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WORKING PAPER

FDI Spillovers and the Time since Foreign Entry

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Abstract

This study relates the effect of FDI on local firms' productivity to the time since foreign entry. We relax the standard implicit assumption that technological spillovers following foreign entry are immediate and permanent. We find that the entry of majority foreign owned firms has a fairly rapid, though not immediate, short run negative effect on the productivity of local competitors. This is more than offset by a positive effect for longer periods since foreign entry. The entry of minority foreign owned firms has an immediate, but 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 impact of foreign firms' characteristics has been analysed by a.o. Marin and Bell (2006) and Javorcik and Spatareanu (2008).

In this paper we allow FDI spillovers to vary with the number of years since an MNE has entered the domestic economy. Although the literature has acknowledged that FDI spillover effects may require time to materialize after entry, 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, the spillover effect of all foreign investment in a given year -recent and more 'mature'- is lumped together in one variable. Lagging the spillover variables does not adequately address the time since entry dynamics of spillovers because 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 the domestic economy 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 transmission channels of spillover effects. Teece (1977) for example already suggests that technology imitation and worker mobility might be important channels of horizontal spillovers. However, neither the mobility

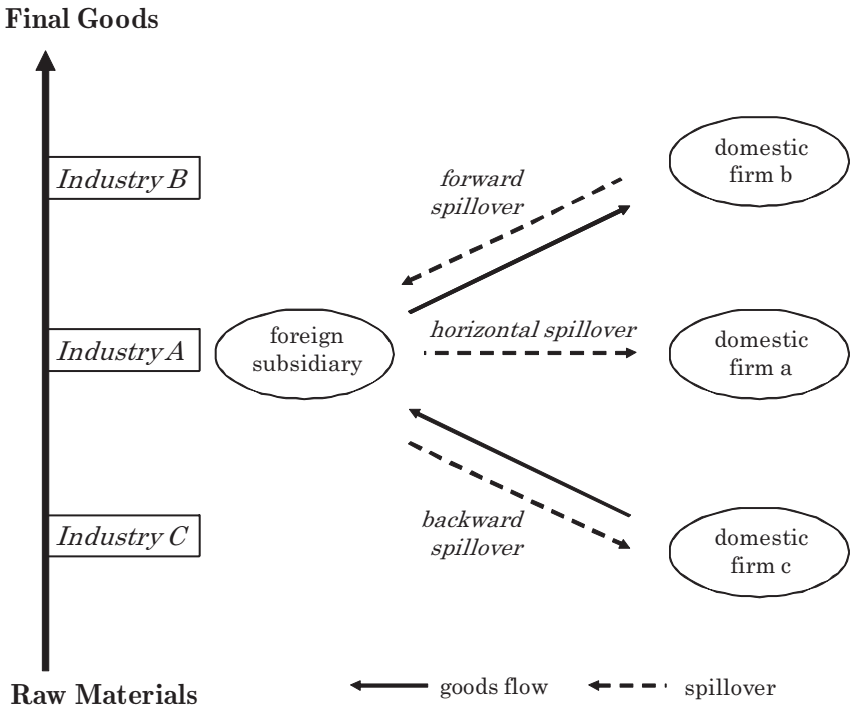

Figure 1: Horizontal, forward and backward spillovers through the supply chain

of workers trained by foreign firms, nor technology imitation are likely to materialize immediately following foreign entry. Workers need to receive training and absorb technologies before they can move to a domestic firm to improve the latter's productivity. Increased foreign competition may initially hurt domestic companies before it makes them better (e.g. through succesful imitation). Likewise, vertical spillovers driven by access to better inputs produced by foreign firms or by supplying inputs to multinational companies are not necessarily instantaneous after entry, nor permanent. The presence of better foreign inputs probably requires an adaptation effort, before domestic firms can reap the full benefits of it. If foreign affiliates tend to increase their local sourcing over time, backward spillovers will not rise to their full effect immediately. 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 indeed 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' impact on local suppliers in Malaysia and Vietnam. Local suppliers benefit significantly less from 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) con-

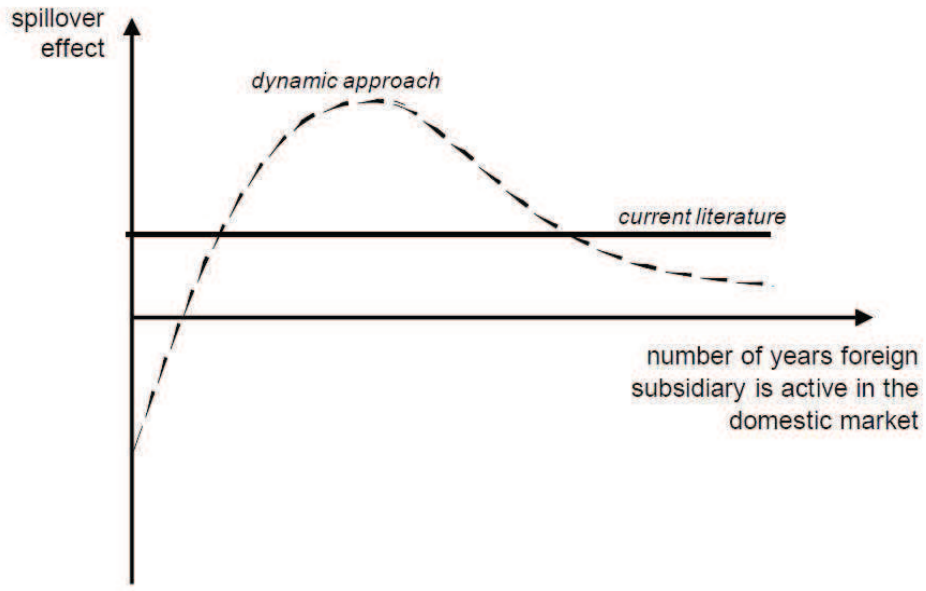

Figure 2: Intensity of the spillover effect to domestic firms' productivity for a given year as a function of the time since foreign entry in the domestic market: current literature versus dynamic approach

clude 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. These arguments suggest that the current 'static' empirical approach may be inadequate to identify spillovers accurately. Our dynamic approach is illustrated in figure 2. The figure displays spillover effects at a specific point in time generated by MNEs that differ in the number of years they have been active in the domestic market. The bold line represents the entry time-invariant spillover effect found in most of the current literature. Introducing spillover variables with a time lag would shift the bold line to the right. How long the MNE has been present in the host country is still (implicitly) assumed irrelevant for the spillover effect, however. The dashed line, on the other hand, shows a hypothetical[1] pattern where MNEs first generate a negative spillover effect, say there is an adjustment cost, that becomes positive as the number of years of presence in the domestic market increase and finally fades out[2].

Understanding the dynamic nature of spillovers also has a clear policy relevance for e.g.

[1] This pattern serves as an illustration, any other pattern in time since entry is possible.

[2] The literature does not provide clear guidance on what to expect with respect to the effect of MNEs that have been present for longer periods. E.g. spillovers due to labour mobility may not fade out with longer periods since entry.

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 a longer period in the host country before domestic firms experience a positive contribution to their productivity growth. The impact of majority foreign owned firms that entered the domestic economy more recently is negative, possibly 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 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, but there are indications that they are less immediate. Although the effect lasts longer than for minority foreign owned firms, it also fades out for longer periods since MNE entry. We do not find evidence for the existence of forward spillovers, a finding that is in line with 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 FDI spillovers and how our MNE entry time approach fits in with the litearture. Section 3 lays out the data and estimation strategy. Results and interpretation are provided in section 4. Section 5 concludes.

2 Spillovers and time since MNE entry

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) confirm the latter by showing that training activities by foreign subsidiaries are related to stronger horizontal spillovers in Argentina. 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, but inputs due to foreign investment may enhance the productivity of firms that use these inputs, but inputs produced locally by foreign firms may also be more expensive and less adapted to local firm requirements and thus dent local firm productivity (negative forward spillover).

The current empirical literature applies a definition for the variable that is intended to capture horizontal spillovers that at least dates back to Caves (1974). Typically, the

horizontal spillover variable HR_{jt} captures the degree of foreign presence in industry j at time t and is measured as:

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

where Y_{it} is the output produced by firm i in year t. HR_{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} is most often the exact share of foreign participation in firm i in year t. Alternatively, F_{it} is sometimes 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 by a single investor of at least 10% is required.[3] HR_{jt} is then combined with technical coefficients obtained from input-output tables to calculate vertical spillover variables. For the measurement of the backward spillover variable BK_{jt}, the literature employs:

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

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 HR_{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 HR_{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 FW_{jt} is defined as:

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

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 HR. HR_{jt}, BK_{jt}, and FW_{jt} are then related to domestic firms' productivity to infer the direction, magnitude and significance of spillovers.

