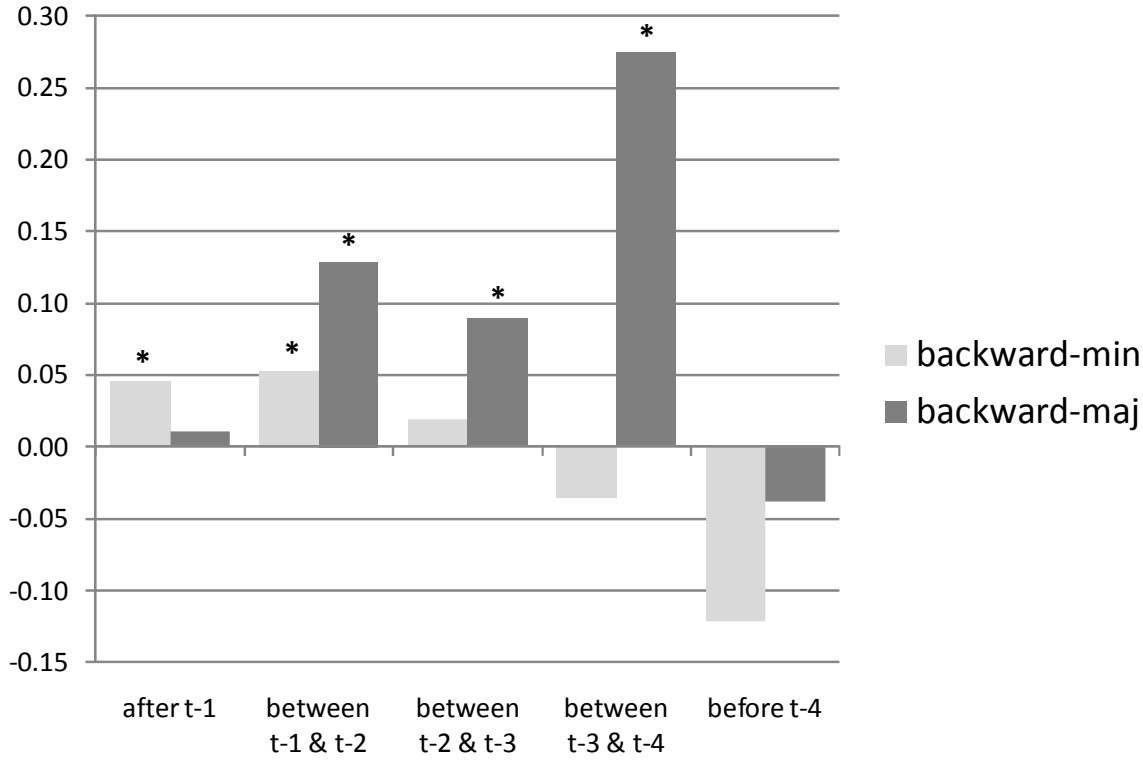

Figure 5: Contribution of 2001-05 mean backward spillovers to 2001-05 mean log tfp of domestic firms as implied by specification (1) of table 7 (stars indicate statistically significant coefficients; average log ACF tfp of domestic firms is 5.62)

impact on productivity, but altogether not an unrealistically large one. The positive backward spillover is large but short-lived. The effect even turns negative, though insignificant, for minority foreign owned firms that entered between t-3 and t-4. The longer term coefficients are also negative but not significantly different from zero. Backward spillovers from majority foreign owned firms are also positive, but the effect is less immediate and longer lived than for minority foreign owned firms. Majority foreign owned firms need to be present for at least a full year for domestic firms to grasp positive backward spillover effects, but positive effects are enjoyed up to 4 years after foreign entry. The longer term coefficients are again insignificant. Note that the result on the backward majority spillover seems more robust across columns than the result on the backward minority spillover.

These results are consistent with the thesis that domestic firms receive immediate, well tailored assistance from the minority foreign owned entrant they supply. Given a domestic majority, the minority foreign owned firms are probably better aware of possible constraints at their domestic suppliers and more willing to provide initial relatively straightforward assistance. The foreign minority shareholder may on the other hand not bring in its most

advanced technologies, implying a limited scope for spillovers. Hence an immediate, but rather short-lived positive contribution to productivity growth. For domestic firms supplying to majority foreign owned firms it may take more time to benefit from this relationship, because they need to get acquainted with the demands and technologies of their majority foreign owned clients, but benefits are large and positive once they arrive and they last longer. A lasting impact is absent as well, however.

4.3 Firm-level heterogeneity

In line with Békés et al. (2009) who show that firms' size and productivity are potential drivers of the intensity of spillover effects and other recent literature that stresses the importance of firm level heterogeneity in analyzing firms (see e.g. Melitz, 2003 and Helpman et al., 2004), we allow the timing of entry pattern to differ according to absorptive capacity and firm size. Following Damijan et al. (2008) we define the following size classes: micro firms ($5 \leq$ empl. ≤ 10), small firms ($10 <$ empl. ≤ 50), medium firms ($50 <$ empl. ≤ 250), and large firms (empl. > 250).

