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WORKING PAPER

Distance, Time since Foreign Entry, and Knowledge Spillovers from Foreign Direct Investment

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Distance, Time since Foreign Entry and Knowledge Spillovers from Foreign Direct Investment

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Abstract

This paper investigates the effect of foreign direct investment on the productivity of local firms. We decompose traditional country-wide spillover measures in different components according to both distance between foreign and domestic firms and time-since-foreign-entry. We find larger and faster spillover effects for local suppliers of foreign firms at shorter distance, driven mainly by recent foreign entrants. Irrespective of distance, foreign firms of medium maturity generate backward spillover effects that fade away with longer presence. A positive effect on local competitors is not significantly affected by distance and requires the presence of mature foreign firms.

JEL classification: F2, D24.

Keywords: FDI, Spillovers, Dynamics, Timing, Regions, Distance.

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1 Introduction

Nowadays, countries actively and fiercely compete to attract foreign direct investment (see Harding and Smarzynska Javorcik (2011)). Policymakers are eager to do so for several reasons. First of all, they expect to benefit in terms of faster economic growth in their country through additional foreign capital and higher employment. Second, foreign firms are expected to bring more advanced technology (see Markusen (1995)) which policymakers believe to 'spill over' to domestic firms, with increased domestic productivity as a result. Spillovers from foreign to domestic firms have been investigated at least since Caves (1974). Initially, it proved difficult to detect clear evidence of aggregate positive FDI spillovers (see Görg and Greenaway, 2004; Crespo and Fontoura, 2007). Following Smarzynska Javorcik (2004), the literature now distinguishes between spillovers within the same industry (horizontal spillover effects) as well as those resulting from vertical links along the supply chain (backward and forward spillover effects). The recent literature seems to have established fairly robust evidence of positive backward spillover effects from foreign firms to their domestic suppliers. By means of a meta-analysis Havránek and Irŝová (2011) confirm that the average backward spillover effect is both statistically and economically significant.

Following new theoretical insights that stress the importance of firm level heterogeneity in the study of firms' participation in international markets (see Melitz (2003) and Helpman et al. (2004)), the literature has moved away from the idea that spillovers are unconditional and uniform. The focus has instead turned to the identification of characteristics that facilitate positive spillover effects, often concerning domestic firms' characteristics such as absorptive capacity (e.g. Merlevede and Schoors (2007)) or foreign firms' characteristics such as ownership structure (e.g. Smarzynska Javorcik and Spatareanu (2008) and Kamal (2014)). In this paper we combine two other potential determinants of spillover effects. We focus on distance between foreign and domestic firms and combine this with a recent finding by Merlevede et al. (2014) who relate foreign firms' spillover potential to the duration of their presence in the host country, i.e. their maturity. We analyse whether spillovers vary with distance and whether it takes more time for spillovers to manifest themselves over longer distances.

Several authors have investigated whether spillovers entail a regional dimension. This has resulted in mixed findings. For instance Aitken and Harrison (1999) found no evidence of local horizontal spillover effects, nor of country-wide spillover effects in Venezuela. Mariotti et al. (2014) find that spillover effects are strong in knowledge intensive sectors, but geographical proximity is not relevant. Both Keller (2002) and Halpern and Muraközy (2007), on the other hand, do find that spillover effects decline or disappear with distance. Using data for Portugal, Crespo et al. (2009) confirm the importance of considering the geographical proximity between MNCs and domestic firms in relation to the occurrence of FDI spillovers. Finally, Altomonte and Colantone (2008) and Wen (2013) report mixed results, with only some regions recording positive spillovers, suggesting that, aside from distance, other regional characteristics, such as differences in foreign firms' entry and maturity patterns, might be driving responses to FDI inflows.

We contribute to this literature by incorporating an additional element in the analysis of the impact of distance on FDI spillover effects: time-since-foreign-entry. Recently, Merlevede et al. (2014) have shown that adequately accounting for time-since-foreign-entry reveals new insights in the case of country-wide spillovers. They show that positive horizontal spillover effects require the presence of mature foreign firms, while positive backward spillover effects arise rapidly following foreign entry, but are transient.

In this paper we use a panel of Romanian manufacturing firms that allows us to investigate whether spillover effects are limited to the regional level or whether it takes more time for spillovers to manifest themselves over longer distances, across region borders. We use variation across 40 Romanian NUTS 3 regions[1] to identify regional patterns. We find negative horizontal spillover effects for medium maturities of foreign firms, but larger positive spillover effects for foreign firms that have been present for at least four full years in the domestic economy. Results indicate that, on aggregate, the effect of distance on horizontal spillover effects is limited. Point estimates do suggest that distance mitigates the negative effects, while it increases the positive spillover effects from foreign firms with longer presence. Point estimates cannot, however, be rejected to be equal over different distances at conventional levels. This suggests that mechanisms behind horizontal spillover effects are largely independent of distance. Backward spillover effects, however, are affected by distance. Domestic firms located in the same region as a foreign client are found to experience an immediate bonus effect upon foreign entry. We find that 'relocating' a firm from its own region to Bucharest-Ilfov, the capital region and top FDI location, is associated with an 11 per cent larger backward spillover effect on average over the sample period. For medium maturities of foreign firms, we find a significant positive backward spillover effect which is not related to distance. In line with Merlevede et al. (2014), backward spillover effects are absent for foreign firms that have been present for at least four full years in the domestic

[1] The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU. A NUTS level 3 region is a "small region for specific diagnoses". The minimum and maximum population thresholds for a NUTS 3 region are defined as 150,000 and 800,000.

economy. These results are robust to foreign firm location choice. Considering regional heterogeneity, we find the same pattern of backward spillover coefficients for above median productivity regions. For below median productivity regions, on the other hand, we no longer observe a significant immediate backward effect upon entry of foreign clients in the region. Furthermore, the within region backward spillover coefficients are no longer significant, neither are they significantly different from backward spillover coefficients from other regions. Consistent with the view that it might take time for spillovers to be absorbed over larger distances, domestic firms in below median productivity regions do experience positive backward spillover effects from further away, but more mature foreign firms.

The remainder of the paper is structured as follows. In section 2 we discuss the current spillovers literature and introduce the standard measurement and empirical framework. Section 3 introduces our regional time-since-foreign-entry approach to spillovers. Section 4 discusses the data and in section 5 we present results. Finally, we conclude in section 6.

2 Literature, standard measurement and empirical framework

The current literature distinguishes between several types of 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, however. Labor market dynamics may entail negative spillovers such as a brain drain of local talent to foreign firms to the detriment of local firm productivity (see Blalock and Gertler (2008)) or an overall increase in wages irrespective of productivity improvements caused by foreign firms paying higher wages (see 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 (see Aitken and Harrison (1999), on this market-stealing effect). These partial effects are hard to disentangle empirically and a general measure for horizontal spillover potential is typically used to identify the net effect of all these channels.