Employing the above measures in a regression analysis implicitly assumes the spillover intensity, i.e. the coefficients of the spillover variables in the regression, to be constant in

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

time since MNE entry.[4] However, as discussed in the introduction, there are a number of reasons why spillover effects may differ in time since MNE entry. Moreover, to our knowledge there is no theoretical guidance towards a uniform effect in time since entry. Therefore, we define $\widetilde{F}^x$ as a variable indicating foreign ownership status *and* time since entry x. $\widetilde{F}^x_{it}$ will equal the percentage of shares owned by foreign investors in firm i at time t if at least 10% of shares were owned by at least one single foreign investor in year $t-x$ and this was not the case in $t-x-1$. $\widetilde{F}^x_{it}$ thus indicates that foreign firm i observed in year t became foreign owned in $t-x$. Technically, for firm i observed in year t, $\widetilde{F}^x_{it}$ is set to the percentage of shares owned by foreign investors in firm i at time t if

$$\widetilde{F}^x_{it} = \%_t \text{ if } \left(\sum_{v=0}^{x-1} F_{i,t-v} = x\right) \wedge \left(\sum_{v=x}^{\infty} F_{i,t-v} = 0\right) \tag{4}$$

and zero otherwise. This definition can now be used to decompose the traditional horizontal spillover variable (1) as follows:

$$HR_{jt} = \frac{\sum_{i\in j} \widetilde{F}^0_{it} Y_{it}}{\sum_{i\in j} Y_{it}} + \frac{\sum_{i\in j} \widetilde{F}^1_{it} Y_{it}}{\sum_{i\in j} Y_{it}} + ... + \frac{\sum_{i\in j} \widetilde{F}^n_{it} Y_{it}}{\sum_{i^2\in j} Y_{it}} \tag{5}$$

HR_{jt} is thus broken down along the lines of time since MNE entry ranging from zero to n. Denote the components on the right-hand side of (5) as HR^0_{jt}, ..., HR^n_{jt}. Then HR^2_{jt}, for example, is industry j's share of year t output that is produced by foreign firms that have entered the domestic market in $t-2$. In our empirical analysis we will employ these time since entry-specific components, calculated as in (6), without restricting their coefficients to be equal. Time since entry definitions for BK^x_{jt}, and FW^x_{jt} then follow from (2) and (3) above:

$$HR^x_{jt} = \frac{\sum_{i\in j} \widetilde{F}^x_{it} Y_{it}}{\sum_{i\in j} Y_{it}} \tag{6}$$

$$BK^x_{jt} = \sum_{k \ if \ k\neq j} \gamma_{jkt} * HR^x_{kt} \tag{7}$$

$$FW^x_{jt} = \sum_{l \ if \ l\neq j} \delta_{jlt} * HR^x_{lt} \tag{8}$$

[4] Altomonte and Pennings (2009) is a related study that investigates threshold effects generated by incremental entry and cumulative presence of the number foreign investors. They restrict their attention to horizontal spillovers only.

Table 1: Time since entry variables and calendar time in the dataset

		MNE - time since entry (superscript)					
		HR^0	HR^1	HR^2	HR^3	HR^{4+}	traditional HR
calendar time	2001	A			B		A&B
	2002		A			B	A&B
	2003			A		B	A&B
	2004	C			A	B	A&B&C
	2005		C			A&B	A&B&C

Considering that we have ten years of data (1996-2005, *cf. infra*) and that we do not know the year of entry of firms that are foreign in the first year of our datatset, we opt to include HR_t^0 to HR_t^3 and create a variable HR_t^{4+}. The latter 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 because of missing values for HR_t^1 to HR_t^{4+} for the first years of the dataset. Table 1 illustrates how three MNEs (A, B, and C) that entered the domestic economy in 2001, 1998, and 2004 respectively affect the value of the different spillover variables in different calendar years. Firm A first contributes to HR^0 in 2001, the year of entry, then in consecutive years contributes to HR^1, HR^2, HR^3, and finally from 2005 onwards contributes to HR^{4+}. Firm B entered Romania earlier and contributes from 2002 onwards to HR^{4+}. In 2005 both A and B contribute to HR^{4+}. Note the difference with the traditional measure in the last column where spillovers are implictly assumed to be independent of time since entry. Late entrant C will only affect HR^0 in 2004 and HR^1 in 2005.

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 HR, BK, and FW, 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 production 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 or fixed effects 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 makes use of the ideas in these papers, but does not suffer from these collinearity problems. As the discussion is still ongoing we will present results using ACF-tfp as our base case and 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:

$$tfp_{ijt} = Y_{ijt} - \widehat{\beta}_{lj} l_{ijt} - \widehat{\beta}_{kj} k_{ijt} - \widehat{\beta}_{mj} m_{ijt} \tag{9}$$

In addition to methodological robustness checks (FE, OP[5], DPD), we will also include robustness checks using a tfp measure obtained from a translog specification (TL, estimated by OLS) rather than from a Cobb-Douglas specification and using labour productivity rather than total factor productivity. Finally, we also present results with a measure for total factor productivity that is derived using an index number approach. Labour productivity and the index approach do not impose a specific form on the production function, thereby allowing for cross-firm differences in production technology in a Nace 2-digit manufacturing industry. For the index we follow the formula proposed by Good et al. (1996) that combines the chained

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

Divisia approach with the representative firm index proposed by Caves et al. (1983).

$$
\begin{aligned}
tfp_{it} \;=\; & \left[(y_{it} - y_t^*) + \sum_{s=2}^{t} \left(y_s^* - y_{s-1}^* \right) \right] \\
& - \left[\frac{1}{2} \sum_{j=1}^{n} \left(S_{ijt} + S_{jt}^* \right) \left(x_{ijt} - x_{jt}^* \right) + \sum_{j=1}^{n} \sum_{s=2}^{t} \frac{1}{2} \left(S_{js}^* + S_{j,s-1}^* \right) \left(x_{js}^* - x_{j,s-1}^* \right) \right]
\end{aligned} \tag{10}
$$

where y_{it} denotes log value added of firm i in period t, S the share of each of the n production factors in total costs and x_{ijt} the log of the quantity factor j used in the production of firm i in period t. Variables indicated with an asterisk refer to the representative firm, e.g. y_t^* is the log output of the representative firm in period t. Following Caves et al. (1983), the values of the variables for the representative firm equals the mean of that variable over all firms in a given year. The index contains a component reflecting the change in TFP of a firm relative to the productivity of the representative firm (i.e. efficiency) and a component reflecting the evolution in the productivity of the representative firm over time (technological change).

In the second step, we relate tfp_{ijt} to a firm specific effect, a vector of spillover variables, $\mathbf{FDI}_{jt}$, a vector of control variables, and time dummies (α_t). Note that (11) now pools firms from all industries together in one large panel, whereas (9) is estimated by industry.

$$
tfp_{ijt} = \alpha_i + \Psi_1 f\left(\mathbf{FDI}_{jt-1}\right) + \Psi_2 \mathbf{Z}_{i(j)t} + \alpha_t + \xi_{ijt} \tag{11}
$$

The vector of spillover variables ($\mathbf{FDI}_{jt-1}$) covers the different horizontal and vertical spillover variables described in (1)-(8). $\mathbf{Z}_{i(j)t}$ is a vector of control variables. Specifically we control for within-industry competition, measured by the Herfindahl index, import competition in the industry, industry export intensity, the share of supplied intermediates in total industry output, and firm age. Specification (11) is first-differenced and then estimated by OLS. After first-differencing we include industry (α_j) and region (α_r) dummies in the specification. First-differencing does not remove the time dummies ($\Delta\alpha_t = \alpha_t$). This results in (12) as final specification to be estimated.

$$
\Delta tfp_{ijrt} = \Psi_1' \Delta f\left(\mathbf{FDI}_{jt-1}\right) + \Psi_2' \Delta \mathbf{Z}_{i(j)t} + \alpha_t + \alpha_j + \alpha_r + \varepsilon_{ijrt} \tag{12}
$$

Because $\mathbf{FDI}_{jt}$ and some control variables are defined at the industry level, while 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).

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 good candidate to study time since MNE entry as a determinant of FDI spillovers. Macroeconomic data show that 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. 1997 marks the first substantial wave of FDI inflows, 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 Electronic Publishing. Amadeus is a pan-European database of financial information on public and private companies. The Amadeus database has been widely used for reasearch and the Romanian subset of firms is known for its good quality and representativeness.[6] About 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 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.[7] 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

[6] E.g. Altomonte and Colantone (2008), Altomonte and Pennings (2009), Damijan et al. (2008), Javorcik and Spatareanu (2008), and Konings (2001) also have used the Romanian subset of firms. Altomonte and Colantone (2008) also contains a detailed discussion about the representativeness of the firms covered.

[7] 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.

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.[8]

Data are deflated using industry price level data at Nace rev.1.1 2-digit level[9]. 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 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. The IO tables also provide us with the data for the import competition, export intensity, and supplied intermediates control variables. These are therefore definied at the same level of industry aggregation as the spillover variables.

< insert table 2 and 3>

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.[10] Table 2 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 3

[8] e.g.

	Amadeus	immediate
2000	40	40
2001	.	40
2002	50	50

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

[10] 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.