Absorptive capacity has been stressed in the FDI spillover literature (see e.g. the survey by Crespo and Fontoura, 2007). Rather than the pure productivity level, absorptive capacity refers to the ability of firms to assimilate outside knowledge and technology. Blomström (1986) finds that foreign firms are more likely to eliminate the local competition when the initial level of technology is low and human capital is poor, i.e. if the absorptive capacity is low. Kokko *et al.* (1996) find that horizontal spillovers are positive and significant only for plants with small or moderate technology gaps relative to foreign firms. Findlay (1978) on the other hand constructs a model of technology transfer through FDI from developed to developing countries. His model stresses a 'scope' argument and suggests that spillovers are a negative function of the level of technology, while the absorptive capacity interpretation suggests a positive relation. Our measure of absorptive capacity is defined as the ratio of the mean productivity of domestic firm i over the sample period and the mean productivity of all foreign firms in the same industry. We will estimate separate regressions for four quartiles of our measure of absorptive capacity.

Table 8 presents the results. For ease of comparison the first column under the heading 'basic' replicates the first column of table 7, i.e. the results for the sample of firms with on average more than five employees with ACF-tfp as dependent variable and the share versions of the spillover variables. Columns 2 to 5 present the results for the different size classes, whereas columns 6 to 9 present the results for four quartiles of the mean absorptive capability.

< insert table 8 >

With respect to firm size our main findings are confirmed. The 'medium-run' positive backward spillover from majority foreign owned firms and the short-lived positive backward spillover from minority foreign owned firms are present and comparable in all size classes. Additionally, both medium and large firms seem to experience negative productivity effects when supplying minority foreign owned firms that entered before t-3. The longer term positive horizontal spillover effect from majority foreign owned firms is present in all size classes. Medium sized firms seem, however, to be hit significantly harder by the presence of majority foreign owned firms that entered between t-1 and t-3 in their industry, while large firms do not experience any medium term negative impact. The patterns for medium and large firms with respect to the horizontal productivity impact of minority foreign owned firms show that they immediately benefit from the presence of minority foreing owned firms. The negative impact for minority foreign owned firms entering between t-3 and t-4 is present for all firms except for the small firms. It is noteworthy that the pattern for micro firms show relatively large negative -though insignificant- coefficients.

The results for four quartiles of the mean absorptive capacity largely confirm our main findings for different absorptive capacity quartiles. For all four quartiles we find strong positive longer term horizontal-majority, strong medium-run backward-majority, and immediate short-lived backward minority spillovers. There is a number of deviations from the general pattern, however. The firms with the lowest absorptive capacity experience immediate negative productivity effects from majority foreign owned firms in their industry. Also firms in the second quartile experience a similar stronger negative impact, but to a lesser extent. Firms with higher absorptive capacity (Q3 and Q4) are more resistant. Q3 and Q4 firms do experience negative productivity effects when supplying minority foreign owned firms that entered between t-3 and t-4 (as do Q1 and Q2 firms). Further, the firms with the highest absorptive capability (Q4) seem to benefit somewhat less and somewhat later both from minority and majority backward spillovers. This may be explained by a scope effect where they can benefit less from easy to implement improvements that immediately affect productivity. Additionally these firms may also be the firms that supply the toughest foreign firms in terms of input requirements.

4.4 Further robustness checks

In this section we present some further tests on the robustness of the patterns in entry timing we found. Table 9 presents the estimation results. For ease of comparison column 1 again repeats our basic specification, i.e. the results for the sample of firms with on average

more than five employees with ACF-tfp as dependent variable and the share versions of the spillover variables. The latter three definitions are maintained throughout table 9 in contrast to the different columns in table 7 that explored sensitivity to these definitions.

< insert table 9 >

Column 2 drops the insignificant forward spillover variables from the list of explanatory variables. Our earlier results are confirmed. Only the immediate backward minority effect is somewhat less precisely estimated, but it is still significant at the ten percent level. Columns 3 and 4 again include forward spillovers but drop minority and majority spillovers respectively. The patterns for spillovers from majority foreign owned firms is confirmed in column 3. Column 4 shows that the backward minority spillover from firms entering after t-1 is no longer significant at conventional levels. The negative horizontal effect for firms entering between t-3 and t-4 also disappears. Column 5 presents results for a balanced sample of firms over the period 2001-2005. Our qualitative results are not affected. The only exception is that delivering goods to minority foreign owned firms generates a negative impact for firms entering between t-3 and t-4.[10] Columns 6 and 7 relate back to figure 3. In column 6 we restrict the sample to make sure that the $before\ t-4$ spillover variables now include at least the first significant wave of entry of foreign firms. In column 7 we restrict the sample at the end to exclude the impact of the surge of FDI inflows in 2004 and 2005 (see figure 3) on the $after\ t-1$ spillover variables. Column 6 shows robust patterns for the horizontal and backward spillovers from majority foreign-owned firms. With the exception of a marginally significant negative longer term backward spillover from majority foreign-owned firms. The pattern of the backward spillover form minority foreign-owned firms changes. The positive impact now only realises when the foreign firm has been present for at least two full years and decays in entry timing. There is also a marginal indication of a longer term positive impact (borderline significant at 10% level). Column 7 reports results when the impact of the surge of FDI inflows on the $after\ t-1$ spillover variables at the end of the sample has been excluded. The entry timing patterns are again fairly similar to our basic result, especially with respect to our main findings. The initial stages of the pattern for the horizontal majority spillovers now resembles the pattern for the lowest absorptive capability quartiles (Q1-2) in table 8. In both columns 6 and 7 the longer term horizontal impact of minority foreign owned firms is now positive and significant in addition to the significant negative impact from firms entering between three and four years ago.