Backward spillovers run from the foreign firm to its upstream local suppliers. Thus, even if foreign firms attempt to minimise their technology leakage to direct competitors (i.e. the horizontal effect), they may still want to assist their local suppliers in providing inputs of sufficient quality in order to realise 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 a 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. Rodríguez-Clare (1996) shows that the backward linkage effect is more likely to be favourable 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. Forward spillovers run from a foreign firm to its local buyers. In their meta-study Havránek and Irŝová (2011) indicate that the best practice estimate of forward spillover effects is insignificant. Given these findings and in line with other recent work such as Damijan et al. (2013), we focus on backward spillovers.[2]

The empirical framework to analyse spillover effects can be seen as an 'augmented' production function, where spillover variables are added to other explanatory variables such as labour, capital, and material inputs. The typical measure employed to identify horizontal or within-industry spillover effects is given by Equation (1). For a (domestic) firm i in industry j at time t it is of the following form:

$$\mathrm{HR}_{jt} = \frac{\sum\limits_{i \in j} F_{it} Y_{it}}{\sum\limits_{i \in j} Y_{it}} \tag{1}$$

where Y is output and F is the percentage of shares owned by foreign investors. In line with the definition commonly applied by the OECD or the IMF, at least 10% of shares should be owned by a single foreign investor for a firm to be considered as foreign. HR_{jt} in (1) measures the share of output that is produced by foreign firms in industry j. Since this

[2]Furthermore, Damijan et al. (2013) indicate that foreign affiliates in Eastern Europe (we consider Romania) are mainly engaged in end-user consumer goods.

spillover variable is built up to industry level from firm-level data, HR_{jt} has the same value for all firms i in industry j at time t. The definition of the backward spillover variable, BK_{jt}, starts from the horizontal measure and combines it with information from input-output tables as in:

$$\text{BK}_{jt} = \sum_{k \neq j} \gamma_{jkt} * HR_{kt} \tag{2}$$

where γ_{jkt} is the proportion of industry j's output supplied to sourcing industry k at time t. The γ's are calculated from (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, nor 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 line with BK_{jt}, we can define FW_{jt} as $\sum_{l \neq j} \delta_{jlt} * HR_{lt}$ where δ_{jlt} is the proportion of industry j's inputs sourced from industry l at time t. The spillover variables HR_{jt}, BK_{jt}, and FW_{jt} are then regressed on the productivity of (domestic) firm i in industry j. The size, sign, and significance of the resulting coefficients are then taken as evidence of spillover effects.

As indicated above, FDI spillovers are commonly analyzed in a production function framework. Firm level total factor productivity is obtained in a first step estimation and in a second step the FDI spillover variables together with some further controls are treated as additional 'input' explaining domestic firms' productivity. The careful estimation of the production function 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 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. 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 papers by Olley and Pakes (1996) and 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 therefore use the ACF estimator to obtain our indicator of total factor productivity (TFP). A measure of TFP 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:

$$tfp_{ijt} = Y_{ijt} - \widehat{\beta}_{lj} l_{ijt} - \widehat{\beta}_{kj} k_{ijt} - \widehat{\beta}_{mj} m_{ijt} \quad (3)$$

Following the literature (e.g. Smarzynska Javorcik (2004)), in the second step tfp_{ijt} is related to a firm specific effect, a vector of spillover variables, $\mathbf{FDI}_{jt}$, and firm and industry level controls, $\mathbf{Z}_{i(j)t}$. Note that (4) now pools firms from all industries together in one large panel, whereas (3) is estimated by industry. This approach is what Havránek and Irŝová (2011) define as best practice.

$$tfp_{ijt} = \alpha_i + \Psi_1 f\left(\mathbf{FDI}_{jt-1}\right) + \Psi_2 \mathbf{Z}_{i(j)t} + \xi_{ijt} \tag{4}$$

Ψ_1 in equation 4 allows us to identify the sign, size, and significance of the impact of foreign presence on the productivity of local firms. In the next section we define our vectors of spillover variables, $\mathbf{FDI}_{jt}$, and control variables, $\mathbf{Z}_{i(j)t}$.

3 A regional dynamic approach to spillovers

In this section we introduce our regional dynamic approach to the identification of spillover effects in the above framework. Whereas we do not have information on the exact location of foreign firms in our dataset (cf. infra), we do know in which NUTS 3 region a firm is located. We use the NUTS 3 classification as our regional dimension. At this level Romania is divided in 42 territorial units, i.e. 41 counties and the capital Bucharest. Our data, however, do not allow us to discriminate between Bucharest and the surrounding county Ilfov. Therefore, we have 41 territorial units in our analysis. The NUTS 3 level is appropriate because we find quite some heterogeneity between regions in terms of foreign presence and larger regional aggregates (e.g. the NUTS 2 division) would hide this heterogeneity. The NUTS 3 division also follows an original administrative structure for which we are able control by means of region fixed effects.

Figure 1 plots the share of industry output produced by foreign firms in a region from the total country-wide output of that industry (the average over manufacturing industries in a given region is plotted). The figure clearly shows that foreign presence is not uniformly spread across regions. Over the sample period the dispersion of FDI intensity at the regional level (measured by the standard deviation) has increased from 1.7 in 2000 to 1.9 in 2005. Given the potential contribution of spillover effects to economic growth, it is important to test whether these regional differences in FDI intensity have an impact on where spillover effects are generated, whether spillover effects differ in size across regions and whether and how spillover effects spread from one region to another. We now introduce our methodological approach. We first introduce the distance dimension, and then interact it with the time-since-foreign entry dimension.

[Insert Figure 1 near here]

3.1 Spillovers and distance

The typical measure to capture within-industry spillover effects HR_{jt} in (1) is the share of output that is produced by foreign firms in industry j. For a given firm i in industry j in region r at time t we can break HR_{jt} down into different 'geographical' subcomponents as follows:

$$\mathrm{HR}_{jt} = \frac{\sum\limits_{i \in j} F_{it} Y_{it}}{\sum\limits_{i \in j} Y_{it}} \tag{5}$$

$$= \frac{\sum R_{it} F_{it} Y_{it}}{\sum Y_{it}} + \frac{\sum NB_{it} F_{it} Y_{it}}{\sum Y_{it}} + \frac{\sum \left(1 - R_{it} - NB_{it}\right) F_{it} Y_{it}}{\sum Y_{it}} \tag{6}$$

where R_{it} indicates whether firm i is located in region r, and NB_{it} indicates whether firm i is located in a contiguous region of r. Finally, $(1 - R_{it} - NB_{it})$ will equal 1 if firm i is located in a further-away non-neighbouring region, i.e. a rest-of-country category.[3] We refer to this regional decomposition as 'distance'.

From (6) it becomes clear that introducing HR_{jt} as a single variable in a regression involves the implicit assumption that the spillover intensity -as measured by the coefficient obtained on HR_{jt}- is the same within and across regions. In our empirical analysis we relax this assumption and allow the coefficients to differ between the different subcomponents in (6), obtaining estimates for region, neighbour and rest-of-country components respectively. A regional definition for BK follows from (2) above. Since we only have input-output tables at the country-level, we assume that technical coefficients are similar across regions and equal those derived from country-level input output tables.