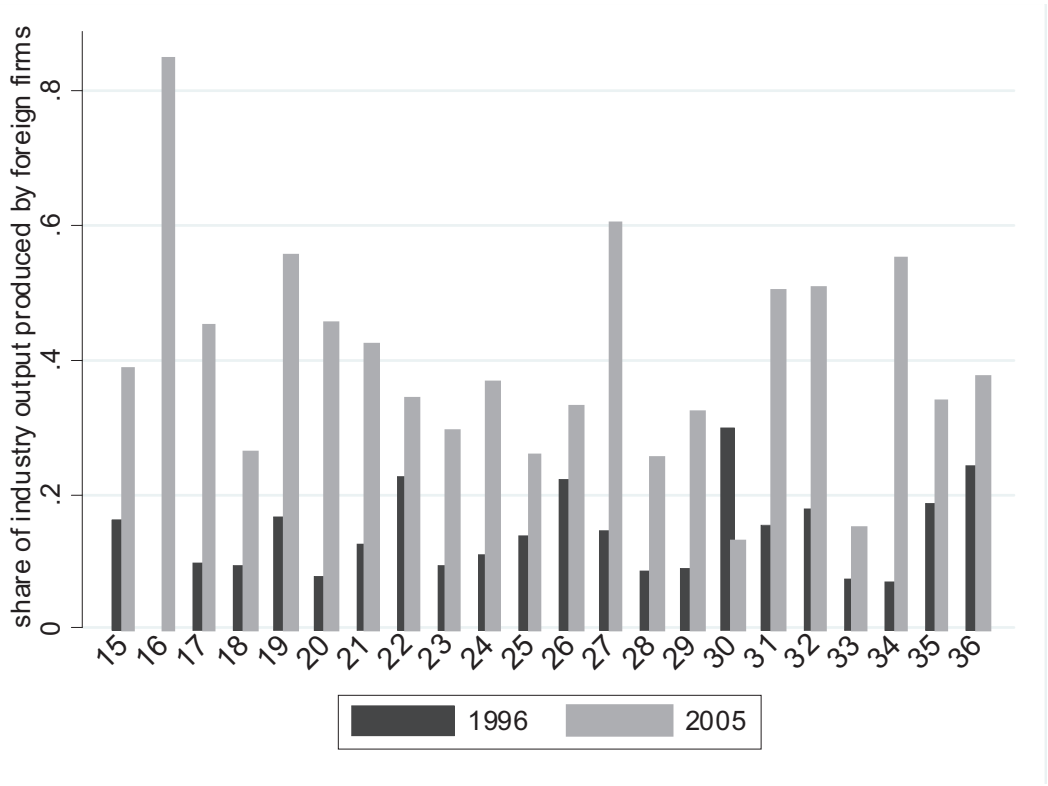

Figure 3: Share of Nace 2-digit industry output produced by foreing firms in 1996 and 2005

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.

Figure 3 shows a breakdown by Nace 2 digit industry of the share of output produced by foreign firms for the first and last year of our sample. Left aside the highly concentrated tobacco industry (Nace 16), 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. Finally, figure 4 gives an idea about the distribution and values of the spillover variables in the time since entry dimension across different spillover categories. The boxplots are based on the estimation sample collapsed to the industry level (59 manufacturing industries from the IO-tables). The figure illustrates that the value of the spillover variables tends to increase with longer periods of foreign presence. The correlation across years and spillovers is limited. Majority foreign owned firms clearly account for the bulk of the share produced by foreign firms. In all industries, except the tobacco industry,

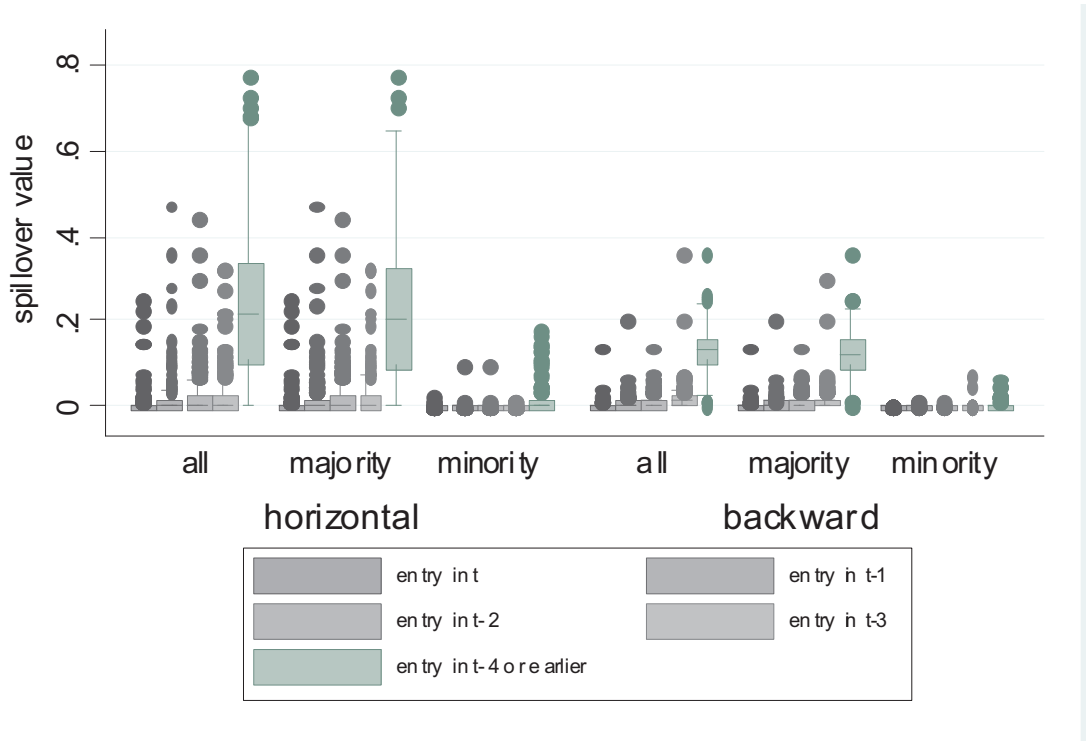

Figure 4: Boxplots of horizontal and backward spillover variables, for all, majority, and minority foreign owned firms, at industry aggregation found in the Romanian IO tables for the period 2001-2005

there are both majority and minority foreign firms.[11]

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. Regressions always include time, industry and region dummies. Further control variables (always included) are age, industry competition, intermediates supplied as a share of industry ouput, competition from imports in the industry, and industry export intensity. Therefore changes in openness at the industry level are accounted for. 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. The structure of tables 4,

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

5, and 6 is similar and the different columns present results for alternative tfp estimation methodologies and alternative functional forms of the production function that are used to obtain the dependent variable. We show results for tfp measures based on Cobb Douglas specifications applying the ACF, OP, DPD and FE estimators in columns 1-4. In column 5 our tfp measure is obtained from a translog specification estimated by OLS rather than from a Cobb-Douglas specification. In columns 6 and 7 we employ labour productivity and tfp based on an index approach as dependent variable.[12]

4.1 No time since entry

As a starting point, table 4 presents the estimation results for the standard non-dynamic specification found in the literature. The estimates in table 4 are based on our 'long' sample running from 1996 to 2005. All columns use the sample of firms with at least five employees on average and the share definition of the spillover variables (cf. section 2). Except for the case of labour productivity, 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. The presence of foreign competitors therefore seems to have contributed positively to domestic firms' productivity growth. These results are consistent throughout the other columns of table 4. 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 time since entry regressions).

< insert table 4>

4.2 The impact of time since entry

< insert table 5 >

In table 5 we allow FDI spillovers to differ according to the time since entry of the foreign firm. Column headings are the same as those in table 4. As indicated above, 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 a longer time since entry horizon effect. Further note that the average values of

[12]OLS and LP results are similar and available on request.

these 4+ variables are considerably larger than the variables capturing entry in a specific more recent year. This needs to be taken into account when interpreting coefficients and the variables' contribution to firm-level productivity. Gauging across the different columns in table 5, results generally suggest a positive horizontal spillover effect on a longer time since entry horizon. Firms that recently entered the host economy have no impact on domestic firms' tfp, whereas firms that have been present for four years or more generate strong positive spillovers that are significant in all 7 columns of table 5. 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 affects domestic firm productivity faster than the horizontal spillover, though not immediately. The strongest positive backward spillovers are found for foreign firms that entered one year ago. There is a smaller, but still positive effect for firms entering between two and three years earlier, but the evidence is more mixed across columns. A longer time since entry 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 (not shown) no significant impact remains.

4.3 Time since entry and 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 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 6. This is done by considering two versions of (6) where our single foreign ownership variable $\widetilde{F}^{x}_{i,t}$ is now broken down in two versions $\widetilde{F}^{xM}_{i,t}$ and $\widetilde{F}^{xm}_{i,t}$. $\widetilde{F}^{xM}_{i,t}$ is the share of majority foreign participation (50% or more) taken x years ago in firm i in year t, and is set to zero if foreign participation is smaller than 50%. Likewise $\widetilde{F}^{xm}_{i,t}$ is then the share of minority foreign participation (less than 50%, but more than 10%) taken x years ago in firm i in year t, and is set to zero if foreign participation exceeds 50% or is smaller than 10%. (13) and (14) are then used to generate both majority and minority foreign owned versions of all our previously defined spillover variables along the lines of (7)-(8). Note that both minority and majority foreign-owned firms are present in all industries.

$$Horizontal^{xM}_{jt} = \frac{\sum_{i \in j} \widetilde{F}^{xM}_{i,t} * Y_{it}}{\sum_{i \in j} Y_{it}} \tag{13}$$

$$Horizontal^{xm}_{jt} = \frac{\sum_{i \in j} \widetilde{F}^{xm}_{i,t} * Y_{it}}{\sum_{i \in j} Y_{it}} \tag{14}$$

< insert table 6>

In table 6 we jointly consider ownership structure and time since entry effects. Reassuringly, the patterns found are fairly stable across the different tfp-measures. The effects of minority and majority foreign firms, in function of their time since entry, on the productivity of their local competitors and suppliers that are implied by column (1) in table 6 are visualised in figure 5. The effects in figure 5 are obtained as estimated coefficient times mean of the respective spillover variables. This allows for a better comparison of effects since comparing the relative size of the coefficients is pointless bearing in mind the large differences in the values of the spillover variables in figure 4. The upper panels show the time since entry pattern for horizontal and backward effects from majority foreign owned firms and 95% confidence intervals around them. The lower panels show a comparison for both spillovers with their minority foreign owned firms' counterparts. A star indicates that the estimated coefficient is significant at at least the 10% level.

