

**IMPACT OF FIRM HETEROGENEITY ON DIRECT
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MICRO EVIDENCE FROM TEN TRANSITION
COUNTRIES**

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Abstract

This paper presents a comparative study of the importance of direct technology transfer and spillovers through FDI on a set of ten transition countries, using a unique firm-level dataset of some 91,500 firms. The main novelty of the paper is the explicit control for various sources of firm heterogeneity when accounting for effects of FDI on firm performance. We find that the heterogeneity of firms in terms of absorptive capacity, size, productivity and technology levels affect the results. Only more productive firms and firms with higher absorptive capacities are able to benefit from horizontal and vertical spillovers from foreign affiliates.

Keywords: Foreign direct investment, technology transfer, spillovers, transition economies, firm heterogeneity

JEL Classification: D24, F14

1. Introduction

Foreign investors can transfer technology in two ways: directly to the affiliates under their ownership and control, and indirectly to other firms in the host economy through spillovers. There is ample empirical evidence of positive direct technology transfers from a multinational company (MNC) to its foreign affiliates in terms of higher productivity levels and growth. On the other hand, despite the theoretical justification of potential spillovers, the evidence of technology spillovers from a foreign affiliate to its host country horizontal competitors and/or vertically linked suppliers and customers is weak or even negative. Potential reasons for empirical failure to find significant spillovers include a lack of differentiation between vertical and horizontal spillovers, the low absorption capacity of host country firms, and the failure to take into account that only some categories of domestic firms are able to absorb FDI spillovers. This puts forward the issue of firm heterogeneity.

This paper has two primary objectives. The first is to provide a comparative firm-level study on the importance of direct technology transfer and spillovers through FDI in a group of comparable countries. The second objective is to account for the inherent heterogeneity of firms. This paper explicitly accounts for different aspects of firm heterogeneity, including size, absorptive capacity, productivity and the technology gap relative to foreign affiliates. We differentiate between direct effects of FDI from the parent firm to foreign affiliates and horizontal and vertical spillovers from these affiliates to local firms. The importance of these different channels of technology transfer is then estimated in the framework of the growth-accounting approach using a unique firm-level database that consists of a panel of some 91,500 firms in 10 transition countries (Bulgaria, Croatia, Czech Republic, Estonia, Latvia, Lithuania, Poland, Romania, Slovenia and Ukraine)² from 1995-2005. We use several correction methods to account for possible biases in the data. We deal with the simultaneity problem by using the Olley - Pakes method and we correct for potential selection bias by using a generalized Heckman two-step procedure.

Over the course of the estimations, the dataset is divided by country, and then into smaller subsamples according to size, productivity, and technology gaps, controlling for firm absorptive capacity. Results show that the heterogeneity of firms, in terms of absorptive capacity, size, productivity and technology level, significantly affects the results.

The paper is organized as follows. Section 2 discusses channels of technology transfer through FDI, and Section 3 presents empirical model that allows for accounting for different measures of spillovers at the firm level. Section 4 describes the data and the econometric approach employed. Section 5 presents the results, and the final section discusses the impact of this study and its implications for future research.

2. Channels of technology transfer through FDI

Foreign investors can transfer technology in two ways: directly to the affiliates under their ownership and control, and indirectly to other firms in the host economy through spillovers. There is ample empirical evidence on positive direct technology transfers

² The selection of countries has been determined by data availability and quality.

from MNCs to their foreign affiliates in terms of higher productivity levels and growth (see, for instance, Haddad and Harrison, 1993; Blomström and Wolff, 1994; Blomström and Sjöholm, 1999; Aitken and Harrison, 1999; Girma et al, 2001; Barry et al, 2005; Alvarez et al, 2002; Blalock, 2001; Damijan et al, 2003b; Arnold and Smarzynska-Javorcik, 2005; Girma and Görg, 2006). The extent and scope of technology transfers from MNCs to their foreign affiliates heavily depends on the position of foreign affiliates in the MNCs' international production network (White and Poynter 1984, Bartlet and Ghoshal 1989, Birkinshaw and Hood 1998). This points to the importance of including parameters of foreign affiliates' heterogeneity in the analysis of technology transfer from their parent companies.

The other method of technology transfer through FDI is spillovers from foreign affiliates to domestic firms. These transfers take place when the entry or presence of foreign affiliates, which typically have better technologies and organizational skills than domestic firms, increases the knowledge of domestic firms and foreign investors do not fully internalize the value of these benefits (Griliches 1979, 1992). FDI spillovers can occur between firms that are vertically integrated with the MNC (vertical, inter-industry spillovers) or in direct competition with it (horizontal, intra-industry spillovers). The substantial body of empirical literature on FDI spillovers, which has developed over the last 30 years, has produced mixed empirical results. The econometric analyses have found positive, neutral, and negative spillovers from foreign subsidiaries to domestic firms. Traditionally, FDI spillovers were assessed by sectoral studies. They demonstrated mostly positive FDI spillovers. Lately, firm level panel data based studies dominate the field. The main reason that empirical analysis moved towards using firm level data was a heterogeneity problem (Keller, 2004). Most firm level studies cast doubt on the existence of FDI spillovers.³

The evidence on FDI spillovers in transition countries from firm-level panel data analysis suggests only a few intra-industry spillovers from FDI. Konings (2001) provides no evidence of positive horizontal spillovers to local firms in Bulgaria, Poland or Romania, but instead finds significant evidence of negative spillovers in Poland. Djankov and Hoekman (2000) also provide evidence of negative spillovers in the Czech Republic. Kinoshita (2000) provides evidence of spillovers in the Czech Republic, that are limited to firms engaged in R&D or in the production of electrical equipment. Tytell and Yudaeva (2007) demonstrate positive FDI spillover effects on domestic firms in Poland, Romania, Russia and Ukraine, but only in the case of export-oriented FDI. Damijan et al (2003b), Gorodnichenko et al (2007), Schoors and van der Tool (2001), and Smarzynska-Javorcik (2004) all find some evidence of (backward) vertical spillovers from FDI in transition countries, but much less evidence, if any, for horizontal spillovers. Nicolini and Resmini (2006) find evidence of horizontal, vertical-backward and vertical-forward FDI spillovers on domestic firms in Bulgaria, Romania and Poland.