We differ from earlier literature by explicitly structuring the regional dimension as a decomposition of the traditional nation-wide definition. By introducing all three subcomponents of (6) in our analysis we also differ from part of the regional FDI spillover literature that

[3] Clearly, (6) could be further decomposed in a straightforward manner to account for second- or even higher-order neighbours. However, since adding second-order neighbour effects does not affect our estimates with respect to region, neighbour, and rest-of-country, we focus on the three aforementioned dimensions. These results are available on request.

does not allow for cross-regional spillovers. Often only the first term of the decomposition is included among the regressors, thereby implicitly assuming that spillovers are confined to region boundaries and do not cross borders. This runs counter to Halpern and Muraközy (2007) who find that horizontal spillovers vary with distance, but do not disappear. It also runs counter to macro-spillover studies as Keller (2002) who finds that spillovers between countries are declining with distance. We further distinguish ourselves from the existing literature by modeling cross-region spillover effects. Consider the following reformulation of (6), where summation is over firms i in industry j:

$$\begin{aligned}\mathrm{HR}_{jt} &= \frac{\sum R_{it}F_{it}Y_{it}}{\sum R_{it}Y_{it}} \times \frac{\sum R_{it}Y_{it}}{\sum Y_{it}} \\ &+ \frac{\sum NB_{it}F_{it}Y_{it}}{\sum NB_{it}Y_{it}} \times \frac{\sum NB_{it}Y_{it}}{\sum Y_{it}} \\ &+ \frac{\sum \left(1 - R_{it} - NB_{it}\right) F_{it}Y_{it}}{\sum \left(1 - R_{it} - NB_{it}\right) Y_{it}} \times \frac{\sum \left(1 - R_{it} - NB_{it}\right) Y_{it}}{\sum Y_{it}} \qquad (7)\end{aligned}$$

Studies that focus on regional spillovers typically apply the traditional nation-wide definition to their regional spillover variable. This spillover variable is constructed as output produced by foreign firms in industry j in region r as a share of total *regional* industry j output, i.e. the first part of the first term in (7), rather than as a share of country-wide industry j output.

The definition of an appropriate measure relates to one's idea about spillover potential (this is what the variables are intended to capture). Consider two regions A and B. In region A 10 out of the total of 100 units are produced by foreign firms, while in region

B 10,000 out of the total 100,000 units are produced by foreigners. $\sum R_{it}F_{it}Y_{it}/\sum R_{it}Y_{it}$ is appropriate if one believes that the spillover potential is the same in both regions. In the former case, spillovers should be thought of as limited to the region level since it is difficult to carry this definition through to the cross-region level. Suppose regions A and B are neighbours. Following a logic of relative within territorial unit presence, the spillover from neighbours could be measured as $\sum NB_{it}F_{it}Y_{it}/\sum NB_{it}Y_{it}$. This results in a value of 0.10 for both region A and B. However, it seems counterintuitive that the spillover potential from region A to B would equal the spillover potential from B to A. This is not the case when using the second subcomponent of our decomposition in (6). In our example, this results in a spillover potential from A to B of $10/100,100$ and a spillover potential from B to A of $10,000/100,100$. These values seem better aligned with the cross-region spillover potential one would expect. Regions where a larger share of the foreign activity is located carry a larger spillover potential and therefore should be reflected in the measure employed in empirical work. Therefore, we apply the decomposition in (6) and allow for coefficient heterogeneity for the different subcomponents.

3.2 Spillovers and time-since-foreign-entry

Abstracting for the moment from the geographical dimension in HR_{jt} discussed in the previous subsection, (1) hides another important dimension that deserves a closer inspection. To see things more clearly, consider the following alternative breakdown of (1):

$$\mathrm{HR}_{jt} = \frac{\sum \widetilde{F}^{1}_{it}Y_{it}}{\sum Y_{it}} + \frac{\sum \widetilde{F}^{2}_{it}Y_{it}}{\sum Y_{it}} + ... + \frac{\sum \widetilde{F}^{n}_{it}Y_{it}}{\sum Y_{it}} \tag{8}$$

where $\widetilde{F}^x$ is a variable indicating foreign ownership status *and* entry timing. $\widetilde{F}^x_{it}$ equals the percentage of shares owned by foreign investors in firm i if at least 10% of shares were owned by a single foreign investor in year $t-x+1$ and firm i was not foreign owned in year $t-x$, i.e. the investment took place between $t-x+1$ and $t-x$. So $\widetilde{F}^x_{it}$ is set to the percentage of shares owned by foreign investors if

$$\left(\sum_{v=0}^{x-1} F_{i,t-v} = x\right) \wedge \left(\sum_{w=x}^{\infty} F_{i,t-w} = 0\right) \tag{9}$$

HR_{jt} is thus broken down into HR^1_{jt}, HR^2_{jt}, and so on, along the lines of foreign entry timing (note the difference with pure calendar time or taking lags of HR_{jt}). A time-since-foreign-entry definition for BK^x_{jt} follows from (2) and (8) above:

$$\mathrm{BK}^x_{jt} = \sum_{k\neq j} \gamma_{jkt} * HR^x_{kt} \tag{10}$$

Various transmission channels discussed above imply an impact of foreign entry timing. 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 access to better inputs produced by foreign firms or by supplying inputs to multinational companies might not necessarily be instantaneous nor permanent. For the Irish electronics sector Görg and Ruane (2001) find 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. Based on their Volvo case study Ivarsson and Alvstam (2005) conclude that technology transfer to suppliers seems more efficient in older MNE plants. Within multinationals technology is also not necessarily easily or rapidly transferred (see Urata and Kawai (2000)). This may give rise to specific time patterns in the transfer of technology to foreign affiliates and the ensuing spillovers. Merlevede et al. (2014) introduce a time-since-foreign-entry pattern of spillover effects by allowing every term in (8) to have its own coefficient $\alpha_{\widetilde{F}(x)}$.

We combine the regional and time-since-foreign-entry aspects into a single comprehensive approach, as summarized in Table 1. We believe that combining both dimensions can provide new insights due to interaction between both factors. It is not unlikely that the time-since-entry pattern for within-region spillovers is different from the time-since-entry pattern for cross-region or rest-of-country spillovers, since it may take more time for domestic firms to absorb spillovers from foreign firms in further-away regions. A failure to find cross-region spillovers on the basis of aggregate variables as in (6) could be due to the fact that time-since-foreign-entry has been neglected, rather than that these spillovers are truly non-existent. Further note that some papers limit the scope of spillovers to the boundaries of a region by the construction of their spillover variables (see Nicolini and Resmini (2010)). We model the potential regional pattern explicitly and combine it in a novel way with time-since-foreign-entry effects.

[Insert Table 1 near here]

3.3 Empirical approach

Our empirical approach detailed in (4) above closely follows the existing literature described earlier. We estimate domestic industry production functions using the ACF estimator separately for each NACE[4] 2-digit manufacturing industry j in the period 1996-2005. Cap-

[4]NACE stands for *Nomenclature générale des Activités économiques dans les Communautés Européennes.*

ital, labor, and material inputs elasticities are thus treated as industry-specific. Firms that are foreign at some point in time are excluded from the estimation.