Panel A and C show that the positive time-invariant horizontal spillover effect from table 4 is mainly driven by a positive spillover effect from majority foreign owned firms that have entered the domestic economy four or more years ago. The horizontal spillover from

majority foreign owned firms (horizontal majority spillover henceforth) seems to become more negative with time since entry for recent entrants -significantly so for entry in *t-2*-, before this is reversed with longer time since entry, where the spillover turns strongly positive. This 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. Panel C also shows that the productivity spillovers from minority foreign owned firms are much smaller (recall that they also account for a substantially smaller share of industry output). The initial impact is insignificant, but the spillover turns negative for firms that entered in *t-3*. Taking into account average values of the variables concerned (cf. figure 4), we may conclude that the spillovers from minority foreign owned firms are fairly small relative to these from majority foreign owned firms.

Panel D, however, indicates that minority foreign owned firms do generate immediate positive backward spillover effects. The first two years after foreign entry domestic firms enjoy a substantial contribution to productivity. This positive backward spillover from minority foreign owned firms is short-lived, however. The effect even turns negative, though insignificant, for minority foreign owned firms that entered a longer time ago. Panels B & D indicate how the backward spillovers from majority foreign owned firms also boost productivity. The effect seems less immediate, but 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 meaningful positive backward spillover effects. These positive effects are enjoyed also from firms that entered two and three years ago. The coefficients for longer periods since entry turn again insignificant.

< insert table 7>

By means of a range of tests for the equality of coefficients table 7 confirms that time since entry matters. For almost all tfp-measures we can reject for all types of spillovers that all coefficients in time since entry are equal. We also perform some additional tests with respect to the patterns we identified. The coefficient for horizontal spillovers from majority foreign owned firms that entered in *t-4* or earlier is significantly different from the effect of entrants in *t-3* or *t-2*. Spillovers from backward majority foreign owned firms that entered recently are significantly different from those from firms entering in *t-4* or earlier. The coefficient for the most recent entrants is estimated relatively imprecisely and it cannot be rejected to

be equal to the coefficients for entrants in *t-1*, *t-2*, *t-3*. Do note that in terms of the actual contribution to productivity -as illustrated in Figure 5- recent entrants hardly contribute to domestic firms' tfp. Therefore we have indications that the backward spillovers from majority foreign owned firms are less immediate than those from minority foreign owned firms. Backward spillovers from minority foreign owned firms are indeed confirmed to be immediate upon entry and to differ between recent and more mature entrants.

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.

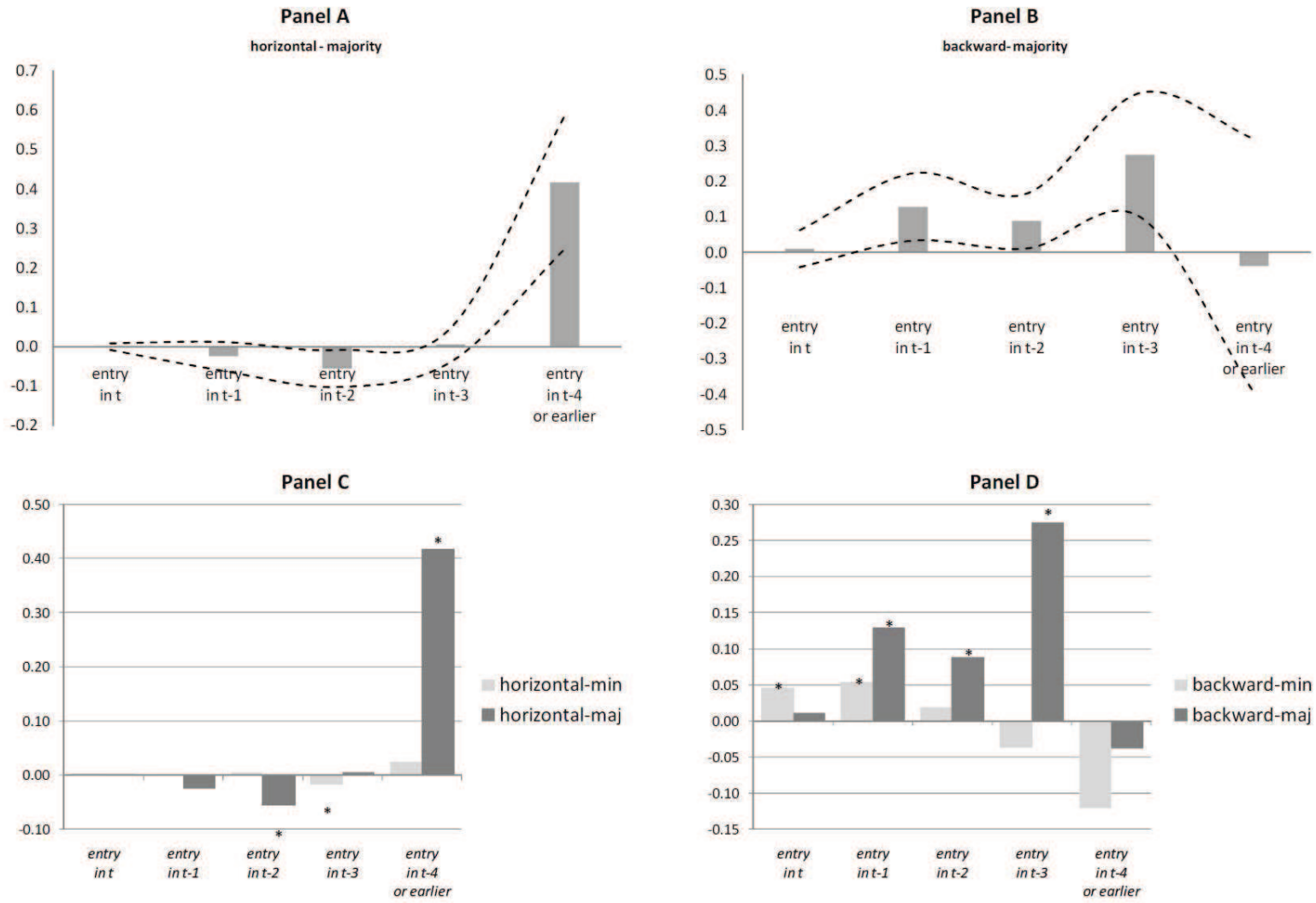

Figure 5: Contribution of 2001-05 mean horizontal and backward spillovers to 2001-05 mean log ACF-tfp of domestic firms as implied by specification (1) of table 6 (dotted lines in panels A and B show a 95%-confidence interval; stars in lower panels indicate statistically significant coefficients; average log ACF-tfp of domestic firms is 5.69)

5 Further robustness checks

In this section we present three sets of further robustness checks: i) sensitivity to the exclusion of specific spillover variables and introduction of a set of industry-year dummies (table 8); ii) sensitivity to the sample constellation (table 9); and iii) sensitivity to the construction of spillover variables (table 10). For the ease of comparison, column 1 of each of the tables repeats our basic specification, i.e. the results for the sample of firms with on average more than five employees, ACF-tfp as dependent variable, and the share version of the spillover variables.

< insert table 8 >

Columns 2 and 3 of table 8 drop minority and majority spillovers respectively. The patterns for spillovers from majority foreign owned firms is confirmed in column 2. Column 3 shows that the backward minority spillover from firms entering in t is no longer significant at conventional levels. Column 4 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. Finally in column 5 we repeat column 4, but replace the seperate industry and year dummies by a full set of industry-year interaction dummies. Although we already control for competition, import competition and export intensity at the IO table industry level, our spillover variables may still capture some other unobserved industry-year effects since they are defined at the industry-year level. We cannot control for a full set of industry-year fixed effects since their dimension perfectly overlaps with our spillover variables, but we can introduce industry-year effects at a sligthly higher level of industry aggregation. Since the Romanian industry classification maps into a combination of Nace 2 and 3 digit levels, we include Nace subsection[13]-year fixed effects in specification 5 of table 8. This is a tough test, but the main results are again very robust. We find i) a positive horizontal effect from majority foreign owned firms provided they have been in the domestic economy for four years or more; ii) an immediate postive backward spillover from minority foreign owned firms that dies out fairly rapidly; and iii) a postive backward spillover from majority foreign owned firms that takes more time to manifest itself, but is not everlasting in time since entry either.