All in all our findings suggest important and strong positive longer term horizontal

[10] cf. the larger firms and the firms with more absorptive capacity in table 8.

spillovers from majority foreign owned firms and strong medium term backward spillovers also from majority foreign owned firms.[11] Our results also suggest important immediate but short-lived backward minority spillovers. The latter finding is, however, somewhat less stable across our various robustness checks in tables 7 through 9.

5 Conclusions

This study analyzes horizontal and vertical productivity spillovers of foreign direct investment on domestic Romanian manufacturing companies from 1996 to 2005. We add to the literature by investigating the impact of the timing of entry on spillovers. Spillover variables are typically based on foreign firms' share in total industry output. Therefore the spillover effects of all foreign investment, new and old, are lumped together in one variable. We allow spillovers to vary over time according to the timing of foreign entry and find that spillovers from foreign investments do vary over time in ways that are economically intuitive and consistent with theory. In the short run backward spillovers seem to dominate the analysis, but in the longer run horizontal spillovers emerge as important channels of productivity spillovers too. More specifically, domestic firms seem to experience positive horizontal spillover effects from majority foreign owned firms, but only in the longer run. This is consistent with the thesis that domestic firms need time and effort to absorb the foreign technology, but also with the labour market channel of spillovers. The horizontal impact of minority foreign owned firms, who account for a substantially smaller share of industry output, is much smaller. Minority foreign owned firms do generate immediate and strong positive backward spillover effects though. The first two years after entry, domestic firms that supply minority foreign entrants enjoy a substantial contribution to productivity growth, but this positive impact fades out rather quickly. Backward spillovers from majority foreign owned firms are also positive, but the effect is less immediate and longer lived, though it also fades out in the longer run. We do not find evidence for the existence of forward spillovers, a finding that is in line with most of the literature. Attracting foreign direct investment therefore raises the level of local firm productivity, but contrary to what the literature has implictly been

[11] An unreported regression where we created for each spillover a 6+ (rather than 5+) variable that brings together all foreign firms that have been present for at least *five* (rather than four) full years on the domestic market also confirms that the horizontal effect is on a longer term, while the backward effect is shorter-lived. This is illustarted by the following selected coefficients from thi regression:

$$-\underset{[0.93]}{0.32}HR^{1,Maj} - \underset{[1.37]}{1.97}HR^{2,Maj} - \underset{[1.11]}{3.45}^{a}HR^{3,Maj} - \underset{[0.60]}{0.71}HR^{4,Maj} + \underset{[0.58]}{0.03}HR^{5,Maj} + \underset{[0.41]}{1.49}^{a}HR^{6+,Maj}$$
$$+\underset{[9.40]}{11.49}BK^{1,Maj} + \underset{[6.12]}{15.88}^{a}BK^{2,Maj} + \underset{[3.49]}{4.40}BK^{3,Maj} + \underset{[4.39]}{14.29}^{a}BK^{4,Maj} - \underset{[3.62]}{1.25}BK^{5,Maj} - \underset{[1.47]}{2.07}BK^{6+,Maj}$$

assuming the impact of foreign presence depends strongly on its maturity.

Finally, our results raise a number of questions. What are the precise channels for the positive effects of foreign investments and their entry timing pattern? Does the effect in the host country depend on the characteristics of the home country? In what way can governments maximize the positive spillover effects through domestic policies? We defer these questions to further research.

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Table 1: Number of firms, entry, and exit by year

	All firms			*of which Foreign firms*			
	# firms	entry	exit	# firms	entry	exit	penetration
1996	14,393			2,242			0.16
1997	15,618	1057	91	2,615	315	32	0.17
1998	16,768	996	190	3,005	328	59	0.18
1999	18,054	1200	761	3,464	373	169	0.19
2000	19,480	1845	301	3,940	472	72	0.20
2001	20,908	1374	507	4,458	445	119	0.21
2002	21,912	1224	988	4,792	332	305	0.22
2003	22,579	1336	2447	4,896	298	493	0.22
2004	21,525	1066	562	4,831	314	168	0.22
2005	20,963			4,667			0.22