The vector of spillover variables ($\mathbf{FDI}_{jt-1}$) covers different horizontal and vertical spillover variables described above. More specifically, HR, BK, and FW are decomposed in function of both the geography and time-since-foreign-entry dimensions (for clarity industry and time subscripts are dropped in (11)). We consider three different regional dimensions: within-region spillovers, HR_reg^{t-x}, first-order neighbour spillovers, HR_nb^{t-x}, and spillovers from the regions that make up the rest-of-country, HR_roc^{t-x}. Considering the time span of our dataset (1996-2005, *cf. infra*) we opt to include HR_x^{t} to HR_x^{t-3} and create a variable HR_x^{t-4+} which aggregates all foreign firms that have been present for at least four full years on the domestic market, hence the summation from t to $t-4+$ in (11). Since we do not have information on exact dates of foreign entry prior to 1996, the time span of the dataset for the estimations reduces to 2001-2005 because of missing values.

$$\begin{aligned}\Psi_1 f\left(\mathbf{FDI}_{jt-1}\right) = & \sum_{x=0}^{4+}\left(\alpha_{reg}^{t-x} HR\_reg^{t-x} + \alpha_{nb}^{t-x} HR\_nb^{t-x} + \alpha_{roc}^{t-x} HR\_roc^{t-x}\right) \\ & + \sum_{x=0}^{4+}\left(\alpha_{reg}^{t-x} BK\_reg^{t-x} + \alpha_{nb}^{t-x} BK\_nb^{t-x} + \alpha_{roc}^{t-x} BK\_roc^{t-x}\right) \\ & + \sum_{x=}^{4+}\left(\alpha_{reg}^{t-x} FW\_reg^{t-x} + \alpha_{nb}^{t-x} FW\_nb^{t-x} + \alpha_{roc}^{t-x} FW\_roc^{t-x}\right) \qquad (11)\end{aligned}$$

Through the vector $\mathbf{Z}_{i(j)t}$ 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. Further we use the region-industry share of national industry activity and the region's share of national manufacturing activity to control for region and region-industry agglomeration effects. Specification (4) is first-differenced and estimated by OLS. We also introduce industry (α_j), region (α_r), and time dummies (α_t) in the first-differenced specification to account for unobserved factors that could be driving *growth* performance at the region or industry level. This results in (12) as final specification to be estimated. Since $\mathbf{FDI}_{jt}$ 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 region, industry and year (see Smarzynska Javorcik (2004)).

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

4 Data

We use firm-level data for a panel of Romanian manufacturing firms during 1996-2005. Since most foreign investment entered the country after 1996, Romania makes a very good candidate to study the dynamic impact of recent foreign investment on domestic firm productivity (see Hilber and Voicu (2010)). Moreover, in a bid to bring all regions to a similar level of economic development , the country has undergone a massive forced industrialisation for about two decades prior to 1990s (see Ronnås (1984)). This was at least partially successful due to the wide dispersion of natural resources across the country. Although the process did not level out all regional differences that developed over centuries, it did reduce some disparities and created a more standardised structure of counties with strong manufacturing bases and improved urban networks. The fall of communism in 1989 was accompanied by a reversal of at least some of these policies, with severe restructuring in the industrial setup of the country as a consequence. As a result, regional inequalities have risen due to both market forces and a decrease in state intervention (see Antonescu (2012)). While we do not have data for the 1990-1995 period, our sample still covers the early stages of the transition period and therefore a relatively homogeneous regional setup.

Our firm-level data are taken from Amadeus, a Bureau van Dijk Electronic Publishing database. 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 of the DVD contains 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. [5] 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

[5]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.

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.[6] We focus on a sample of firms that report unconsolidated data.

Data are deflated using industry price level data at NACE rev.1.1 2-digit level. These are taken from the Industrial Database for Eastern Europe from the Vienna Institute for International Economic Studies (2008) and from the Romanian National Statistical Office (RNSO) (2005). 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 tangible 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)). Detailed IO tables containing 105 (59 manufacturing) sectors for the period 1996–2005 were obtained from the RNSO.

We restrict the dataset to firms with on average at least 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.[7] The share of foreign firms in the total number of sample firms steadily increased

[6] e.g.

	Amadeus	immediate
2000	40	40
2001	.	40
2002	50	50

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

from 17% to 24% (10% to 15% if small firms are not excluded). Table 2 lists summary statistics for both 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 productivity bonus of foreign over domestic firms is 26% in case of the ACF methodology.

[Insert Table 2 near here]

Based on 15164 industry-region-year observations Table 3 reveals that on average over industries, regions, and years about 25% of output is produced by foreign firms. The vast majority of foreign output is on average produced in the rest-of-country, with within-region and neighbouring-region aggregates accounting for 1 and 3.2 percentage-points only. The interquartile range suggests limited variation for within-region and neighbouring-region aggregates. Some industries are, however, fairly concentrated as testified by the maximum value of 80%. Backward spillover variables show a more mitigated pattern as they are a weighted average of downstream horizontal variables. The correlation between region-neighbour, region-rest-of-country, and neighbour-rest-of-country are virtually zero at 0.03, -0.05, and -0.07. Table 4 shows that for each regional aggregate foreign firms which have been present for at least four years account for the largest share of output produced by foreign firms in the industry and region. One should bear these numbers in mind when interpreting the results below.

[Insert Table 3 near here]

[Insert Table 4 near here]

5 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 the results on the control variables here. If not mentioned otherwise, we include age, industry competition, competition from imports in the industry, the share of intermediates supplied in total industry output, and time, industry and region dummies as control variables. We consider horizontal, backward and forward spillovers. In line with the literature the latter turn out to be insignificant (see Havránek and Irŝová (2011)). We think of them as additional control variables and for reasons of clarity and space we only report forward spillover results in the first results table and omit them from further tables. We first discuss results that only focus on the distance decomposition of the spillover variables. Then we combine the distance and time-since-foreign-entry decompositions of the spillover variables and present our main results. We refer the reader to Merlevede et al. (2014) for results on the time-since-entry decomposition by itself.

5.1 Distance decomposition

Table 5 presents results for the distance decomposition. The table contains both the estimated coefficients for spillover effects over different distances and an F-test for the equality of the estimated coefficients over distance. We observe that all horizontal spillover coefficients are significant. The estimated coefficients increase with distance which suggests that while positive spillover channels dominate, negative effects such as increased competition are somewhat stronger for nearby foreign firms. We cannot reject the different coefficients to be equal, however. Therefore, distance between the foreign and domestic firms seems unimportant for horizontal spillover effects and domestic firms benefit both from nearby and far away foreign firms in the same industry. Backward spillover effects are only statistically significant from firms located further away, specifically in the rest-of-country area. This result could reflect that backward spillover effects originate from firms concentrated in a small number of regions and from there spread to other regions of the country. For the average Romanian region these regions would pertain to the rest-of-country category. Nonetheless, the test for equality of coefficients again is unable to reject the null hypothesis that coefficients are equal. The third column shows that forward spillovers are insignificant, a finding in line with the literature.