The overall impression of the lack of evidence on FDI spillovers is predominantly due to the results of the firm-level panel data analysis. This is important because this is the most appropriate way to account for FDI spillovers.

³ For overviews of the literature on FDI spillovers see, for instance, Görg and Strobl, 2001; Görg and Greenaway, 2004; Hanson, 2001; Smarzynska-Javorcik, 2004; Keller and Yeaple, 2003; Keller, 2004.

By applying the firm-level panel data analysis, this paper specifically tackles some of the problems of accounting for FDI spillover as outlined by Görg and Greenaway (2001, 2004). We distinguish between vertical and horizontal spillovers and introduce the heterogeneity of domestic firms as far as technological capacities, productivity, human capital and size are concerned. These factors determine domestic firms' absorption capacity for spillovers. Absorption capacity for knowledge spillovers is most frequently directly 'measured' by a firm's *level of technological capacity*. The empirical literature (Perez, 1998; Halpern and Murakozy, 2007; Ben Hamida and Gugler, 2007; Abraham et al, 2006; Girma et al, 2006) predominantly confirms that knowledge spillovers occur more frequently if the technology gap between domestic and foreign firms is not too large and thus a sufficient absorptive capacity is available in domestic firms. Differences in the technological capacity of domestic firms are frequently proxied by *differences in their productivity levels*. According to Keller and Yeaple (2003), and Nicolini and Resmini (2006) only more productive firms are able to acquire FDI related spillovers. Quite the opposite, Haskel et al (2007) estimate that on average, less productive (and smaller) plants receive stronger FDI spillovers than more productive (and larger) ones, while Castellani and Zanfei (2003) find that high productivity gaps tend to favor positive effects of FDI. *Human capital capacity* has been argued to increase the ability of domestic firms to benefit from positive spillovers (Borensztein et al, 1998; Meyer and Sinani, 2001; Ben Hamida and Gugler, 2007; Girma et al, 2006). Yet another determinant of domestic firms' absorption capacity and knowledge spillovers via FDI identified in the literature is *firm size*. Size seems to have a positive influence on domestic firms' absorption capacity (Veugelers and Cassiman, 1999; Ornaghi, 2004). Bekes et al (2006) provide convincing evidence from a sample of Hungarian firms that larger and more productive firms (defined by the deciles of size and productivity) are more able to reap spillovers from MNCs.

3. Modeling direct and spillover effects of FDI

Empirical studies on technology spillovers have to differentiate between the direct and indirect effects of FDI as well as between horizontal and vertical spillovers. In searching for horizontal spillovers, the technology gap between foreign affiliates and local firms must be accounted for, while the analysis of vertical spillovers should differentiate between backward and forward linkages induced by foreign affiliates.

We measure the impact of external technology spillovers by including the technology variables directly in the production function, a method similar to the endogenous growth models. This approach provides a way to study the various factors that affect productivity growth, including technological accumulation. This is done using the growth-accounting approach and decomposing total factor productivity (TFP) into factors internal and external to the firm, such as R&D activity, human capital and channels of technology transfer.

We assume that each firm has a production function for gross output:

$$(1) \quad Y_{it} = Q^i(K_{it}^\alpha L_{it}^\beta T_{it}) \quad i=1, \dots, n,$$

where Y_{it} is value added in firm i at time t , which is a firm specific Q^i function of K_{it} , L_{it} , and T_{it} (capital stock, number of employees, and technology parameters, respectively). The production function (1) is homogenous of degree r in K and L , such that $r=\alpha+\beta \neq 1$, which implies that Q^i may have non-constant returns to scale.

Differentiating equation (1) with respect to time, we get:

$$(2) \quad y_{it} = \alpha k_{it} + \beta l_{it} + t_{it},$$

where lowercase variables indicate the logarithmic growth rates of K , L and T , and α and β represent the elasticity of output with respect to k and l . We assume that the technology stock T is a function of internal technology variables \mathbf{G}_{it} and of various spillover effects \mathbf{Z}_{it} :

$$(3) \quad T_{it} = f^i(\mathbf{G}_{it}, \mathbf{Z}_{kt}),$$

where

$$\begin{aligned} (F_{it}, H_{it}) &\in \mathbf{G}_{it} \\ (ES_{kt}, HS_{kt}, VSb_{kt}) &\in \mathbf{Z}_{kt}, \end{aligned}$$

where the elements of \mathbf{G}_{it} are foreign ownership F_{it} and firm human capital H_{it} , measured with the firm average wage bill. \mathbf{Z}_{kt} consists of potential home market spillovers ES_{kt} (external economies of scale at the industry level k), horizontal spillovers HS_{kt} and vertical backward spillovers VSb_{kt} , all measured at the industry level k .

The basic idea underlying equation (3) is that an individual firm can boost its technology level either internally through an appropriate ownership structure and its own investments into human capital, and/or by relying on external sources of knowledge spillovers, such as home market spillovers and horizontal and vertical spillovers from MNC affiliates.