Table 2: Summary statistics for firm-level and industry level variables

	All firms		Domestic firms		Foreign firms	
	n = 133154		n = 105854		n = 27300	
	mean	sd	mean	sd	mean	sd
ln(real output)	13.74	1.90	13.53	1.84	14.52	1.94
ln(employment)	98.97	432.98	83.11	394.16	160.49	554.31
ln(capital)	12.08	2.32	11.82	2.26	13.06	2.29
ln(real value added)	12.67	2.09	12.43	2.03	13.62	2.05
ln(tfp) *ACF*	5.74	1.52	5.69	1.52	5.95	1.47
ln(tfp) *OP*	2.09	0.87	2.06	0.85	2.20	0.94
ln(tfp) *LP*	6.93	1.79	6.86	1.81	7.22	1.70
ln(tfp) *DPD*	2.30	1.29	2.27	1.27	2.42	1.33
ln(tfp) *OLS*	2.43	1.01	2.39	0.98	2.61	1.10
ln(tfp) *FE*	2.00	0.96	1.95	0.91	2.21	1.11

	Spillovers (industry-year; n = 649)					
	all foreign owned firms		majority foreign owned firms		minority foreign owned firms	
	mean	sd	mean	sd	mean	sd
horizontal *dummy*	0.40	0.16	0.26	0.21	0.06	0.12
horizontal *share*	0.28	0.14	0.22	0.19	0.02	0.04
backward *dummy*	0.24	0.07	0.17	0.08	0.04	0.05
backward *share*	0.17	0.05	0.15	0.07	0.01	0.02
forward *dummy*	0.26	0.09	0.17	0.09	0.05	0.03
forward *share*	0.18	0.08	0.14	0.08	0.01	0.01

Table 3: Correlation between different productivity measures

	OLS	FE	DPD	Lpva	OP
FE	0.87				
DPD	0.69	0.60			
Lpva	0.57	0.39	0.69		
OP	0.91	0.75	0.68	0.58	
ACF	0.67	0.54	0.50	0.87	0.65

Table 4: Values for horizontal, forward, and backward in 1996 and 2005

	1996				2005			
Nace	# *firms*	*horizontal*	*backward*	*forward*	# *firms*	*horizontal*	*backward*	*forward*
15	4,138	0.22	0.11	0.07	4,712	0.40	0.20	0.19
16	3	0.00	0.10	0.02	17	0.85	0.23	0.09
17	695	0.10	0.11	0.04	1,024	0.45	0.27	0.16
18	1,509	0.17	0.11	0.10	2,671	0.43	0.24	0.37
19	501	0.17	0.06	0.07	1,082	0.56	0.18	0.26
20	1,324	0.08	0.09	0.07	1,989	0.46	0.22	0.12
21	193	0.13	0.17	0.06	282	0.42	0.28	0.23
22	807	0.23	0.16	0.12	1,016	0.34	0.14	0.19
23	17	0.18	0.10	0.10	28	0.57	0.25	0.18
24	432	0.13	0.13	0.12	517	0.42	0.27	0.21
25	528	0.15	0.10	0.06	859	0.34	0.24	0.13
26	530	0.11	0.09	0.10	815	0.24	0.24	0.25
27	158	0.13	0.09	0.08	220	0.43	0.26	0.22
28	1,281	0.09	0.08	0.09	2,101	0.25	0.25	0.34
29	437	0.08	0.09	0.10	640	0.29	0.26	0.37
30	104	0.30	0.12	0.10	132	0.13	0.23	0.18
31	203	0.16	0.08	0.09	348	0.50	0.19	0.23
32	61	0.18	0.09	0.04	84	0.51	0.29	0.28
33	154	0.07	0.16	0.12	231	0.15	0.27	0.32
34	149	0.07	0.06	0.10	209	0.55	0.18	0.36
35	133	0.17	0.05	0.11	268	0.49	0.09	0.37
36	1,036	0.16	0.15	0.09	1,718	0.36	0.21	0.35

Table 5: Time invariant spillover effects

	(1) ACF share ≥ 5L	(2) DPD share ≥ 5L	(3) OP share ≥ 5L	(4) LP share ≥ 5L	(5) FE share ≥ 5L	(6) ACF dummy ≥ 5L	(7) ACF share all
horizontal	1.374^a	0.407^a	0.380^a	1.350^a	0.390^a	0.630^b	1.344^a
	[0.395]	[0.136]	[0.136]	[0.396]	[0.137]	[0.298]	[0.447]
backward	2.152^b	1.055^a	0.991^a	2.128^b	1.032^a	1.502^b	2.270^b
	[0.851]	[0.272]	[0.285]	[0.859]	[0.282]	[0.685]	[0.941]
N	78592	105583	105635	85560	105635	78592	129317
R-squared	0.1	0.06	0.06	0.1	0.05	0.09	0.08

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition, importance of intermediates and firm age. The dependent variable is first-differenced firm level TFP based on first-step production function estimates by industry according to the indicated methodology on top of the columns. Column 6 repeats column 1 with the dummy version of the spillover variables. All columns are based on the sample of firms with on average more than 5 employees, except column 7 that is based on the sample of all firms. All estimations include forward spillover variables as control. Standard errors are clustered at the industry-year level. t-statistics in brackets; a/b/c denotes significance at 1/5/10 percent.