[Insert Table 5 near here]

5.2 Distance and time-since-foreign-entry decomposition

Results in Table 5 do not account for the time-since-foreign-entry dimension which has been found to be an important factor in shaping FDI spillover effects. Table 6 therefore shows our central result that combines the regional dimension with the time-since-foreign-entry dimension. From specification (1) we infer that horizontal spillover effects (column a) are negative in the first years after entry, but turn positive when foreign firms 'mature'. The intensity of horizontal spillovers again does not seem to vary in terms of FDI location (nearby or far away), with very similar spillover coefficients for same region, neighbouring region, and rest-of-country aggregates. This is confirmed by the results in column 1 of Table 7, as we cannot reject the equality of the horizontal spillover coefficients across the regional dimension. This suggests that, independent of distance, the effect of foreign presence has similar impact on domestic firm productivity. Therefore, for a similar share of foreign sales at each level, domestic firms experience similar productivity effects whether foreign firms are located in their own region, in a neighbouring region or in the rest-of-country. **All in all, it seems that the channels for horizontal spillovers are not localised, but operate nation-wide.**

[Insert Table 6 near here]

The time-since-entry dimension suggest that domestic firms experience an initial negative impact following foreign firms' entry, which could be due to considerable negative competition effects or labour cherry picking. However, once foreign firms have been present for a sufficiently long period in the domestic economy (entry in t-4 or earlier), positive spillover effects do arise and they are sufficiently large to compensate for earlier negative effects. In line with Table 5, point estimates again hint at a larger (or less negative) impact for foreign firms located in the rest-of-country versus the own region, confirming that distance might offer some protection against negative effects.

Backward spillover effects in specification (1) column (b), on the other hand, show a larger sensitivity to the distance between domestic and foreign firms. Both distance and time-since-foreign-entry are important determinants of the magnitude of the backward spillover effect accruing to domestic firms. Taking time-since-foreign-entry into account, we find that entry of foreign firms in the same region entails an immediate positive contribution to the domestic firms' productivity. In addition, positive spillover effects from further away foreign firms need more time to manifest themselves. To better illustrate the impact of backwards spillovers, in

Figure 2 we plot the total expected contribution to a domestic firm's TFP level of a foreign entrant producing 2 per cent of downstream output annually, i.e. the backward spillover effect. From panel A of Figure 2 we clearly infer that a domestic firm would prefer to see the foreign firm enter in its own region, as the expected backward spillover effect over the foreign firm's life time is at least twice as large there compared to those from the other two regional dimensions. The F-tests in Table 7 confirm a statistically significant bonus of being close to foreign clients. Moreover, specifications (2) and (3) in Table 6 show that the 'being close' bonus is not driven by a specific correlation structure between the different elements of the regional decomposition, since the exclusion of the *neighbour* variables or the *neighbour* and $rest-of-country$ variables does not affect the results of the *region* variable. Panel B of Figure 2 shows that positive and significant backward spillover effects are arising from foreign firms with limited maturity (this is in line with Merlevede et al. (2014)). Allowing for the time-since-foreign-entry pattern shows a very strong initial impact of supplying intermediate inputs to foreign firms located in the host region which decays over time and disappears for more mature firms. The patterns for backward spillover effects from foreign firms in neighbouring regions or in rest-of-country regions are very similar and not statistically different from one another (cf. F-tests in Table 7). These spillover effects take more time to manifest themselves and also disappear once a foreign firm has been present for a longer period in the host country. This explains the difference with our findings in Table 5 where we did not account for the time-since-foreign-entry pattern. Since only recent foreign entrants drive regional differences in backward spillover effects, lumping all firms together in terms of time-since-foreign-entry prevents us from seeing this effect.

[Insert Figure 2 near here]

[Insert Table 7 near here]

Since Figure 2 does not convey much about the actual in-sample contribution to productivity for Romanian firms, we offer two additional views of our results. First, we calculate the period-average contribution to the TFP-level of the average domestic firm of the different spillover variables, as shown in Figure 3. This is achieved by multiplying the average amount of foreign presence at all three regional levels with their respective coefficients. Moreover, it gives a better indication of what foreign entry has brought for Romanian firms over 2001-2005. Figure 3 suggests that the average contribution of the rest-of-country horizontal spillover is larger than those from either the own or neighbouring regions. This is due to the combination of similar sized coefficients as well as the fact that on average the amount of foreign activity in the rest-of-country regional aggregate is much larger than in either the own or neighbouring regions. From panel A of Figure 3 it is also clear that the positive contribution after four years of foreign presence outweighs the negative effects foreign firms generate in the first three years. This confirms the fact that after an initial adjustment period, domestic firms do benefit from the presence of foreign firms in their own industry (cf. Merlevede et al. (2014)). Backward spillover effects are limited to the first years after foreign entry. For the average domestic firm the rest-of-country backward spillover effect is the largest because most of the foreign firms are located there, but the within-region contribution is non-negligible.

[Insert Figure 3 near here]

Second, since the previous result does not take into account regional heterogeneity in Romania, we recalculate the expected impact in terms of spillover effects on TFP from moving a domestic firm between regions. We firs 'relocate' a firm from Vaslui, a subpar performing region in the North-East at the border with Moldova, to Timiş, a regional hub in the South-West of Romania. This move increases the total spillover effect on the log of the TFP-level of the firm with 0.036. The effect is for about two thirds driven by an increase in the horizontal spillover effect which in turn is driven mainly by an increase in the within-region effect (the negative neighbour and positive rest-of-country components are smaller and cancel out). A further move from Timiş to Bucharest-Ilfov increases the total spillover effect by 0.058. In contrast to the previous move, the increase is now due to the combination of a decrease in the horizontal effect (-0.032) that is more than compensated by a larger increase in the backward spillover effect (0.091). The latter is due to the fact that being in the same region as foreign entrants carries a statistically significant bonus in terms of backward spillover effects, as well as that Bucharest-Ilfov is the main TFP-hub in Romania, dwarfing the other regions in terms of foreign presence and foreign entry over the sample period. This also explains a within-region negative horizontal effect in Bucharest-Ilfov, compared to Timiş. In the latter the horizontal effects from the many foreign firms located in Bucharest-Ilfov have a more benign effect as they are part of the rest-of-country component for firms located there. The regions recording the smallest total spillover effects over the sample period are neighbours of Bucharest-Ilfov. This occurs due to the fact that they are less protected from negative horizontal effects from foreign firms in Bucharest-Ilfov as well as that they are not close enough in order to benefit from the immediate positive backward spillover effects generated by the large number of foreign entrants in Bucharest-Ilfov. Note that all this is derived on the basis of point estimates and should be considered as indicating the direction of the effects. F-tests revealed that only the 'immediate' within-region backward spillover effect (the largest source of spillover effects) is found to be statistically different from the other geographical components.