Regarding the impact of FDI, MNCs can transfer newer technology and organizational skills both directly to the affiliate and indirectly to other firms in the host economy. On the one hand, direct effects generally appear to affiliates as changes in productivity (shown in Q^i) and as potential better utilization of existing inputs. The presence of an affiliate, on the other hand, can also indirectly increase the rate of technical change and technological learning in the economy through knowledge spillovers to local firms. The innovation system and social capabilities of the host economy, together with the absorptive capacity of other firms in the host economy measured by their own investments into human capital (H_{it}), will then determine the pace of technological progress in the economy as a whole.

Knowledge spillovers can occur either between firms in the industry (external spillovers) or between foreign owned firms. Knowledge spillovers stemming from foreign owned firms arise between firms that are vertically integrated with the foreign affiliate (inter-industry spillovers) or in direct competition with it (intra-industry spillovers). Kokko (1992) identifies at least four ways that technology might be diffused from foreign affiliates to other firms in the host economy: the demonstration-imitation effect, the competition effect, the foreign linkage effect and the training effect. Although there are clear differences among these types of knowledge spillovers, the empirical literature mainly captures those spillovers occurring among firms within the same industry. The reason for this is that competitive effects within an industry are much easier to measure than linkage effects across industries. Studies that estimate spillover effects using the production function approach, similar to the one specified in equation (2) subject to (3), unintentionally pick up inter-industry effects contained in the

variable Y . In the present study, we draw on Blalock (2001) and Damijan et al (2003b) in order to capture inter-industry effects by incorporating direct requirement coefficients derived from the input-output accounts from each country into the empirical model.

To disentangle the two spillover effects, we define the scope for intra-industry spillovers, or horizontal spillovers, as the share of an industry's output produced by the foreign affiliates:

$$(4) \quad HS_{kt} = \frac{\sum_{i=1}^n FA_{ikt}}{\sum_{i=1}^n (FA_{ikt} + DF_{jkt})}, \quad i=1, \dots, n,$$

where HS_{kt} is horizontal spillovers in industry k in period t and FA_{ikt} and DF_{ikt} are the value added of foreign affiliate i and domestic owned firm i in industry k and period t , respectively. These spillovers mainly reflect the competitive pressures that encourage local firms to introduce new products to defend their market share and adopt new management methods to increase productivity. Imitation, reverse engineering, personal contact and industrial espionage may also be captured by this variable. However, exports often comprise a large proportion of the output of foreign affiliates, reducing the impact they might have had on the domestic market. To compensate for this reduction of competitive pressures in the domestic market, we correct the measure of horizontal spillovers in (4) by the proportion of their value added Y_{ikt} made up of exports of foreign affiliates EX_{ikt} :

$$(5) \quad \overline{HS}_{kt} = \frac{\sum_{i=1}^n FA_{ikt}}{\sum_{i=1}^n (FA_{ikt} + DF_{jkt})} * \left(1 - \sum_{i=1}^n \frac{EX_{ikt}}{Y_{ikt}}\right),$$

In the next step, we account for potential vertical spillovers of foreign affiliates, i.e., for the impact of foreign affiliates on their upstream suppliers.⁴ Foreign affiliates often provide resources to improve the technological capabilities and quality standards of their upstream suppliers. We account for these backward linkages Vsb_{kt} as the sum of the output of industries r purchased by firms in industry k weighted by the share of total foreign output HS_{kt} :

$$(6) \quad Vsb_{kt} = \sum_{r,k=1}^p (\alpha_{krt} * HS_{kt}), \quad r,k=1, \dots, p,$$

where α_{krt} ($0 \leq \alpha_{krt} \leq 1$) is the proportion of industry r 's output consumed by industry k . These direct input requirements are obtained from the input-output accounts. Again, foreign affiliates tend to purchase a larger proportion of their inputs abroad than do domestic firms, hence reducing the actual demand for domestic intermediate goods. Therefore, the measure of backward linkages in (6) should be corrected by foreign affiliates' import share:

⁴ This paper only accounts for backward linkages, that is, for the impact of foreign affiliates on their upstream suppliers. As foreign affiliates are mainly engaged either in end-user consumer goods for local market or as suppliers to their parent companies abroad, forward linkages in local market have been found to be rather low or insignificant (Smarzynska-Javorcik, 2004; Gorodnichenko et al, 2007; Halpern and Murakozy, 2007). For this reason, we neglect this issue in the present study.

$$(7) \quad \overline{VSb}_{kt} = \sum_{r,k=1}^p \left((\alpha_{krt} * HS_{kt}) * \left(1 - \sum_{i=1}^n \frac{IM_{ikt}}{MC_{ikt}} \right) \right), \quad r,k=1,\dots,p,$$

where IM_{ikt} and MC_{ikt} are the imports and material costs of foreign affiliate i .

It is important to note that not all spillovers are positive. The parent firm can also have a negative impact on the direct transfer of technology to its affiliate and reduce knowledge spillovers to the local economy. For example, MNCs can provide their affiliates with too few, or the wrong kind, of technological capabilities. This can also reduce the scope for spillovers to the domestic economy. The parent firm can also reduce the potential for knowledge spillovers by limiting downstream producers to low value-added activities, or by relying on foreign suppliers for higher value-added intermediate products. Domestic firms that do not have the capability to adapt can also be crowded out of the market.