< insert table 9 >

[13]Section D is manufacturing, subsections refer to one or more Nace 2-digit industries. They are labeled DA, DB, ..., DN. We obtain 14 Nace 2 subsections that on average contain a little more than four industries as defined in the Romanian classification.

In table 9 we test for alternative sample constellations. In column 2 small firms with less than five employees on average have been included in the sample as well. The main results are again unaffected. Column 3 that contains the results for a balanced sample over the period 2001-2005 again confirms the main findings. Columns 4 and 5 relate to the macroeconomic pattern of FDI inflows in Romania. Romania experienced two major shifts of the level of FDI inflows in 1997 and 2004-2005. To rule out that our results on the *entry t-4 or earlier* spillover variables are driven by the first shift, we drop the first years of the estimation sample in column 4. We find robust patterns for the horizontal and backward spillovers from majority foreign-owned firms, our main results. The negative longer term backward spillover from majority foreign-owned firms turns marginally significant. The pattern of the backward spillover form minority foreign-owned firms changes slightly. Column 5 drops the last years from the sample. By doing so we test whether the impact of the surge of macroeconomic FDI inflows at the end of the sample is driving our results on the *entry in t* and *t-1* spillover variables. The time since entry patterns we obtain are again fairly similar to our basic result, especially with respect to our main findings. This suggests we have reason to claim positive horizontal spillovers from majority foreign owned firms for longer times since entry and positive backward spillovers from majority foreign owned firms for medium time since entry.[14] Our results also suggest important immediate but short-lived backward minority spillovers. The latter finding is, however, somewhat less stable across the various robustness checks.

< insert table 10 >

Finally, in table 10 we introduce some further robustness checks that go into the construction of the spillover variables. Column 2 uses a dummy version of the spillover variables, rather than a share-version. Horizontal and backward majority spillover results are again confirmed, backward minority spillovers more or less disappear. Driffield (2006) argues that one should consider the share in capital rather than the share in production, because it is the incoming capital and technology that will drive the spillover effect. Therefore column 3 replaces output Y with our measure of capital in the spillover definition (6). Our main findings

[14] A regression where we created for each spillover a 5+ (rather than 4+) variable that brings together all foreign firms that have entered in *t-5 or earlier* confirms that the horizontal effect is on a longer term, while the backward effect is shorter-lived. This is illustrated by the following selected coefficients from the regression:

$$\underset{[1.08]}{-0.41}HR^{1,Maj} \underset{[1.27]}{-1.79}HR^{2,Maj} \underset{[1.09]}{-3.56}{}^{a}HR^{3,Maj} \underset{[0.69]}{-0.53}HR^{4,Maj} \underset{[0.71]}{-0.41}HR^{5,Maj} \underset{[0.45]}{+1.43}{}^{a}HR^{6+,Maj}$$

$$\underset{[9.57]}{+15.58}BK^{1,Maj} \underset{[5.57]}{+15.39}{}^{a}BK^{2,Maj} \underset{[4.14]}{+5.21}BK^{3,Maj} \underset{[5.25]}{+16.57}{}^{a}BK^{4,Maj} \underset{[3.70]}{-1.51}BK^{5,Maj} \underset{[1.47]}{-2.07}BK^{6+,Maj}$$

are confirmed once more. In a recent contribution Barrios et al. (2010) present an interesting discussion of the correct measurement of the backward spillover variable. Although we cannot accommodate all their suggestions due to lack of data, we show the robustness of our results to some of their points. In columns 4 and 5 we follow their suggestion that one should use the share in material cost, rather than the share in output, to calculate the backward spillover. Therefore we recalculate our backward spillovers accordingly. Column 4 uses output for the horizontal variables, whereas column 5 uses employment as a basis for the horizontal variables. Our results are fairly robust to this alternative specification and the time since entry pattern with respect to backward spillovers remains in place: immediate backward minority, medium time since entry for the backward majority. In column 5 where the horizontal spillover is based on the share in employment, we observe that the negative medium term horizontal spillover falls away, while the positive long term horizontal spillover is strongly confirmed. This is an indication that the medium term negative horizontal spillover found in most specifications is probably mainly driven by the competition effect and that labor market spillovers are essentially positive. Barrios et al. (2010) additionally suggest to use the input output tables from the home countries to measure backward spillover variables because the new incoming technology will resemble the technology of the home country rather than that of the host country. We cannot implement this suggestion directly because of data limitations, but accomodate this view by using the technical coefficients of the 2005 IO table for the calculation of the spillover variables in all years. By 2005 the foreign involvement in most of the industries was already very considerable (see figure 3) and therefore the industrial structure found in the 2005 IO table already better reflects modern production technologies. Results in column 6 thus take into account the suggestion to use material costs for the calculation of backward spillovers and to use modern technical coefficients to calculate vertical spillovers. Again the main time since entry patterns in our results are robust to this further spillover variable refinements.

6 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 time since 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 11 presents the results. For ease of comparison the first column under the heading 'basic' replicates the first column of table 6. Columns 2 to 5 present the results for different size classes, whereas columns 6 to 9 present the results for four quartiles of the mean absorptive capability.

< insert table 11 >

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 and *t-2* 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 in *t-3* 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 posi-

tive 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 in *t-3* (as do Q1 and Q2 firms, but not significantly). 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.

7 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 relationship between the time since foreign entry and 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 time since foreign entry and find that spillovers from foreign investments do vary in ways that are economically intuitive and consistent with theory. In the first years following entry backward spillovers seem to dominate the analysis, but for longer periods since entry 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 if the latter have been present in the domestic economy long enough. This is consistent with the thesis that domestic firms need time and effort to absorb the foreign technology, but also with a 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 positive 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, longer lived, and stronger. The effect also fades out in the

longer run, though. 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 assuming the impact of foreign presence strongly varies with its maturity.

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Table 2: 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 3: 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)	3.08	1.47	2.93	1.40	3.67	1.57
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) DPD	2.30	1.29	2.27	1.27	2.42	1.33
ln(tfp) FE	2.00	0.96	1.95	0.91	2.21	1.11
ln(tfp) TL	6.45	2.09	6.44	2.07	6.50	2.13
ln(tfp) LProd	10.65	1.36	10.60	1.33	10.86	1.47
ln(tfp) Index	-0.25	2.20	-0.28	2.18	-0.15	2.25

	Spillovers (industry-year; n = 649)					
	all foreign owned firms		majority foreign owned firms		minority foreign owned firms	
	mean	sd	mean	sd	mean	sd
horizontal	0.28	0.14	0.22	0.19	0.02	0.04
backward	0.17	0.05	0.15	0.07	0.01	0.02
forward	0.18	0.08	0.14	0.08	0.01	0.01

Table 4: Time invariant spillover effects

	(1) ACF	(2) OP	(3) DPD	(4) FE	(5) TL	(6) LProd	(7) Index
horizontal	1.373^{a}	0.380^{b}	0.407^{b}	0.390^{b}	0.408^{b}	0.530^{a}	1.416^{a}
	[0.466]	[0.170]	[0.171]	[0.172]	[0.173]	[0.193]	[0.494]
backward	2.148^{b}	0.994^{a}	1.051^{a}	1.033^{a}	1.007^{a}	0.525	2.561^{b}
	[0.972]	[0.325]	[0.312]	[0.320]	[0.327]	[0.407]	[1.001]
N	78592	105583	105635	105635	105635	109181	55772
R-squared	0.10	0.06	0.06	0.05	0.05	0.03	0.09

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition, industry export intensity, 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. All columns are based on the sample of firms with on average more than 5 employees. All estimations include forward spillover variables as control. Standard errors in brackets are clustered at the industry-year level. $a/b/c$ denotes significance at 1/5/10 percent.

Table 5: Time varying spillover effects

	(1) ACF	(2) OP	(3) DPD	(4) FE	(5) TL	(6) LProd	(7) Index
horizontal							
entry in t	0.450	0.132	0.072	0.072	0.108	0.407	0.561
	[0.851]	[0.315]	[0.302]	[0.305]	[0.316]	[0.357]	[0.925]
entry in t-1	-1.234	-0.569^{c}	-0.526^{c}	-0.539^{c}	-0.562^{c}	-0.319	-1.047
	[0.956]	[0.323]	[0.306]	[0.307]	[0.320]	[0.420]	[0.997]
entry in t-2	-1.603^{c}	-0.608^{b}	-0.596^{b}	-0.597^{b}	-0.569^{b}	-0.327	-1.442^{c}
	[0.837]	[0.271]	[0.262]	[0.259]	[0.259]	[0.292]	[0.797]
entry in t-3	0.501	0.064	0.064	0.044	0.064	0.084	0.411
	[0.599]	[0.170]	[0.165]	[0.168]	[0.166]	[0.216]	[0.565]
entry t-4 or earlier	1.976^{a}	0.359^{b}	0.361^{b}	0.364^{b}	0.361^{b}	0.577^{a}	2.052^{a}
	[0.497]	[0.149]	[0.151]	[0.148]	[0.148]	[0.192]	[0.510]
backward							
entry in t	3.902	2.223	1.949	2.301	1.368	2.663	4.541
	[5.134]	[1.705]	[1.680]	[1.684]	[1.754]	[2.354]	[4.895]
entry in t-1	8.498^{b}	3.236^{b}	3.166^{b}	3.298^{b}	2.937^{b}	3.792^{b}	8.544^{b}
	[3.626]	[1.314]	[1.320]	[1.288]	[1.319]	[1.615]	[3.530]
entry in t-2	4.331	1.840^{b}	1.750^{c}	1.838^{b}	1.767^{c}	2.168^{c}	3.801
	[2.742]	[0.914]	[0.906]	[0.886]	[0.908]	[1.235]	[2.616]
entry in t-3	6.049^{c}	2.629^{a}	2.568^{a}	2.603^{a}	2.500^{a}	1.779	5.858^{c}
	[3.282]	[0.867]	[0.875]	[0.862]	[0.867]	[1.137]	[3.174]
entry t-4 or earlier	-0.655	0.070	0.162	0.078	0.051	-0.199	-0.085
	[1.367]	[0.419]	[0.416]	[0.415]	[0.413]	[0.509]	[1.367]
N	49344	62816	62843	62843	62843	65047	29237
R-squared	0.07	0.04	0.04	0.03	0.04	0.02	0.08

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition, industry export intensity, 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. All columns are based on the sample of firms with on average more than 5 employees. All estimations include forward spillover variables as control. Standard errors in brackets are clustered at the industry-year level. $a/b/c$ denotes significance at 1/5/10 percent.