Table 6: Time varying spillover effects

	(1) ACF share ≥ 5L	(2) DPD share ≥ 5L	(3) OP share ≥ 5L	(4) LP share ≥ 5L	(5) FE share ≥ 5L	(6) ACF dummy ≥ 5L	(7) ACF share all
horizontal							
entry t	0.429	0.047	0.101	0.417	0.041	0.043	0.908
	[0.694]	[0.242]	[0.250]	[0.712]	[0.241]	[0.546]	[0.751]
entry t-1	-1.254	-0.551[b]	-0.599[b]	-1.27	-0.569[b]	-0.677	-1.14
	[0.831]	[0.264]	[0.278]	[0.839]	[0.266]	[0.542]	[0.928]
entry t-2	-1.611[b]	-0.608[a]	-0.624[b]	-1.616[b]	-0.612[a]	-0.655	-1.492[b]
	[0.767]	[0.234]	[0.243]	[0.781]	[0.233]	[0.560]	[0.700]
entry t-3	0.492	0.054	0.052	0.509	0.033	0.068	0.258
	[0.531]	[0.142]	[0.146]	[0.538]	[0.145]	[0.492]	[0.504]
entry prior to t-4	1.973[a]	0.359[a]	0.356[a]	1.938[a]	0.361[a]	1.146[a]	1.899[a]
	[0.406]	[0.114]	[0.113]	[0.409]	[0.113]	[0.314]	[0.495]
backward							
entry t	3.709	1.776	2.016	3.394	2.091	-0.249	2.931
	[4.418]	[1.405]	[1.438]	[4.446]	[1.410]	[2.428]	[4.627]
entry t-1	8.444[a]	3.122[a]	3.182[a]	8.575[a]	3.247[a]	4.322[c]	7.886[b]
	[3.147]	[1.089]	[1.089]	[3.238]	[1.068]	[2.333]	[3.142]
entry t-2	4.320[c]	1.751[b]	1.843[b]	4.083[c]	1.840[a]	2.063	4.599[c]
	[2.296]	[0.719]	[0.722]	[2.302]	[0.701]	[1.474]	[2.387]
entry t-3	6.033[b]	2.564[a]	2.626[a]	5.921[c]	2.601[a]	1.783	5.091[b]
	[2.975]	[0.792]	[0.783]	[3.023]	[0.784]	[1.683]	[2.265]
entry prior to t-4	-0.635	0.176	0.088	-0.64	0.095	-0.338	0.015
	[1.201]	[0.372]	[0.375]	[1.225]	[0.372]	[1.005]	[1.235]
N	49344	62843	62816	52696	62843	49348	79854
R-squared	0.07	0.04	0.04	0.07	0.04	0.06	0.05

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition, importance of intermediates and firm age. The dependent variable is first-differenced firm level TFP based on first-step production function estimates by industry according to the indicated methodology on top of the columns. Column 6 repeats column 1 with the dummy version of the spillover variables. All columns are based on the sample of firms with on average more than 5 employees, except column 7 that is based on the sample of all firms. All estimations include forward spillover variables as control. Standard errors are clustered at the industry-year level. t-statistics in brackets; a/b/c denotes significance at 1/5/10 percent.

Table 7: Time varying spillover effects from majority and minority owned foreign firms