Finally, it is important to consider the external knowledge spillovers that are generated at the industry level, which can benefit all the firms in the industry. Ethier (1979), Markusen and Melvin (1981) and Helpman (1984) emphasize the importance of external spillovers among differentiated firms in an industry. The larger the industry, the larger the scope either for inter-firm exchange of components or for competition among differentiated firms. We capture these spillovers by the size of the industry, measured with the aggregate value added:

$$(8) \quad ES_{kt} = \sum_{i=1}^n Y_{ikt}, \quad i=1,\dots,n, \dots$$

Castellani and Zanfei (2007) emphasize that in addition to the horizontal spillovers variable, the size of the sector (i.e., external spillovers) should also be included in the empirical model. The reasoning for this is straightforward, as horizontal spillovers are defined as the ratio of the value added of foreign owned firms relative to the total industry value added. The elasticities of domestic firms' productivity to foreign and total industry activity are restricted to be equal in magnitude but with inverted signs. Clearly, when this restriction is not satisfied, the horizontal spillover coefficient may be downward biased. Using the case of Italian manufacturing firms, the authors demonstrate that a more accurate specification of externalities yields larger (positive and significant) spillover effects.

4. Data and econometric approach

4.1 Data

Data at the firm level provide the best way to test for FDI productivity spillovers. In order to analyze the importance of different channels of technology transfer via FDI in a comparative way, we gathered panel data for 10 transition economies: Bulgaria, the Czech Republic, Croatia, Estonia, Latvia, Lithuania, Poland, Romania, Slovenia and Ukraine. Balance sheet and financial statement data were collected for 1995-2005 for most of the countries, with the exception of Estonia (1997-2005), Latvia (1996-2005), Slovenia (1995-2003) and Ukraine (1998-2005). The source of these data is the Amadeus database (Bureau van Dijk), while for Slovenia, data were obtained from the

local statistical office. We use the full Amadeus database but limit our database to manufacturing firms only, with no limitations on the size threshold. Thus, these data include firms from all size classes, including micro and small firms. The dataset consists of more than 90,000 firms with up to 11 annual observations, which would theoretically yield almost one million annual observations. However, the dataset is not balanced. Due to the requirements of the econometric methods used in this paper (Olley-Pakes corrections), we only include firms with 5 or more annual observations in the empirical estimations. These restrictions limit the size of our data to some 315,000 annual firm observations. Still, this is by far the largest firm level dataset used so far by any study on the spillover effects of FDI.

[Insert Table 1]

Some basic characteristics of the data are reported in Table 1. The best firm level data coverage is for Romania (48,500 firms), followed by Bulgaria (9,500 firms), the Czech Republic (8,500 firms), Poland (6,000 firms) and Ukraine (5,500 firms), while for Croatia, Estonia and Slovenia we have between 3,000 and 4,000 annual firm observations. On the other hand, we have relatively poor coverage for Lithuania (700 firms) and Latvia (1,500 firms).⁵ The most reliable dataset in this country sample is for Slovenia, which is obtained from the national statistical office and which covers virtually all manufacturing firms that were active in the period and that had at least one employee.

We also have data on the share of foreign investors in the total equity of domestic firms. According to other studies and our previous work, the foreign ownership variable is constructed as a dummy variable F_i equal to 1 when the share of foreign equity in the total capital of a domestic firm exceeds 10%, and 0 otherwise. Note that we are using the Amadeus database over a range of years, which allows us to detect any changes in ownership that occurred between two consecutive years. This allows the foreign ownership variable to change over time. Table 1 reveals that although the share of foreign firms in the total number of firms in the sample varies between 4% (Bulgaria) and 10% (Poland), their contribution to the value added of the sample firms varies between 7% (Bulgaria) and 29% (Poland). This shows that foreign owned firms are larger than domestic owned firms, indicating possible selection problems, which we will deal with in the next subsection.

Labor data enter our estimations as the number of employees, which is calculated from effective hours worked, while data on value added and capital are taken in local currencies. Capital data were deflated using GDP deflators, while data on sales were deflated using NACE 2-digit producer price indices for each country.⁶

Data on input-output accounts come from local statistical offices. These data, conducted at the NACE 2-digit level, refer mainly to individual years between 2000 and 2003. Unfortunately, these input-output tables are not available at a more disaggregated level, and are not available for all years in our sample. This, of course, may substantially limit our potential to discover possible vertical spillovers, since these

⁵ We had to omit from our sample countries like Hungary and Slovakia, which are extremely poorly represented in the Amadeus database.

⁶ GDP deflators and PPI data for individual countries is taken from the Eurostat, with the exception of Croatia and Ukraine, for which the data sources are national statistical offices.

normally take place at a lower level of disaggregation. We are also forced to exclude dynamic changes in the structure of the studied economies. As a way of overcoming these limitations, we have applied the NACE 2-digit input-output coefficients to the NACE 3-digit sectors when calculating the vertical spillovers. We report summary results with both levels of spillover aggregation, while more detailed results are reported only for NACE 2-digit level.⁷

4.2. Correction for selection bias

The usual problem with empirical studies on the firm level effects of FDI is an inherent selection bias. This is due to the fact that foreign investment decisions are not randomly distributed, but instead are likely subject to firms' characteristics and their initial performances. Many studies report that foreign investors tend to acquire shares in the largest and most successful domestic firms (Hoekman and Djankov, 2000; Damijan et al, 2003b). Hence, treating foreign and domestic firms as homogenous units of observation will likely produce biased results due to the possible endogeneity of foreign investment decisions. We deal with this problem using the two-step method proposed by Heckman (1979).