Table 6: Time varying spillover effects from majority and minority owned foreign firms

	(1) ACF	(2) OP	(3) DPD	(4) FE	(5) TL	(6) LProd	(7) Index
horizontal-majority							
entry in t	0.165	0.066	-0.021	-0.004	-0.005	0.242	0.280
	[0.833]	[0.330]	[0.324]	[0.324]	[0.321]	[0.393]	[0.854]
entry in t-1	-1.375	-0.641	-0.626	-0.622	-0.625	-0.290	-1.052
	[1.113]	[0.403]	[0.379]	[0.384]	[0.390]	[0.462]	[1.135]
entry in t-2	-2.001^{b}	-0.706^{b}	-0.709^{b}	-0.691^{b}	-0.683^{b}	-0.384	-1.721^{b}
	[0.912]	[0.293]	[0.280]	[0.280]	[0.276]	[0.299]	[0.854]
entry in t-3	0.180	0.046	0.040	0.029	0.021	0.059	0.047
	[0.721]	[0.205]	[0.199]	[0.202]	[0.199]	[0.242]	[0.706]
entry t-4 or earlier	1.805^{a}	0.372^{a}	0.372^{a}	0.377^{a}	0.374^{a}	0.564^{a}	1.842^{a}
	[0.431]	[0.136]	[0.135]	[0.135]	[0.136]	[0.201]	[0.441]
horizontal-minority							
entry in t	7.113	2.333	2.053	1.863	3.047	6.147	0.178
	[8.530]	[2.859]	[2.776]	[2.772]	[2.855]	[3.845]	[8.599]
entry in t-1	4.472	2.677	2.478	2.551	2.857	4.545	1.295
	[7.848]	[2.337]	[2.222]	[2.259]	[2.402]	[3.552]	[7.488]
entry in t-2	6.099	0.304	0.084	0.112	0.234	2.304	0.258
	[10.653]	[2.957]	[2.914]	[2.915]	[2.967]	[4.063]	[9.984]
entry in t-3	-11.070^{b}	-5.011^{a}	-5.414^{a}	-5.043^{a}	-5.121^{a}	-5.170^{b}	-11.010^{b}
	[5.594]	[1.614]	[1.616]	[1.600]	[1.637]	[2.200]	[5.520]
entry t-4 or earlier	2.060	-0.247	-0.412	-0.334	-0.278	0.611	1.742
	[1.875]	[0.611]	[0.585]	[0.595]	[0.608]	[0.845]	[1.807]
backward-majority							
entry in t	3.081	1.708	1.614	2.230	1.174	1.436	2.680
	[7.940]	[2.617]	[2.568]	[2.594]	[2.614]	[3.141]	[7.958]
entry in t-1	11.593^{b}	5.099^{a}	4.968^{a}	5.280^{a}	4.765^{a}	3.891^{c}	11.803^{b}
	[4.915]	[1.678]	[1.669]	[1.647]	[1.674]	[2.160]	[4.846]
entry in t-2	5.353^{c}	3.018^{a}	2.980^{a}	2.964^{a}	2.917^{a}	3.164^{b}	3.502
	[2.908]	[1.047]	[1.048]	[1.029]	[1.053]	[1.460]	[2.923]
entry in t-3	14.069^{a}	5.332^{a}	5.277^{a}	5.324^{a}	5.303^{a}	4.686^{b}	13.489^{a}
	[4.807]	[1.397]	[1.375]	[1.371]	[1.391]	[1.869]	[4.749]
entry t-4 or earlier	-0.350	0.342	0.443	0.377	0.336	-0.483	0.094
	[1.554]	[0.524]	[0.514]	[0.512]	[0.516]	[0.612]	[1.571]
backward-minority							
entry in t	132.687^{b}	46.674^{b}	39.592^{b}	42.162^{b}	39.398^{b}	42.274^{b}	125.266^{b}
	[56.291]	[18.839]	[18.375]	[18.513]	[19.115]	[19.895]	[50.716]
entry in t-1	115.141^{a}	19.767	18.184	18.047	19.870	35.744^{b}	113.363^{a}
	[36.365]	[12.864]	[12.457]	[12.691]	[12.505]	[16.679]	[35.527]
entry in t-2	40.716	-3.452	-5.603	-4.215	-4.275	0.902	39.519
	[44.369]	[14.813]	[15.142]	[14.863]	[14.846]	[19.862]	[42.109]
entry in t-3	-43.644	-13.369	-13.612	-14.376	-14.779^{c}	-19.541^{c}	-52.181^{c}
	[28.890]	[8.978]	[8.898]	[8.783]	[8.942]	[11.466]	[28.961]
entry t-4 or earlier	-14.872	-3.990	-4.305	-5.119	-4.194	-0.940	-16.092
	[16.059]	[5.338]	[5.332]	[5.322]	[5.299]	[5.985]	[16.217]
N	47609	60766	60793	60793	60793	62927	28213
R-squared	0.09	0.05	0.04	0.04	0.05	0.03	0.10

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition, industry export intensity, 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. Results are based on the sample of firms with on average more than 5 employees. All estimations include forward spillover variables as control. Standard errors in brackets are clustered at the industry-year level. $a/b/c$ denotes significance at 1/5/10 percent.

Table 7: Selection of tests for the equality of coefficients constituting the time since entry patterns

	(1) ACF	(2) OP	(3) DPD	(4) FE	(5) TL	(6) LProd	(7) Index
horizontal-majority							
$e_t = e_{t-1} = e_{t-2} = e_{t-3} = e_{t-4+}$	5.01^a	3.74^a	4.08^a	4.03^a	4.01^a	2.63^b	4.69^a
$e_{t-3} = e_{t-4+}$	4.86^b	2.87^c	3.08^c	3.33^c	3.45^c	4.33^b	4.24^a
$e_{t-2} = e_{t-3} = e_{t-4+}$	8.84^a	7.17^a	7.75^a	7.68^a	7.53^a	4.92^a	5.89^a
horizontal-minority							
$e_t = e_{t-1} = e_{t-2} = e_{t-3} = e_{t-4+}$	1.96^c	3.08^b	3.33^b	3.07^b	3.20^b	2.78^b	1.48
backward-majority							
$e_t = e_{t-1} = e_{t-2} = e_{t-3} = e_{t-4+}$	2.84^b	4.54^a	4.26^a	4.66^a	4.33^a	3.03^b	2.32^c
$e_{t-1} = e_{t-2} = e_{t-3}$	1.84	1.44	1.42	1.62	1.49	0.34	1.8
$e_{t-1} = e_{t-2} = e_{t-3} = e_{t-4+}$	3.76^a	5.87^a	5.52^a	6.11^a	5.55^a	4.05^a	3.08^b
$e_t = e_{t-1} = e_{t-2} = e_{t-3}$	1.25	1.26	1.25	1.28	1.34	0.38	1.21
$e_t = e_{t-1} = e_{t-2}$	1.06	1.37	1.33	1.38	1.38	0.37	0.99
$e_t = e_{t-1}$	1.22	2.02	2.01	1.66	2.28	0.73	0.92
backward-minority							
$e_t = e_{t-1} = e_{t-2} = e_{t-3} = e_{t-4+}$	4.47^a	2.05^c	1.77	1.92^c	1.92^c	2.35^c	3.94^a
$e_t = e_{t-1}$	0.07	1.58	1.06	1.31	0.83	0.08	0.12
$e_t = e_{t-1} = e_{t-2}$	1.22	2.24^c	1.86	1.93	1.81	1.53	0.99
$e_t = e_{t-1} = e_{t-2} = e_{t-3}$	5.51^a	2.73^o	2.35^c	2.56^c	2.56^c	3.07^o	4.89^a

$a/b/c$ denotes rejection of the null hypothesis (indicated on the left) at 1/5/10 percent.