	(1) ACF share ≥ 5L	(2) DPD share ≥ 5L	(3) OP share ≥ 5L	(4) LP share ≥ 5L	(5) FE share ≥ 5L	(6) ACF dummy ≥ 5L	(7) ACF share all
horizontal-majority							
entry t	0.089	-0.078	-0.004	0.059	-0.073	-0.184	0.475
	[0.709]	[0.281]	[0.285]	[0.736]	[0.279]	[0.691]	[0.767]
entry t-1	-1.408	-0.654[c]	-0.677[c]	-1.479	-0.655[c]	-1.14	-1.205
	[1.060]	[0.357]	[0.378]	[1.081]	[0.361]	[0.902]	[1.144]
entry t-2	-2.037[b]	-0.735[a]	-0.740[a]	-2.063[b]	-0.723[a]	-1.658[b]	-2.008[b]
	[0.874]	[0.266]	[0.278]	[0.886]	[0.267]	[0.786]	[0.827]
entry t-3	0.155	0.024	0.027	0.144	0.009	0.004	-0.277
	[0.637]	[0.170]	[0.175]	[0.648]	[0.173]	[0.597]	[0.649]
entry prior to t-4	1.815[a]	0.379[a]	0.380[a]	1.756[a]	0.385[a]	1.563[a]	1.707[a]
	[0.375]	[0.111]	[0.113]	[0.376]	[0.112]	[0.378]	[0.451]
horizontal-minority							
entry t	6.797	1.92	2.177	6.626	1.706	0.015	15.822[b]
	[8.235]	[2.746]	[2.849]	[8.265]	[2.760]	[2.193]	[7.360]
entry t-1	3.676	2.009	2.125	4.035	1.989	-0.801	5.608
	[6.683]	[2.094]	[2.244]	[6.645]	[2.152]	[1.296]	[5.784]
entry t-2	5.467	-0.235	-0.067	6.188	-0.268	-1.26	7.087
	[9.368]	[2.609]	[2.660]	[9.415]	[2.624]	[2.198]	[9.634]
entry t-3	-11.074[b]	-5.397[a]	-4.993[a]	-11.522[b]	-5.020[a]	-1.254	-15.175[a]
	[5.104]	[1.429]	[1.430]	[5.141]	[1.424]	[1.391]	[5.154]
entry prior to t-4	2.073	-0.402	-0.231	1.856	-0.322	0.339	-0.86
	[1.689]	[0.503]	[0.525]	[1.734]	[0.515]	[0.494]	[1.826]
backward-majority							
entry t	2.608	1.336	1.385	1.802	1.897	2.482	-6.406
	[6.622]	[2.197]	[2.246]	[6.734]	[2.236]	[6.056]	[7.315]
entry t-1	11.557[a]	4.941[a]	5.069[a]	11.278[b]	5.250[a]	12.882[a]	12.319[b]
	[4.378]	[1.437]	[1.444]	[4.493]	[1.425]	[4.195]	[4.815]
entry t-2	5.395[b]	3.025[a]	3.074[a]	5.317[b]	3.019[a]	1.855	5.268[b]
	[2.413]	[0.827]	[0.829]	[2.434]	[0.815]	[2.376]	[2.590]
entry t-3	13.989[a]	5.232[a]	5.278[a]	14.134[a]	5.271[a]	7.256[b]	17.663[a]
	[4.563]	[1.270]	[1.284]	[4.630]	[1.268]	[3.413]	[4.171]
entry prior to t-4	-0.301	0.471	0.375	-0.251	0.41	-0.272	0.932
	[1.448]	[0.492]	[0.502]	[1.503]	[0.490]	[1.269]	[1.427]
backward-minority							
entry t	128.929[b]	36.914[b]	43.522[a]	131.746[b]	38.962[b]	7.181	119.352[b]
	[51.945]	[16.329]	[16.436]	[51.947]	[16.110]	[5.412]	[49.727]
entry t-1	115.098[a]	17.936	19.451	112.899[a]	17.735	10.956	86.034[a]
	[34.441]	[11.516]	[11.898]	[35.254]	[11.714]	[8.310]	[23.085]
entry t-2	38.429	-7.074	-5.181	33.421	-5.97	14.884[b]	17.052
	[35.372]	[11.945]	[11.754]	[35.986]	[11.754]	[6.364]	[29.561]
entry t-3	-42.54	-12.793	-12.369	-48.446[c]	-13.399	0.685	-72.818[a]
	[27.631]	[8.270]	[8.345]	[28.025]	[8.239]	[6.269]	[27.882]
entry prior to t-4	-14.891	-4.215	-3.875	-14.9	-5.005	-2.192	-10.799
	[14.816]	[4.940]	[4.934]	[15.260]	[4.928]	[4.126]	[12.699]
N	47609	60793	60766	50856	60793	47609	78070
R-squared	0.09	0.04	0.05	0.09	0.04	0.08	0.07

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition, importance of intermediates and firm age. The dependent variable is first-differenced firm level TFP based on first-step production function estimates by industry according to the indicated methodology on top of the columns. Column 6 repeats column 1 with the dummy version of the spillover variables. All columns are based on the sample of firms with on average more than 5 employees, except column 7 that is based on the sample of all firms. All estimations include forward spillover variables as control. Standard errors are clustered at the industry-year level. t-statistics in brackets; a/b/c denotes significance at 1/5/10 percent.