In the Heckman procedure, the bias that results from using non-randomly selected samples is dealt with as an ordinary specification bias arising due to the omitted variables problem. Heckman proposes to use estimated values of the omitted variables (which give rise to the specification error when omitted from the model) as regressors in the basic model. Hence, in the first step, we account for the probability p_i [0, 1] that a firm's selection for FDI is conditional on its initial structural characteristics before the takeover. We estimate the following probit model:

$$(9) \quad \Pr(p_{it_0} = 1 | \mathbf{X}_{i,jt_0}) = S(\mathbf{X}_{it_0} \neq \mathbf{X}_{jt_0}),$$

where i and j ($i=1, \dots, n$, $j=1, \dots, m$) indicate individual foreign and domestic firms, respectively. The error terms are assumed to be IID and normally distributed, thus $S(\cdot)$ is a cumulative distribution function of the standard normal distribution. \mathbf{X}_{i,jt_0} is a matrix of firms' structural characteristics in the initial year, including firm size, capital intensity, labor productivity and industry characteristics such as the size of the industry and foreign penetration to the industry.⁸ We estimate the probit model using the data for the initial period (i.e., the first year a firm has entered our sample). As already noted above, the foreign ownership variable is also time variant since we are able to track changes in ownership throughout the whole period. In order to avoid autocorrelation, the first year's observations are then excluded from the estimations of our main empirical model (see model (11) below).

Based on these probit results, the so-called inverse Mill's ratios (λ_i) for all observations are calculated (for non-zero as well as zero observations regarding foreign investment choices). A vector of λ_i (lambdas) is then included in our second step

⁷ Detailed results for NACE 3-digit level are available upon request from the authors.

⁸ Foreign penetration of the industry is measured as the share of the total value added of the industry accounted for by foreign affiliates. The industry is defined at the NACE 2-digit level.

estimations as an additional independent variable, which controls for the unobserved impact of foreign investment decisions.

4.3 Econometric approach

To analyze the impact of different channels of technology transfer on a firm's TFP, we estimate a growth model (2) augmented by a firm's technology structure (3). Present applications of estimating production functions have revealed significant problems of potential correlation between input levels and the unobserved firm-specific shocks. The idea is that firms that experience a large positive productivity shock may respond by using more inputs, which violates the OLS assumption of strict exogeneity of inputs and the error term. Another source of simultaneity between inputs and output in the production function approach is the selection issue. Olley and Pakes (1996) demonstrate that firm decisions are made, at least to some extent, on their perceptions of future productivity, which in turn are partially determined by the realizations of their current productivity. Considering only those firms that survived over the entire period, this would imply that a sample is being selected, in part, on the basis of the unobserved productivity realizations. This generates a selection bias in both the estimates of the production function parameters and in the subsequent analysis of productivity. Therefore, the authors present an alternative solution that serves to deal with both the simultaneity and self-selection issues at the same time.

In this paper we use a three step Olley - Pakes (OP) approach to deal with this simultaneity problem.⁹ These three steps produce consistent and unbiased estimates of coefficients of capital ($\bar{\alpha}$) and labor ($\bar{\beta}$), which are then used to obtain unbiased estimates of total factor productivity (TFP) as a residual in the consistently estimated production function (1):

$$(10) \quad \overline{TFP}_{it} = y_{it} - \bar{\alpha}K_{it} - \bar{\beta}L_{it} .$$

Note that as a dependent variable in our empirical model, the estimates of TFP from (10) will be used in place of the value added measures. The specification of the empirical model now differs slightly from (2), since capital and labor are no longer included in the estimation. Hence, our empirical model (2) subject to (3) and with both the Heckman and Olley-Pakes corrections can now be written as:

$$(11) \quad tfp_{itk} = \delta F_{ikt} + \gamma w_{ikt} + \phi hs_{kt} + \phi hs_{kt} * w_{ikt} + \eta vs_{kt} + \kappa vs_{kt} * w_{ikt} + \omega es_{kt} + \omega es_{kt} * w_{ikt} + \nu \lambda_{ikt} + \tau + \sigma R + \varepsilon_{ikt} ,$$

where tfp is the logarithmic growth rate of \overline{TFP} . F_{ikt} is a dummy for foreign ownership, w_{ikt} denotes the stock of human capital in the firm (proxied by the average wage bill), hs_{ikt} and vs_{ikt} stand for horizontal and vertical spillovers from FDI at the sectoral level, while es_{ikt} denotes the impact of sector economies of scale (proxied by the sector size). We include interaction terms of the spillover variables with the human capital variable (w_{ikt}) in order to control for the impact of firm absorption capacity on firm ability to reap the benefits of spillover effects from both the foreign and domestic firms in the sector. The variable λ_{ikt} is the inverse Mill's ratio from the Heckman correction for

⁹ For the whole OP procedure please consult Olley and Pakes (1996).

sample selection. Variables T and R denote the year and regional dummies, and ε_{ikt} is the remaining error term.

Note that we measure spillovers (horizontal and vertical spillovers from FDI as well as the general sector spillovers) both at the NACE 2-digit (21 sectors) and NACE 3-digit (129 sectors) levels in order to check for the robustness of the results on spillovers to the aggregation of the industries. Regarding the vertical spillovers from FDI, this is not an entirely correct procedure, as the input-output coefficients for the countries in this sample can only be obtained at the NACE 2-digit level. Thus, we are forced here to apply the common NACE 2-digit technical coefficients to all NACE 3-digit subsectors within the 2-digit sectors, indicating that the major additional variation in the 3-digit vertical spillover variable is stemming from the NACE 3-digit relative to the NACE 2-digit horizontal spillovers.