In Table 8 we further explore regional heterogeneity in the estimation by testing whether the identified patterns are stable across regions that perform above and below median region-productivity. We use the approach of Foster et al. (2001) to calculate initial regional TFP from our firm-level data.[8] Regions with above median region-TFP levels could be interpreted as more dynamic regions with larger absorptive capability, yielding a rationale to expect different patterns. As Table 8 indicates, more productive regions show slightly higher horizontal spillover coefficients compared to the entire sample. This might suggest that firms located in these regions are on average better at adapting to foreign presence in their industry. Coefficients are similar at all regional dimensions, indicating that location is not relevant for horizontal spillover absorption. With respect to backward spillover effects, we confirm the 'being-close bonus', i.e. the significantly larger within-region backward spillover effect from recent foreign entrants. Overall, these patterns are fairly similar to those obtained using the full sample. Differences emerge when we consider spillover patterns in below median region-productivity regions. Within-region positive horizontal spillover effects from foreign firms with sufficient maturity are no longer detected (whereas they still are positive and significant at the neighbour and rest-of-country levels). Similarly, for backward spillover effects, the within-region 'being-close bonus' for new foreign entrants disappears, as do the

[8] We compute this value by a weighted sum of their individual productivities: $P_r = \sum s_{ir} * p_i$ and where s_{ir} is the regional output share of firm i in region r and p_i is its productivity.

positive within-region backward spillover effects from foreign firms entering two and three years earlier. It also takes more time for other positive backward spillover effects to manifest themselves in these regions (3-4 years).

[Insert Table 8 near here]

[Insert Table 9 near here]

5.3 Foreign firms location choice

In table 8 we found that regions above and below the median region-productivity show different spillover patterns. One could argue that foreign firms would tend to locate in the regions where they expect domestic firms with higher productivity (growth) to be located. In order to make sure that our results are not driven by such factors, we analyze foreign firms' location choice within Romania. From panel A in Figure 4 one can observe that the majority of foreign companies locates either near the Western border with Hungary or in Bucharest-Ilfov, the capital region. This indicates that location choice is potentially non-random.

Location choice can be explained by several factors. First of all, it has been suggested that foreign companies investing in developing countries such as Romania face very specific obstacles like widespread bureaucracies, corruption, insufficiently developed financial markets and unpredictable legal systems (see Bitzenis (2006)). Therefore, instead of focusing solely on labour costs, foreign firms would locate in areas with high services agglomeration or, in other words, large cities which allow them to have access to lawyers, accountants, translators and the banking industry (Hilber and Voicu (2010)). Second, location of foreign subsidiaries might also be explained by the proximity to Western borders. Since a large share of foreign investment has European roots, choosing a location closer to home might constitute an advantage for their parents. Moreover, since Western border regions have for a large part of recent history been under the influence of the Habsburg empire, locating in this area might be more appealing from a cultural sense as well (see Becker et al. (2011)).

Nonetheless, there might still be an issue if the most productive (domestic) companies are also located in these regions. Comparing panels A and B of Figure 4 suggests no immediate problem. Nevertheless, we run two simple regressions to investigate how regional productivity growth is related to the location choice of new foreign firms. We perform the analysis at both the region and the region-industry level. We include a Western border dummy because we expect the border to have a significant impact on location choice due to the closeness to Western markets. Further we include a dummy that is set to one if the main national road connecting Bucharest with Hungary passes through the region.[9] Finally, we include the regional rural rate obtained from the Romanian National Statistical Office (RNSO) (2014). The results in Table 10 indicate that location is indeed heavily influenced by our control variables but is not related to the lagged first difference of regional productivity of domestic firms. We therefore conclude that foreign firm location is not influenced by the presence of fast growing domestic firms in the region.

[Insert Figure 4 near here]

[Insert Table 10 near here]

[9] Other roads were underdeveloped and of poor quality during our sample period.

6 Conclusion

This study analyzes horizontal and vertical productivity spillover effects of foreign direct investment on domestic Romanian manufacturing companies from 1996 to 2005. We add to the literature by investigating the combined impact of physical distance and time-since-foreign-entry on spillover effects. Since spillover variables are typically based on foreign firms' share in total industry output, they are often lumped together, new and old, in one variable. Moreover, the literature usually measure spillovers at country level, disregarding the potential effect of distance between foreign and domestic firms. We allow spillover effects to vary both over time-since-foreign-entry and the relative location of foreign and domestic firms according to their NUTS-3 digit geographic location.

Horizontal spillovers are rather homogeneous across distance. Recent foreign entrants have a negative impact on local competitors' TFP which are more than compensated by positive effects once foreign firms have been present for a longer period in the domestic economy. This indicates that it takes time for domestic firms to adjust to foreign presence in the short-run, with productivity improvements being realised provided these companies withstand the initial pressures from foreign entrants and are able to absorb the new foreign technology. This finding does not differ between above and below median productivity regions and is also robust to the removal of the most FDI intensive region of Romania.

In terms of backward spillovers, our results indicate that these manifest themselves relatively fast after foreign entry, but fade away when foreign firms have been present for a longer period. Further, we find that being located in the same region as foreign firms carries an immediate productivity bonus compared to foreign firms located further away. This effect is stronger for domestic firms located in regions with above median productivity levels. When located in below median productivity regions, positive backward spillover effects are not immediate and mainly originate from further away regions. This suggests that over larger distances spillovers are absorbed, but at a slower pace.

All in all, our findings suggest that overall spillover effects from foreign direct investment are likely to be positive, but both horizontal and backward spillover effects vary considerably with foreign firms' maturity. Backward spillover effects are faster and larger when the distance between domestic firms and their foreign clients is smaller. Horizontal spillover effects vary with distance on the basis of point estimates (the closer, the smaller the spillover effect), but these differences are not statistically significant.

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Figures and Tables

Figure 1: Industry output produced by foreign firms in a NUTS 3 region as a share of total country-wide output of the industry (the average over manufacturing industries in a given region is plotted)

(a) 2000 (b) 2005

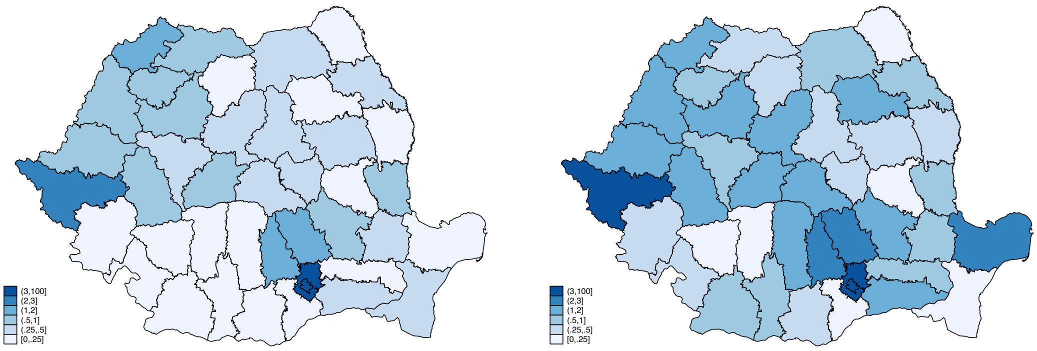
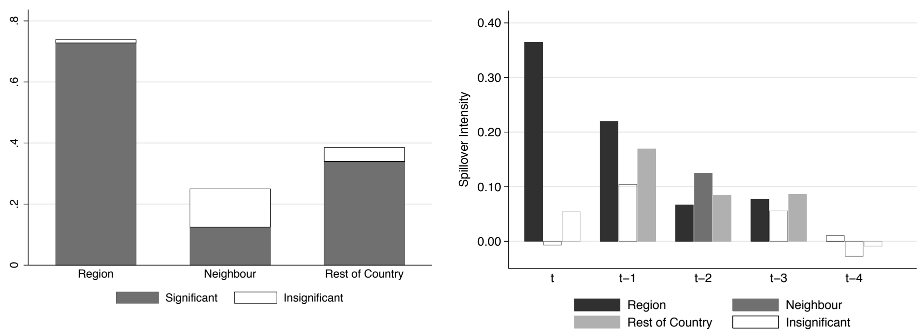