Table 8: Further robustness tests

	(1) basic	(2) basic no min	(3) basic no maj	(4) basic no FW	(5) nace sub no FW
horizontal-majority					
entry in t	0.165	0.564		0.201	-1.088
	[0.833]	[0.870]		[0.922]	[0.715]
entry in t-1	-1.375	-1.167		-1.376	-0.935
	[1.113]	[1.003]		[1.121]	[0.897]
entry in t-2	-2.001^{b}	-1.675^{b}		-1.749^{b}	-0.908
	[0.912]	[0.843]		[0.804]	[0.749]
entry in t-3	0.180	0.586		0.731	-0.178
	[0.721]	[0.596]		[0.617]	[0.626]
entry t-4 or earlier	1.805^{a}	1.939^{a}		2.117^{a}	0.948^{b}
	[0.431]	[0.572]		[0.568]	[0.469]
horizontal-minority					
entry in t	7.113		-5.543	6.274	6.356
	[8.530]		[12.368]	[10.681]	[6.904]
entry in t-1	4.472		-0.403	3.123	4.893
	[7.848]		[8.040]	[7.447]	[4.935]
entry in t-2	6.099		-2.336	3.631	12.474
	[10.653]		[10.012]	[7.980]	[10.071]
entry in t-3	-11.070^{b}		-2.797	-8.587^{c}	-14.425
	[5.594]		[5.987]	[4.427]	[8.821]
entry t-4 or earlier	2.060		3.655	2.647	2.630
	[1.875]		[2.933]	[2.097]	[1.909]
backward-majority					
entry in t	3.081	1.676		6.572	1.934
	[7.940]	[5.252]		[8.408]	[6.289]
entry in t-1	11.593^{b}	7.062^{b}		11.103^{b}	2.230
	[4.915]	[3.576]		[4.565]	[3.663]
entry in t-2	5.353^{c}	3.731		5.145^{c}	6.314^{a}
	[2.908]	[2.841]		[3.046]	[3.650]
entry in t-3	14.069^{a}	6.895^{b}		10.402^{b}	11.534^{a}
	[4.807]	[3.454]		[4.178]	[3.311]
entry t-4 or earlier	-0.350	-0.302		-0.207	0.459
	[1.554]	[1.331]		[1.454]	[1.271]
backward-minority					
entry in t	132.687^{b}		77.753	88.046^{c}	78.377^{b}
	[56.291]		[48.686]	[51.530]	[37.691]
entry in t-1	115.141^{a}		112.961^{b}	81.972^{c}	74.943^{a}
	[36.365]		[53.771]	[47.450]	[21.365]
entry in t-2	40.716		38.245	21.159	64.438
	[44.369]		[55.922]	[43.694]	[54.644]
entry in t-3	-43.644		-29.404	-21.48	-65.740^{b}
	[28.890]		[34.864]	[24.656]	[31.276]
entry t-4 or earlier	-14.872		-8.914	-12.927	6.902
	[16.059]		[18.949]	[15.125]	[14.008]
N	47609	49318	47627	47609	47609
R-squared	0.09	0.07	0.06	0.08	0.13

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition, industry export intensity, importance of intermediates, and firm age. Dependent variable is first-differenced ACF tfp. Column 2 (3) only uses majority (minority) spillovers; columns 4 and 5 drop FW-controls. Column 5 uses industry-year dummies defined at Nace subsection level, rather than separate industry and year dummies. 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 in brackets are clustered at the industry-year level. $a/b/c$ denotes significance at 1/5/10 percent.

Table 9: Further robustness tests

	(1) basic	(2) all firms	(3) balanced sample	(4) reduced sample 1	(5) reduced sample 2
horizontal-majority					
entry in t	0.165	0.578	0.066	0.775	-1.175
	[0.833]	[0.812]	[0.808]	[1.030]	[0.947]
entry in t-1	-1.375	-1.156	-1.105	-0.376	-2.512[a]
	[1.113]	[1.186]	[1.063]	[1.106]	[0.863]
entry in t-2	-2.001[b]	-1.964[b]	-1.934[b]	-3.191[a]	-1.785[a]
	[0.912]	[0.869]	[0.936]	[1.224]	[0.540]
entry in t-3	0.180	-0.228	0.024	0.187	-0.032
	[0.721]	[0.732]	[0.747]	[0.735]	[0.470]
entry t-4 or earlier	1.805[a]	1.704[a]	1.666[a]	0.983[b]	2.141[a]
	[0.431]	[0.520]	[0.440]	[0.490]	[0.366]
horizontal-minority					
entry in t	7.113	16.281[b]	4.494	14.901	-3.947
	[8.530]	[7.392]	[8.419]	[12.308]	[9.908]
entry in t-1	4.472	6.905	2.630	8.479	-12.547[c]
	[7.848]	[6.651]	[7.884]	[9.211]	[6.396]
entry in t-2	6.099	8.005	3.580	-6.774	-14.295
	[10.653]	[10.662]	[11.227]	[21.327]	[10.654]
entry in t-3	-11.070[b]	-15.295[a]	-10.585[c]	-15.650[b]	-18.299[a]
	[5.594]	[5.687]	[5.656]	[6.890]	[5.871]
entry t-4 or earlier	2.060	-0.925	1.791	3.517[c]	3.903[b]
	[1.875]	[1.986]	[1.864]	[1.959]	[1.673]
backward-majority					
entry in t	3.081	-5.605	2.463	11.076	1.192
	[7.940]	[8.545]	[7.800]	[10.258]	[7.039]
entry in t-1	11.593[b]	12.610[b]	13.677[a]	13.237[b]	15.146[b]
	[4.915]	[5.365]	[4.637]	[5.340]	[6.265]
entry in t-2	5.353[c]	5.191	4.724[c]	1.895	5.204[c]
	[2.908]	[3.150]	[2.848]	[3.482]	[2.999]
entry in t-3	14.069[a]	17.706[a]	13.907[a]	20.022[a]	13.443[a]
	[4.807]	[4.565]	[4.931]	[4.370]	[4.329]
entry t-4 or earlier	-0.350	0.887	-0.641	-3.335[b]	1.879
	[1.554]	[1.509]	[1.510]	[1.580]	[1.564]
backward-minority					
entry in t	132.687[b]	125.039[b]	120.273[b]	40.274	127.605[b]
	[56.291]	[55.008]	[51.834]	[77.102]	[49.351]
entry in t-1	115.141[a]	87.925[a]	94.393[a]	31.000	143.578[a]
	[36.365]	[23.865]	[34.255]	[44.155]	[38.686]
entry in t-2	40.716	20.342	29.654	179.710[a]	18.083
	[44.369]	[35.212]	[44.179]	[65.120]	[35.717]
entry in t-3	-43.644	-74.172[b]	-47.535	57.140[c]	-70.608[a]
	[28.890]	[30.663]	[29.124]	[32.000]	[26.703]
entry t-4 or earlier	-14.872	-11.391	-12.976	24.453[c]	-20.961
	[16.059]	[14.262]	[16.264]	[13.921]	[14.416]
N	47609	78070	35130	38844	37786
R-squared	0.09	0.07	0.09	0.10	0.12

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition, industry export intensity, importance of intermediates, and firm age. Dependent variable is first-differenced ACF tfp. Results in all columns are based on the sample of firms with on average more than 5 employees, except those in column 2 that are based on the sample of all firms. Column 3 uses a balanced sample; column 4 restricts the sample such that for the first year of sample observations the *t-4 or earlier* variable contains the first large inflow of FDI in 1997; column 5 reduces the sample such that the FDI surges in 2004 and 2005 do not show up in any of the spillover variables. All columns use the share version of the spillover variables. All estimations include forward spillover variables as control. Standard errors in brackets are clustered at the industry-year level. *a/b/c* denotes significance at 1/5/10 percent.