The model (11) is estimated by OLS. Note that firm specific effects are wiped out as we estimate the model with the dependent variable defined in first differences. We also include year dummies to control for common external policy shocks and regional dummies for region specific shocks. Regions are defined at the NUTS 3-digit level. The estimations are performed and reported for each country separately. In order to grasp the variation in these data sets as much as possible, we run the estimations for different sub samples of data for each country. We first estimate the model on the whole sample of firms, and then proceed with separate estimations for each size class (micro, small, medium and large)¹⁰, for each quintile of productivity across sectors (Q1 through Q5) and lastly for each class of technology gap between domestic and foreign owned firms (Gap1 through Gap3). We expect higher FDI spillovers in the case of larger, more productive and technologically more advanced firms.

The measure of the technology gap is defined as the ratio of average productivity of domestic firms to the average productivity of foreign owned firms within each sector (NACE 2- or 3-digit). This continuous gap variable is then sliced into three gap dummies. Gap1, Gap2 and Gap3 refer to domestic firms with a productivity level below 80%, between 80 and 120% and more than 120% of the average productivity of foreign owned firms within each sector, respectively. Gap1 thus denotes that domestic firms are lagging behind the multinational firms in the sector in terms of technology, while Gap3 indicates that domestic firms have a technology advantage over foreign owned firms in the sector. In contrast, Gap2 indicates that domestic and foreign firms are at roughly similar technology levels. Of course, these measures of technology gap refer to the overall absorptive capacity of the sectors, implying that in sectors with a lower technology gap, there is a greater potential for positive spillovers from FDI. The actual “utilization” of this potential, however, depends on an individual firm’s productivity level (indicated by firm classification into specific quintiles of productivity) and individual absorption capacity (indicated by its human capital stock).

Note that we maintain balanced classes of firms according to all three criteria (size, productivity, technology gap) by referring to the mean number of employees and mean productivity levels over the whole period the firm is present in the data set.

¹⁰ Micro firms (< 10 empl.), small firms (10 ≤ empl. < 50), medium firms (50 ≤ empl. < 250), and large firms (250 ≤ empl.).

5. Results

This section first presents estimation results on direct effects as well as on horizontal and vertical spillovers from FDI. In addition to explicit control for individual firms' productivity levels and absorption capacity, we also provide several robustness checks, including a matching technique when accounting for direct effects, and different aggregation of sectors when accounting for horizontal and vertical spillovers from FDI. Note that we estimate the fully specified empirical model (11), while due to the table dimensions, the results are presented separately for direct effects, horizontal effects and vertical effects from FDI.¹¹

5.1 Direct effects from FDI

5.1.1 Basic results

We attribute direct effects of FDI to the impact of foreign ownership on foreign affiliate TFP growth, as foreign ownership is believed to enhance firm performance through direct technology transfers. Table 2 reports the coefficients for F_{ikt} from the regression model (11). By including time and region dummies, the results show that on average, foreign owned firms grew faster in terms of TFP from 1995-2005 in only three out of the ten countries under examination (Czech Republic, Latvia and Slovenia). For other countries, the growth rate of affiliates was also higher than that of domestic firms, but not significantly.¹² The average productivity growth premia of foreign affiliates in this period ranges between 6.6% in Slovenia, 7.2% in Latvia and 9% in the Czech Republic. As demonstrated in Table 2, the results are in general robust to the inclusion of dummies, with exceptions for Romania (the coefficient for direct effects changed from significant to insignificant when region dummies were included) and Latvia (the coefficient for direct effects changed from insignificant to significant when time and region dummies were included).

[Insert Table 2]

We analyze these direct effects further by taking various sources of firm heterogeneity into account. We can see that the productivity growth differential of foreign affiliates relative to domestic firms is driven by small foreign affiliates in the Czech Republic, by micro and large affiliates in Latvia and by medium sized foreign affiliates in Slovenia, as well as by affiliates of medium (Q3 quintile in the Czech Republic) or high productivity (Q4 quintile in Latvia and Q4 and Q5 quintiles in Slovenia). In terms of absorptive capacity, we find significantly higher TFP growth of foreign affiliates with the highest positive technology gap relative to domestic firms (Gap1) in the Czech Republic and affiliates at a roughly similar technology level to domestic firms (Gap2) in Slovenia.

We can also observe significantly higher productivity growth for certain categories of foreign affiliates in Bulgaria and Romania. In Bulgaria, we find significantly higher TFP growth of micro sized and the least productive foreign affiliates (Q1), while in Romania it is the largest and the most productive foreign affiliates (Q5) that show

¹¹ Regression results are suppressed due to space limitations but are available upon request from the authors..

¹² Note that the direct effect of FDI is not negative in any country examined.

significantly higher TFP growth. In Croatia, Estonia, Lithuania and Ukraine, no significant effects are noted for any category of foreign affiliates. In Poland, we notice even significantly lower productivity growth of high productive foreign affiliates (Q4) and of affiliates at approximately the same technology level as domestic firms (Gap2).

5.1.2 Robustness check using the matching approach

Although the results on direct effects from FDI presented in the previous section do control for many aspects of firm heterogeneity there is still a lot of firm heterogeneity that is not controlled for. This section applies an additional robustness check to the above results using the matching and the average treatment effect techniques.

In order to determine the actual effect of foreign ownership on firm productivity growth, the effect of foreign ownership on firm performance has to be estimated by comparing otherwise similar firms. One way of doing this is to employ matching techniques to construct something akin to a controlled experiment. We use firm propensity to become foreign owned to match foreign owned firms with otherwise similar non-foreign owned firms in order to evaluate the effect of foreign ownership on productivity growth. Firms' probability of becoming foreign owned is estimated by estimating the following probit regression:

$$(12) \quad \Pr(F_{ikt-1} = 1) = \alpha + \beta_1 L_{ikt-1} + \beta_2 (K/L)_{ikt-1} + \beta_3 (VA/L)_{ikt-1} + \delta Sector_k + \varepsilon_{ikt-1},$$

where $t-1$ indicates the year before the firm's switch in ownership from domestic to foreign. The probability of a firm becoming foreign owned is determined by the firm's past size (in terms of employment L_{ikt-1}), capital intensity $(K/L)_{ikt-1}$, productivity $(VA/L)_{ikt-1}$ and sector (NACE 3-digit) fixed effects.