Figure 2: Backward spillover effect of a foreign firm producing 2 per cent of downstream output

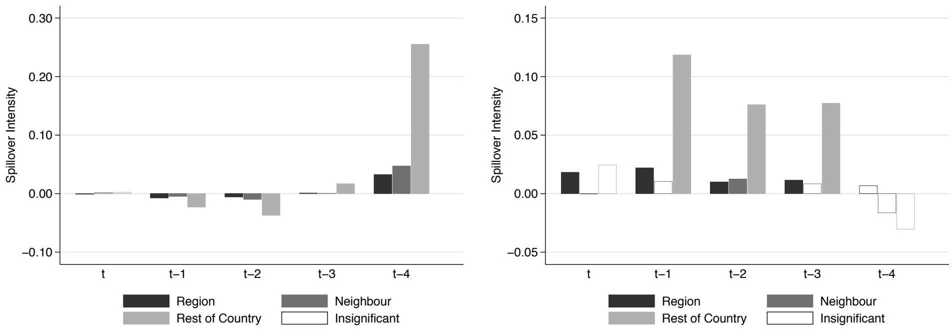
(a) Distance impact (b) Distance and time-since-foreign-entry impact



The figure shows the actual contribution to a domestic firm's TFP level of a foreign firm each year producing 2 per cent of downstream output.

Figure 3: Average effect

(a) Horizontal Spillovers (b) Backward Spillovers



The figure shows the actual contribution of the FDI on the productivity of domestic firms, where each coefficient is augmented by the amount of foreign presence at the respective regional dimension.

Figure 4: Share of foreign firms and regional productivity

(a) 2005 share of foreign firms as percentage of total country number of foreign firms

(b) 2005 regional productivity of domestic firms computed as a weighted sum of their individual productivities

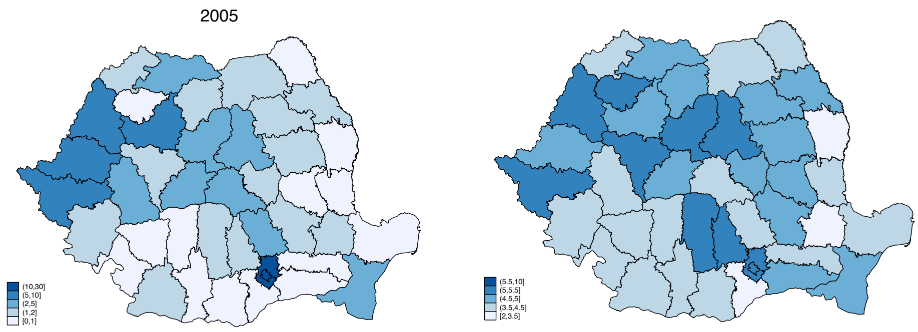


Table 1: Coefficient heterogeneity in a regional time-since-foreign-entry approach

Region/Time-since-foreign-entry	t	t-1	t-2	t-3	t-4+
same region	$C_{R,t}$	$C_{R,t-1}$	$C_{R,t-2}$	$C_{R,t-3}$	$C_{R,t-4+}$
neighbour region	$C_{NB,t}$	$C_{NB,t-1}$	$C_{NB,t-2}$	$C_{NB,t-3}$	$C_{NB1,t-4+}$
rest of country	$C_{RoC,t}$	$C_{RoC,t-1}$	$C_{RoC,t-2}$	$C_{RoC,t-3}$	$C_{RoC,t-4+}$

Table 2: TFP summary statistics

	All firms n=133154		Domestic firms n=105854		Foreign firms n=27300	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
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(tfp) ACF	5.74	1.52	5.69	1.52	5.95	1.47

Summary statistics for foreign and domestic firms.

Table 3: Summary statistics for the distance decomposition

	Mean	Median	IQR	P25	Min	Max
horizontal						
region	1.0	0.0	0.2	0.0	0.0	80.3
neighbour	3.2	0.6	3.1	0.0	0.0	83.5
rest-of-country	20.7	17.5	21.5	8.5	0.0	87.2
backward						
region	0.6	0.1	0.3	0.0	0.0	38.7
neighbour	1.7	0.7	1.2	0.3	0.0	26.8
rest-of-country	14.4	14.5	9.8	9.3	0.1	62.9

Table entries refer to the share of total country-wide industry output produced by foreign firms in the region, neighbouring region, and rest-of-country regional aggregates. Numbers are based on 15164 industry-region-year observations.

Table 4: Summary statistics for the distance and time-since-foreign-entry decomposition

	t	t-1	t-2	t-3	t-4+
region	0.04	0.12	0.14	0.14	0.78
neighbour	0.13	0.37	0.45	0.47	2.59
rest-of-country	0.78	2.40	2.98	3.22	16.52

Table entries refer to the share of total country-wide industry output produced by foreign firms of a given maturity (indicated in column headings) in the region, neighbouring region, and rest-of-country regional aggregates. Numbers are averages over 15164 industry-region-year observations.

Table 5: Results when applying the distance decomposition to spillover variables

	Horizontal	Backward	Forward
same region	0.834*	1.577	-1.924
	[0.461]	[1.058]	[1.261]
neighbouring region	1.117***	0.305	1.465
	[0.287]	[0.916]	[0.914]
rest of country	1.438***	1.354***	0.082
	[0.141]	[0.375]	[0.322]
Reg=NB=RoC	1.269	0.691	2.325*
Observations		49,074	
R-squared		0.05	

The table presents both the regression results for the geographical component alone and a test for the equality of coefficients at regional, neighbour and rest-of-country level with the corresponding F-test. Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. F-test * rejected at 10%; ** rejected at 5%; *** rejected at 1%.