Table 8: Firm level heterogeneity and timing of entry patterns

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	basic	mean firm size classes				mean absorptive capability quartiles			
		micro	small	medium	large	Q1	Q2	Q3	Q4
horizontal-majority									
entry t	0.089	0.388	0.151	-1.090	-1.319	-2.624[c]	-0.101	0.330	0.972
	[0.709]	[0.960]	[0.698]	[0.854]	[1.001]	[1.388]	[0.903]	[0.589]	[0.598]
entry t-1	-1.408	-1.062	-1.507	-2.729[a]	-0.107	-3.770[b]	-1.899[c]	-0.565	-0.309
	[1.060]	[1.230]	[1.129]	[0.926]	[0.691]	[1.706]	[1.091]	[0.823]	[0.917]
entry t-2	-2.037[b]	-2.375[b]	-2.081[b]	-1.380[c]	-1.075	-3.302[b]	-2.966[a]	-1.196	-1.252[b]
	[0.874]	[1.001]	[0.913]	[0.764]	[0.863]	[1.393]	[1.074]	[0.784]	[0.543]
entry t-3	0.155	0.116	0.094	0.483	-0.481	0.098	0.171	0.106	-0.065
	[0.637]	[0.699]	[0.662]	[0.555]	[0.724]	[1.053]	[0.802]	[0.570]	[0.393]
entry prior to t-4	1.815[a]	1.970[a]	1.849[a]	1.699[a]	1.022[a]	2.421[a]	1.948[a]	1.328[a]	1.460[a]
	[0.375]	[0.442]	[0.396]	[0.407]	[0.381]	[0.583]	[0.378]	[0.378]	[0.333]
horizontal-minority									
entry t	6.797	-9.184	9.734	22.876[c]	23.009[b]	9.289	9.572	1.185	8.322
	[8.235]	[9.711]	[9.065]	[13.474]	[10.515]	[14.952]	[9.794]	[7.636]	[8.311]
entry t-1	3.676	-9.746	4.775	25.163[a]	17.763[b]	9.967	3.482	1.034	0.262
	[6.683]	[6.406]	[6.960]	[9.057]	[7.452]	[12.657]	[6.976]	[5.589]	[5.308]
entry t-2	5.467	-16.917	11.571	31.717[a]	12.210	1.321	6.761	6.492	2.133
	[9.368]	[11.431]	[9.468]	[9.116]	[9.095]	[16.803]	[10.370]	[8.320]	[7.660]
entry t-3	-11.074[b]	-15.387[b]	-8.405	-8.670[c]	-8.533[c]	-19.999[b]	-12.930[b]	-9.735[c]	-8.002[c]
	[5.104]	[6.060]	[5.342]	[4.886]	[5.165]	[7.758]	[5.503]	[5.007]	[4.469]
entry prior to t-4	2.073	2.195	2.467	0.198	0.773	3.881[c]	2.575	1.059	-0.946
	[1.689]	[1.992]	[1.752]	[1.830]	[1.825]	[2.227]	[1.774]	[1.601]	[1.883]
backward-majority									
entry t	2.608	-1.049	8.104	4.372	-5.494	13.579	3.989	0.454	-6.412
	[6.622]	[9.221]	[6.952]	[6.668]	[3.938]	[10.903]	[6.957]	[7.285]	[5.604]
entry t-1	11.557[a]	11.887[b]	12.762[a]	9.486[b]	7.382[b]	15.787[a]	12.400[a]	12.075[b]	7.069[c]
	[4.378]	[5.775]	[4.358]	[4.068]	[2.920]	[6.024]	[4.452]	[4.820]	[4.011]
entry t-2	5.395[b]	4.522	4.942[b]	6.610[a]	4.386	3.960	8.587[a]	3.429	4.950[b]
	[2.413]	[3.051]	[2.437]	[2.219]	[2.901]	[3.453]	[2.518]	[2.415]	[2.407]
entry t-3	13.989[a]	15.955[a]	12.607[a]	12.052[a]	14.896[a]	16.465[a]	14.424[a]	14.767[a]	11.371[a]
	[4.563]	[5.307]	[4.596]	[4.063]	[4.041]	[5.795]	[4.900]	[4.396]	[3.486]
entry prior to t-4	-0.301	-2.053	0.353	1.176	-0.975	-0.816	0.052	-0.081	0.027
	[1.448]	[1.750]	[1.540]	[1.363]	[1.276]	[1.975]	[1.626]	[1.242]	[1.258]
backward-minority									
entry t	128.929[b]	132.575[b]	110.612[b]	157.255[a]	161.825[b]	126.480	153.855[a]	115.121[a]	98.106[a]
	[51.945]	[62.615]	[50.452]	[44.134]	[67.705]	[83.335]	[58.650]	[42.772]	[37.370]
entry t-1	115.098[a]	130.414[a]	115.300[a]	65.113[b]	100.282[a]	111.385[b]	119.109[a]	108.072[a]	118.184[a]
	[34.441]	[42.806]	[36.525]	[27.985]	[33.474]	[55.088]	[35.617]	[34.576]	[28.520]
entry t-2	38.429	16.415	54.534	39.251	41.174	63.042	26.655	42.210	25.849
	[35.372]	[42.229]	[37.644]	[31.065]	[39.965]	[62.424]	[39.536]	[34.932]	[27.464]
entry t-3	-42.540	-54.845	-31.984	-57.487[b]	-44.343	-45.712	-26.781	-51.716[b]	-52.006[b]
	[27.631]	[33.718]	[27.449]	[26.091]	[29.531]	[45.127]	[31.915]	[24.724]	[20.478]
entry prior to t-4	-14.891	-13.774	-13.485	-19.079	-29.403[b]	-24.173	-15.853	-14.682	-5.009
	[14.816]	[17.301]	[14.512]	[14.408]	[14.659]	[21.532]	[16.495]	[13.448]	[11.718]
N	47609	16991	22189	5745	2684	9624	13031	13383	11571
R-squared	0.09	0.09	0.1	0.13	0.15	0.09	0.12	0.1	0.11

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition and firm age. The dependent variable is first-differenced firm level ACF TFP estimated by industry. Columns 2 to 5 present estimates for different firm size, while columns 6 to 9 present estimates for different quartiles of the tfp-gap between the domestic firm and the within industry foreign firms' average tfp. All columns are based on the sample of firms with on average more than 5 employees and use the share version of the spillover variables. All estimations include forward spillover variables as control. Standard errors are clustered at the industry-year level. t-statistics in brackets; a/b/c denotes significance at 1/5/10 percent.