Table 10: Further robustness tests

	(1) basic	(2) dummy	(3) tang fixed assets	(4) hor Y BK mat	(5) hor L BK mat	(6) hor Y BK mat 2005 IO
horizontal-majority						
entry in t	0.165	-0.177	0.221	-0.179	2.177	0.302
	[0.833]	[0.849]	[1.266]	[0.768]	[1.551]	[0.815]
entry in t-1	-1.375	-1.134	-0.990	-1.686	0.714	-1.258
	[1.113]	[1.025]	[0.837]	[1.062]	[1.365]	[0.947]
entry in t-2	-2.001^{b}	-1.652^{c}	-1.096	-1.983^{b}	0.080	-2.154^{b}
	[0.912]	[0.838]	[0.691]	[0.851]	[1.013]	[0.961]
entry in t-3	0.180	0.010	-0.049	-0.005	0.067	0.386
	[0.721]	[0.705]	[0.603]	[0.656]	[1.239]	[0.669]
entry t-4 or earlier	1.805^{a}	1.563^{a}	1.061^{a}	1.519^{a}	2.199^{b}	1.605^{a}
	[0.431]	[0.435]	[0.397]	[0.414]	[0.855]	[0.403]
horizontal-minority						
entry in t	7.113	0.031	10.474	10.320	-3.875	8.374
	[8.530]	[2.306]	[15.483]	[7.700]	[7.043]	[9.345]
entry in t-1	4.472	-0.772	42.538^{a}	3.555	-2.311	1.549
	[7.848]	[1.490]	[14.070]	[6.798]	[23.553]	[7.055]
entry in t-2	6.099	-1.227	-8.468	8.031	-2.709	-3.767
	[10.653]	[2.497]	[6.022]	[9.109]	[18.437]	[10.226]
entry in t-3	-11.070^{b}	-1.237	-0.968	-9.628	-13.238	-13.874^{a}
	[5.594]	[1.786]	[3.132]	[6.298]	[10.359]	[7.679]
entry t-4 or earlier	2.060	0.340	0.492	2.332	4.458^{a}	3.970^{a}
	[1.875]	[0.547]	[1.407]	[1.909]	[2.414]	[2.202]
backward-majority						
entry in t	3.081	2.545	5.523	-5.861	-5.931	9.105
	[7.940]	[7.578]	[8.840]	[5.886]	[5.746]	[5.914]
entry in t-1	11.593^{b}	12.907^{a}	7.024^{b}	6.207^{a}	1.884	5.522
	[4.915]	[4.778]	[3.277]	[3.291]	[2.647]	[3.540]
entry in t-2	5.353^{c}	1.855	5.491^{b}	7.074^{a}	4.326	8.378^{a}
	[2.908]	[2.921]	[2.143]	[2.287]	[2.798]	[2.817]
entry in t-3	14.069^{a}	7.258^{c}	4.178^{a}	7.253^{a}	6.283^{a}	5.767^{b}
	[4.807]	[3.901]	[2.523]	[2.388]	[2.174]	[2.765]
entry t-4 or earlier	-0.350	-0.285	0.994	-0.083	-0.121	-3.569^{b}
	[1.554]	[1.411]	[1.625]	[1.059]	[1.209]	[1.683]
backward-minority						
entry in t	132.687^{b}	7.192	60.549^{b}	78.635^{b}	86.943^{b}	27.740
	[56.291]	[6.008]	[27.497]	[39.027]	[41.904]	[23.099]
entry in t-1	115.141^{a}	10.885	28.996	136.617^{a}	133.779^{a}	84.514^{a}
	[36.365]	[9.520]	[21.885]	[34.269]	[36.562]	[30.720]
entry in t-2	40.716	14.929^{c}	154.164^{a}	36.793	40.758	-28.379
	[44.369]	[8.234]	[40.249]	[35.455]	[38.627]	[35.468]
entry in t-3	-43.644	0.686	-24.17	-19.438	-50.874^{a}	-9.894
	[28.890]	[7.980]	[32.443]	[23.667]	[26.071]	[34.713]
entry t-4 or earlier	-14.872	-2.174	-9.868	-2.085	-8.547	-0.380
	[16.059]	[4.631]	[12.159]	[14.716]	[16.108]	[21.598]
N	47609	47609	47609	47609	47609	47609
R-squared	0.09	0.08	0.10	0.09	0.08	0.09

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies. Control variables included are industry competition, import competition, industry export intensity, importance of intermediates, and firm age. Dependent variable is first-differenced ACF tfp. Column 2 uses a dummy rather than a share-version of the spillover variables; column 3 uses tangible fixed assets to calculate (share-version) spillover variables; columns 4 to 6 use the MNEs' share in material inputs to calculate the backward spillover variables; column 4 (5) uses output (employment) to calculate the horizontal spillover variables; column 6 is similar to column 4 but uses only the technical coefficients from the 2005 IO-tables rather than from the annual time-varying IO-tables. All columns are based on a sample of firms with on average more than 5 employees. All estimations include forward spillover variables as control. Standard errors in brackets are clustered at the industry-year level. *a/b/c* denotes significance at 1/5/10 percent.

Table 11: 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 in t	0.165	0.388	0.151	-1.090	-1.319	-2.624^{c}	-0.101	0.330	0.972
	[0.833]	[0.960]	[0.698]	[0.854]	[1.001]	[1.388]	[0.903]	[0.589]	[0.598]
entry in t-1	-1.375	-1.062	-1.507	-2.729^{a}	-0.107	-3.770^{b}	-1.899^{c}	-0.565	-0.309
	[1.113]	[1.230]	[1.129]	[0.926]	[0.691]	[1.706]	[1.091]	[0.823]	[0.917]
entry in t-2	-2.001b	-2.375^{b}	-2.081^{b}	-1.380^{c}	-1.075	-3.302^{b}	-2.966^{a}	-1.196	-1.252^{b}
	[0.912]	[1.001]	[0.913]	[0.764]	[0.863]	[1.393]	[1.074]	[0.784]	[0.543]
entry in t-3	0.180	0.116	0.094	0.483	-0.481	0.098	0.171	0.106	-0.065
	[0.721]	[0.699]	[0.662]	[0.555]	[0.724]	[1.053]	[0.802]	[0.570]	[0.393]
entry t-4 or earlier	1.805a	1.970^{a}	1.849^{a}	1.699^{a}	1.022^{a}	2.421^{a}	1.948^{a}	1.328^{a}	1.460^{a}
	[0.431]	[0.442]	[0.396]	[0.407]	[0.381]	[0.583]	[0.378]	[0.378]	[0.333]
horizontal-minority									
entry in t	7.113	-9.184	9.734	22.876^{c}	23.009^{b}	9.289	9.572	1.185	8.322
	[8.530]	[9.711]	[9.065]	[13.474]	[10.515]	[14.952]	[9.794]	[7.636]	[8.311]
entry in t-1	4.472	-9.746	4.775	25.163^{a}	17.763^{b}	9.967	3.482	1.034	0.262
	[7.848]	[6.406]	[6.960]	[9.057]	[7.452]	[12.657]	[6.976]	[5.589]	[5.308]
entry in t-2	6.099	-16.917	11.571	31.717^{a}	12.210	1.321	6.761	6.492	2.133
	[10.653]	[11.431]	[9.468]	[9.116]	[9.095]	[16.803]	[10.370]	[8.320]	[7.660]
entry in t-3	-11.070b	-15.387^{b}	-8.405	-8.670^{c}	-8.533^{c}	-19.999^{b}	-12.930^{b}	-9.735^{c}	-8.002^{c}
	[5.594]	[6.060]	[5.342]	[4.886]	[5.165]	[7.758]	[5.503]	[5.007]	[4.469]
entry t-4 or earlier	2.060	2.195	2.467	0.198	0.773	3.881^{c}	2.575	1.059	-0.946
	[1.875]	[1.992]	[1.752]	[1.830]	[1.825]	[2.227]	[1.774]	[1.601]	[1.883]
backward-majority									
entry in t	3.081	-1.049	8.104	4.372	-5.494	13.579	3.989	0.454	-6.412
	[7.940]	[9.221]	[6.952]	[6.668]	[3.938]	[10.903]	[6.957]	[7.285]	[5.604]
entry in t-1	11.593b	11.887^{b}	12.762^{a}	9.486^{b}	7.382^{b}	15.787^{a}	12.400^{a}	12.075^{b}	7.069^{c}
	[4.915]	[5.775]	[4.358]	[4.068]	[2.920]	[6.024]	[4.452]	[4.820]	[4.011]
entry in t-2	5.353a	4.522	4.942^{b}	6.610^{a}	4.386	3.960	8.587^{a}	3.429	4.950^{b}
	[2.908]	[3.051]	[2.437]	[2.219]	[2.901]	[3.453]	[2.518]	[2.415]	[2.407]
entry in t-3	14.069a	15.955^{a}	12.607^{a}	12.052^{a}	14.896^{a}	16.465^{a}	14.424^{a}	14.767^{a}	11.371^{a}
	[4.807]	[5.307]	[4.596]	[4.063]	[4.041]	[5.795]	[4.900]	[4.396]	[3.486]
entry t-4 or earlier	-0.350	-2.053	0.353	1.176	-0.975	-0.816	0.052	-0.081	0.027
	[1.554]	[1.750]	[1.540]	[1.363]	[1.276]	[1.975]	[1.626]	[1.242]	[1.258]
backward-minority									
entry in t	132.687b	132.575^{b}	110.612^{b}	157.255^{a}	161.825^{b}	126.480	153.855^{a}	115.121^{a}	98.106^{a}
	[56.291]	[62.615]	[50.452]	[44.134]	[67.705]	[83.335]	[58.650]	[42.772]	[37.370]
entry in t-1	115.141a	130.414^{a}	115.300^{a}	65.113^{b}	100.282^{a}	111.385^{b}	119.109^{a}	108.072^{a}	118.184^{a}
	[36.365]	[42.806]	[36.525]	[27.985]	[33.474]	[55.088]	[35.617]	[34.576]	[28.520]
entry in t-2	40.716	16.415	54.534	39.251	41.174	63.042	26.655	42.210	25.849
	[44.369]	[42.229]	[37.644]	[31.065]	[39.965]	[62.424]	[39.536]	[34.932]	[27.464]
entry in t-3	-43.644	-54.845	-31.984	-57.487^{b}	-44.343	-45.712	-26.781	-51.716^{b}	-52.006^{b}
	[28.890]	[33.718]	[27.449]	[26.091]	[29.531]	[45.127]	[31.915]	[24.724]	[20.478]
entry t-4 or earlier	-14.872	-13.774	-13.485	-19.079	-29.403^{b}	-24.173	-15.853	-14.682	-5.009
	[16.059]	[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	0.087	0.09	0.10	0.13	0.15	0.09	0.12	0.10	0.11

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition, industry export intensity, importance of intermediates, 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 in brackets are clustered at the industry-year level. $a/b/c$ denotes significance at 1/5/10 percent.