Table 6: Horizontal and Backward spillovers

	(1)		(2)		(3)	
	(a) Horizontal	(b) Backward	(a) Horizontal	(b) Backward	(a) Horizontal	(b) Backward
entry in t						
same region	-0.573	18.229***	-0.427	19.850***	-0.163	20.148**
	[0.953]	[6.921]	[0.964]	[7.073]	[1.030]	[9.876]
neighbouring region	0.888	-0.347				
	[0.546]	[5.191]				
rest of country	0.183	2.712	0.421	2.405		
	[0.332]	[1.740]	[0.307]	[1.682]		
entry in t-1						
same region	-2.483***	10.983***	-2.394***	11.733***	-2.620***	9.939***
	[0.814]	[2.929]	[0.821]	[2.937]	[0.861]	[3.329]
neighbouring region	-1.575***	5.202				
	[0.577]	[3.750]				
rest of country	-1.089***	8.464***	-1.104***	8.175***		
	[0.374]	[1.094]	[0.354]	[1.062]		
entry in t-2						
same region	-1.426***	3.342***	-1.393**	3.578***	-1.527**	2.568**
	[0.539]	[1.122]	[0.541]	[1.134]	[0.618]	[1.288]
neighbouring region	-2.461***	6.227**				
	[0.562]	[2.820]				
rest of country	-1.427***	4.223***	-1.549***	4.325***		
	[0.269]	[0.745]	[0.263]	[0.726]		
entry in t-3						
same region	0.263	3.844***	0.238	3.969***	-0.026	2.758*
	[0.437]	[1.415]	[0.439]	[1.465]	[0.490]	[1.454]
neighbouring region	0.083	2.785				
	[0.525]	[2.456]				
rest of country	0.583***	4.287***	0.555***	4.125***		
	[0.193]	[0.971]	[0.186]	[0.939]		
entry in t-4 or earlier						
same region	1.546***	0.525	1.539***	0.543	1.212***	-0.191
	[0.412]	[1.214]	[0.416]	[1.215]	[0.453]	[1.350]
neighbouring region	1.814***	-1.368				
	[0.315]	[1.025]				
rest of country	2.109***	-0.439	2.053***	-0.594		
	[0.155]	[0.435]	[0.152]	[0.418]		
Observations	(49,074)		49,074		49,074	
R-squared	(0.071)		0.070		0.045	

Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7: Test for equality of coefficients

F-test	Horizontal	Backward
Reg_t=NB_t=RoC_t	1.114	2.535*
Reg_t=NB_t	1.833	4.280**
NB_t=RoC_t	1.238	0.331
Reg_t=RoC_t	0.558	4.811**
Reg_{t-1}=NB_{t-1}=RoC_{t-1}	1.313	0.776
Reg_{t-2}=NB_{t-2}=RoC_{t-2}	1.656	0.514
Reg_{t-3}=NB_{t-3}=RoC_{t-3}	0.606	0.197
Reg_{t-4+}=NB_{t-4+}=RoC_{t-4+}	1.249	0.833

The table presents a test for the equality of coefficients at regional, neighbour and rest-of-country level with the corresponding F-test value. * rejected at 10%; ** rejected at 5%; *** rejected at 1%.

Table 8: Horizontal and Backward spillovers in Above and Below median productivity regions

	(1) Above		(2) Below	
	(a) Horizontal	(b) Backwards	(a) Horizontal	(b) Backwards
entry in t				
same region	-0.504	17.618**	0.86	49.695
	[1.130]	[7.697]	[0.993]	[47.094]
neighbouring region	-0.941	-3.248	1.800***	17.84
	[0.848]	[5.904]	[0.520]	[11.637]
rest of country	0.571	2.258	-0.584	4.253
	[0.404]	[2.204]	[0.596]	[2.707]
entry in t-1				
same region	-2.266**	11.669***	-4.242	46.056*
	[0.899]	[3.215]	[5.865]	[26.022]
neighbouring region	-1.662**	3.813	-3.358***	8.43
	[0.705]	[4.240]	[1.090]	[8.258]
rest of country	-0.852*	8.711***	-1.247***	8.071***
	[0.498]	[1.319]	[0.446]	[1.882]
entry in t-2				
same region	-1.316**	3.577***	-10.850**	13.994
	[0.582]	[1.190]	[4.722]	[15.817]
neighbouring region	-2.506***	2.039	-3.255***	19.132***
	[0.705]	[3.140]	[0.889]	[5.051]
rest of country	-1.475***	3.761***	-1.157***	4.962***
	[0.342]	[0.961]	[0.389]	[1.039]
entry in t-3				
same region	0.409	3.808***	-4.784	21.948
	[0.450]	[1.384]	[3.554]	[24.714]
neighbouring region	0.16	1.022	0.089	8.411*
	[0.643]	[2.814]	[0.845]	[4.593]
rest of country	0.767***	3.680***	0.404	5.775***
	[0.253]	[1.283]	[0.277]	[1.240]
entry in t-4 or earlier				
same region	1.713***	0.264	1.652	10.432
	[0.413]	[1.246]	[1.473]	[9.899]
neighbouring region	2.136***	-1.01	1.584***	-2.834
	[0.398]	[1.208]	[0.482]	[2.176]
rest of country	2.301***	-0.383	1.998***	-0.4
	[0.204]	[0.571]	[0.234]	[0.656]
Observations	33,693		15,381	
R-squared	0.075		0.072	

Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 9: Test for equality of coefficients - Above/Below

F-test	(1) Above		(2) Below	
	(a) Horizontal	(b) Backward	(a) Horizontal	(b) Backward
Reg_t=NB_t=RoC_t	1.514	2.303	4.860***	1.094
Reg_t=NB_t	0.103	4.402**	0.885	0.439
NB_t=RoC_t	2.702	0.816	9.643***	1.344
Reg_t=RoC_t	0.797	3.742*	1.662	0.931
Reg_{t-1}=NB_{t-1}=RoC_{t-1}	1.175	1.159	1.88	1.062
Reg_{t-2}=NB_{t-2}=RoC_{t-2}	1.163	0.145	4.347**	4.168**
Reg_{t-2}=NB_{t-2}	1.913	0.208	2.498	0.092
NB_{t-2}=RoC_{t-2}	2.061	0.288	5.035**	7.754***
Reg_{t-2}=RoC_{t-2}	0.068	0.015	4.138**	0.325
Reg_{t-3}=NB_{t-3}=RoC_{t-3}	0.623	0.45	1.114	0.341
Reg_{t-4+}=NB_{t-4+}=RoC_{t-4+}	1.006	0.318	0.381	1.218

The table presents a test for the equality of coefficients at regional, neighbour and rest-of-country level with the corresponding F-test value. * rejected at 10%; ** rejected at 5%; *** rejected at 1%.

Table 10: Location of foreign firms

	New foreign firms (region)	New foreign firms (region industry)
Regional productivity growth	0.021	-0.006
	[0.576]	[0.006]
DN1 road	11.146***	0.220***
	[2.550]	[0.048]
HU border	10.564***	0.313***
	[2.424]	[0.057]
Rural rate	-52.326***	-1.740***
	[11.965]	[0.194]
Observations	369	6,293
R-squared	0.356	0.061

The table shows the regression results of local firm productivity change on foreign firm location. Standard errors are reported in brackets. * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent. The dependent variables are the lag of the first difference in regional/region-industry firm productivity of domestic firms, a dummy indicating whether the main national road is crossing the region, a dummy for bordering regions with Hungary and the regional rural rate.