Table 9: Further robustness tests

	(1) basic	(2) basic no FW	(3) basic no min	(4) basic no maj	(5) balanced sample	(6) sample begin	(7) sample end
horizontal-majority							
entry t	0.089	0.183	0.537		-0.049	0.303	-1.074
	[0.709]	[0.770]	[0.717]		[0.679]	[0.918]	[0.836]
entry t-1	-1.408	-1.387	-1.189		-1.114	-0.578	-2.681[a]
	[1.060]	[1.015]	[0.862]		[0.975]	[1.072]	[0.640]
entry t-2	-2.037[b]	-1.754[b]	-1.687[b]		-1.963[b]	-3.121[b]	-1.804[a]
	[0.874]	[0.729]	[0.763]		[0.864]	[1.218]	[0.506]
entry t-3	0.155	0.726	0.574		-0.249	0.105	0.036
	[0.637]	[0.520]	[0.505]		[0.654]	[0.603]	[0.436]
entry prior to t-4	1.815[a]	2.117[a]	1.936[a]		1.540[a]	1.129[b]	2.086[a]
	[0.375]	[0.443]	[0.448]		[0.381]	[0.438]	[0.329]
horizontal-minority							
entry t	6.797	6.157		-6.326	1.405	11.348	-3.01
	[8.235]	[10.710]		[12.137]	[8.083]	[12.454]	[7.869]
entry t-1	3.676	2.891		-1.676	0.338	3.729	-8.951[c]
	[6.683]	[6.677]		[7.768]	[6.338]	[8.734]	[5.202]
entry t-2	5.467	3.411		-3.31	1.319	-9.976	-11.587
	[9.368]	[7.014]		[8.894]	[9.438]	[20.820]	[9.939]
entry t-3	-11.074[b]	-8.627[b]		-2.805	-11.743[b]	-15.916[b]	-18.923[a]
	[5.104]	[3.832]		[4.175]	[5.179]	[6.356]	[5.365]
entry prior to t-4	2.073	2.650		3.691	1.263	3.739[b]	3.741[b]
	[1.689]	[1.804]		[2.551]	[1.732]	[1.742]	[1.507]
backward-majority							
entry t	2.608	6.400	1.458		1.310	7.885	3.262
	[6.622]	[6.641]	[4.459]		[6.036]	[9.374]	[5.976]
entry t-1	11.557[a]	11.065[a]	7.008[b]		13.639[a]	14.264[b]	14.884[a]
	[4.378]	[3.808]	[3.032]		[4.030]	[5.737]	[5.526]
entry t-2	5.395[b]	5.131[b]	3.724		5.057[b]	2.799	5.556[b]
	[2.413]	[2.433]	[2.375]		[2.286]	[3.395]	[2.484]
entry t-3	13.989[a]	10.378[a]	6.879[b]		14.616[a]	19.415[a]	13.887[a]
	[4.563]	[3.946]	[3.161]		[4.725]	[4.103]	[4.156]
entry prior to t-4	-0.301	-0.189	-0.28		-0.192	-2.246[c]	1.798
	[1.448]	[1.318]	[1.182]		[1.383]	[1.335]	[1.449]
backward-minority							
entry t	128.929[b]	87.234[c]		72.991	119.243[b]	-14.341	136.539[b]
	[51.945]	[51.115]		[46.041]	[46.956]	[71.175]	[57.034]
entry t-1	115.098[a]	81.989[c]		113.580[b]	96.381[a]	24.146	132.606[a]
	[34.441]	[45.727]		[49.339]	[30.483]	[43.336]	[33.712]
entry t-2	38.429	20.653		35.549	24.557	146.934[b]	20.919
	[35.372]	[35.389]		[45.745]	[33.295]	[58.835]	[30.309]
entry t-3	-42.54	-21.354		-28.99	-55.458[b]	59.995[b]	-74.654[a]
	[27.631]	[21.541]		[29.752]	[27.846]	[30.273]	[24.353]
entry prior to t-4	-14.891	-12.914		-9.322	-15.111	24.175[c]	-22.042
	[14.816]	[13.279]		[16.244]	[14.667]	[12.589]	[13.568]
N	47609	47609	49318	47627	31980	38844	37786
R-squared	0.09	0.08	0.07	0.06	0.09	0.10	0.12

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables are industry competition, import competition and firm age. Dependent variable is first-differenced ACF tfp. Column 2 drops FW-controls; column 3 (4) only uses majority (minority) spillovers; column 5 uses a balanced sample; column 6 restricts the sample such that the first year contains the first large inflow of FDI in 1997 in the prior to t-4 variable; column 7 excludes the impact of the FDI surges in 2004 and 2005. All columns are based on the sample of firms with on average more than 5 employees and use the share version of the spillover variables. Except for column 2, all estimations include forward spillover variables as control. Standard errors are clustered at the industry-year level. t-statistics in brackets; a/b/c denotes significance at 1/5/10 percent.