Conditional on satisfying the balancing property of the propensity score, the fitted values obtained from estimating the above probit equation are used to pair foreign owned firms with domestically owned firms, and those matched pairs are subsequently used to estimate the average treatment effect of foreign ownership on subsequent firm productivity growth. The more closely the firms are matched with respect to regressors in (12), the more likely it is that the observed differences in productivity trajectories between foreign owned and domestically owned firms result purely from the fact that some firms have switched status from domestic to foreign ownership. We match foreign owned firms with their domestic owned counterparts using nearest neighbor matching (with random draws), which pairs the treated with the closest non-treated observations with respect to the propensity score. Given that the sample size is very small in some instances, all the reported standard errors were generated by bootstrapping with 100 repetitions.

[Insert Table 3]

Table 3 reports the average treatment effect (ATT) of foreign ownership on subsequent firm TFP growth. We report these results by referring to the technical time (t) after the change in ownership and by accounting for the cumulative change in TFP after the change in ownership. Results up to five years after the change in ownership are reported. Hence, results for the periods $t+1$ through $t+5$ indicate the differences in the accumulated change in the TFP levels between foreign (treated) and domestic owned

(non-treated) firms over one to five years after the firms have switched their status from domestic to foreign ownership.¹³

The results are consistent with the findings in the previous section. When comparing the cohorts of fairly similar foreign and domestic owned firms over time, we find that foreign owned firms persistently outperform domestic firms in terms of TFP growth only in the Czech Republic and Slovenia. In both countries, firms are shown to make permanent productivity improvements after the ownership change, from the first to the last period under examination. In Estonia, Latvia and Poland, these productivity gains are only observed in the first year after the change in ownership, and seem to dissipate afterwards (in Latvia and Poland the TFP premia arise again in the fourth and fifth year, respectively). In Croatia and Romania, benefits of foreign ownership become significant in the second, third and fourth year after the switch in ownership, respectively, but dissipate afterwards. On the other hand, in Bulgaria, productivity improvements from foreign ownership become visible in the fourth year after the ownership change and seem to become permanent. In Ukraine a switch to foreign ownership seems to have a negative impact on firm cumulative TFP performance. These effects, however, are quite divergent over the period, indicating the possibility of significant turbulence in the economic environment in this country.¹⁴

These results confirm that direct productivity improvements from foreign ownership are far from being general, but are subject to foreign affiliate heterogeneity. The productivity gains widely differ, not only across size and productivity classes, but also with regard to the time period after the ownership change. This indicates a huge variation of direct productivity gains from foreign ownership, which can be attributed both to the firms' inherent heterogeneity as well as to quite differential *treatment effects* of foreign ownership when controlling for the exact firm heterogeneity.

5.2 Horizontal spillovers from FDI

Results in Table 4¹⁵ demonstrate that without any control for firm heterogeneity none of the ten countries under examination show positive and significant horizontal spillovers from foreign affiliates. Moreover, in four out of ten countries (Estonia, Romania, Slovenia and Ukraine), significant negative horizontal spillovers are found. These results, however, are reverted when controlling for the absorptive capacity of firms. We find positive horizontal spillovers in six out of ten countries (Czech Republic, Croatia, Estonia, Romania, Slovenia and Ukraine) once we control for individual firms' wage levels as proxies for the levels of human capital. Negative horizontal spillovers are found in one country (Bulgaria) only.¹⁶ On the other hand, after controlling for absorptive capacity, negative horizontal spillovers are not found in any of the countries.

¹³ Note that we keep the samples of treated and non-treated firms for each country constant, allowing us to track the comparative changes in TFP for the same cohorts of firms.

¹⁴ Due to small sample sizes after the exact matching of foreign and domestic owned firms, we do not provide additional results for subsamples of firms with regard to the size and productivity dimensions.

¹⁵ Note that these results include year and region dummies. Due to space limitations, we only present here the coefficients from model (11) related to horizontal spillovers.

¹⁶ These results are quite robust to the level of sectoral aggregation, as at the NACE 3-digit level, positive overall horizontal spillovers are confirmed in seven countries (Czech Republic, Croatia, Estonia, Romania, Slovenia, Ukraine and Poland) after controlling for absorptive capacity.

[Insert Table 4]

There are only three countries (Croatia, Romania and Slovenia) where horizontal spillovers seem to accrue in a non-discriminatory way regardless of firm size. In all three countries, positive horizontal spillover effects tend to increase with firm size. The results in other countries vary considerably.

A similar pattern appears for productivity and technology gap heterogeneity. In Croatia, Romania and Slovenia, horizontal spillovers seem to accrue in a non-discriminatory way to all firms regardless of their productivity levels, while in other countries, positive horizontal spillovers tend to accrue in medium and/or high productivity quintiles. Horizontal spillovers in Slovenia appear in firms at all technology levels, while the situation varies broadly for other countries. Still, the results show that the lower the technological gap, the more positive the horizontal spillovers. Horizontal spillovers seem to be less frequent for foreign affiliates than for domestic firms, which may indicate that foreign affiliates are not fully integrated into the local environment but may depend more on direct links with their parent companies.¹⁷

The main message of the analysis so far is that horizontal spillovers are substantially dependent on the absorptive capacity of individual firms. Harsh competitive pressures within sectors brought about by the enlarged presence of foreign affiliates can have severe negative effects on firms, which are not ready for competition. Only firms with significantly high absorptive capacity can accommodate the competition and enjoy positive learning effects from the competitive pressures.

5.3 Vertical spillovers from FDI

This section estimates the impact of vertical spillovers of foreign affiliates on domestic firms. We focus on backward linkages only, as our preliminary results and other empirical studies (Smarzynska-Javorcik, 2004; Gorodnichenko et al, 2007; Halpern and Murakozy, 2007) demonstrate that forward linkages are rather low or insignificant in transition countries.

[Insert Table 5]

Unlike the horizontal spillovers, vertical spillovers seem to have more heterogeneous effects.¹⁸ Abstracting from the absorption capacity and heterogeneity of firms, there are only two countries (Slovenia and Ukraine) that show positive vertical spillovers from FDI at the NACE 2-digit sector level, while there are four countries (Bulgaria, the Czech Republic, Poland and Romania) that demonstrate significant negative vertical spillover effects (see Table 5). These results change slightly when allowing for the absorptive capacity of firms. In Bulgaria, the Czech Republic and Poland, firms with higher absorption capacity (human capital) are shown to be able to reap positive spillovers from their upstream linkages with foreign firms. Using NACE 3-digit sectors, negative backward spillovers are further reduced to only two countries (Lithuania and Romania), while the number of countries with positive backward spillovers increases to

¹⁷ These results are quite robust to sectoral aggregation, as most of the results obtained by NACE 2-digit sectors are also replicated, both in terms of size as well as the significance of coefficients, when estimating the model with the NACE 3-digit sectors.

¹⁸ Note that we report the results of estimating model (11) including year and region dummies.

four. In Croatia and Ukraine, these backward spillovers are generally accruable to all domestic firms, while in the Czech Republic and Romania, they are limited to firms with sufficient absorptive capacity. Interestingly, we find evidence of positive backward spillovers between foreign affiliates only in Poland and Slovenia, while in Romania, foreign affiliates seem to be affected negatively by other upstream foreign firms. These results are consistent for both levels of sector aggregation.

Allowing for further heterogeneity of firms, there are hardly any patterns, which hold across countries. Positive vertical spillovers appear in all size classes of firms, but most frequently in small and medium sized firms, at all productivity levels and at all technology gaps. We further report on the results using NACE 2-digit sectors and by controlling for the absorption capacity of firms. In Bulgaria, positive vertical spillovers accrue to small and medium sized firms, and firms with the highest productivity (Q5) and technology levels (Gap3). In the Czech Republic, positive backward spillovers are limited to the least (Q1) and the most productive (Q5) firms and to all technology gap classes. In Croatia, positive spillovers are present for medium sized firms and for firms with the lowest productivity levels (Q1), as well as for firms with higher technology levels (Gap3). In Poland, positive backward spillovers are accruable to medium sized firms and firms with lower to medium productivity levels (Q1 through Q4) and lower technology levels (Gap1). In Romania, mainly small domestic firms with higher absorptive capacity and lower technology level (Gap1) benefit from upstream foreign affiliates. In Slovenia, it is also the firms with the lowest productivity levels, which benefit from upstream foreign affiliates.

5.4 Summary of results

In order to summarize our empirical findings on the direct and spillover effects of FDI, we have constructed a table presenting the number of countries with significant coefficients. This illuminates the pattern of results across firms' characteristics and countries. Indeed, Table 6 demonstrates several interesting facts. First, direct effects of foreign ownership on firm performance are only present in three out of the ten transition countries considered here, but when present, they are strictly positive. Second, horizontal spillovers are mostly negative when not controlling for the absorptive capacity of firms. When accounting for firms' absorptive capacity, in most (six to seven out of ten) countries, firms benefit from the increased competition of foreign affiliates in the same sectors. Third, positive horizontal spillovers are equally distributed across size classes of firms, while negative horizontal spillovers seem to be more likely to accrue to smaller firms. Fourth, positive horizontal spillovers seem more likely to be present in medium or high productivity firms with higher absorptive capacities, while negative horizontal spillovers are more likely to affect low to medium productivity firms. Fifth, vertical spillovers are less frequent than horizontal spillovers from FDI. However, if present, smaller and more productive firms are more likely to benefit from positive vertical spillovers, while larger and less productive firms are more likely to suffer from negative vertical spillovers.

[Insert Table 6]

These findings suggest that spillovers from foreign firms substantially depend on the absorptive capacity and productivity level of individual firms. Only more productive firms and firms with higher absorptive capacity are able to both compete with foreign

affiliates in the same sector and benefit from the increased downstream demand for intermediates created by foreign affiliates. Foreign presence may also affect smaller firms to a larger extent than larger firms, but this impact may be in either direction.

6. Conclusions

This paper provides a comparative study of the importance of direct technology transfer and spillovers through FDI on a set of ten transition countries, using a common methodology and taking into account various sources of firm heterogeneity. Firm level panel data were gathered for ten transition economies for 1995-2005. This exhaustive dataset comprises some 90,000 manufacturing firms with up to 11 annual observations, yielding some 315,000 annual firm observations. This study differentiates between the direct effects of FDI from the parent firm to local affiliates as well as between horizontal and vertical spillovers from foreign affiliates to domestically owned local firms. The importance of these different channels of technology transfer via FDI for firm performance is estimated in the framework of a growth-accounting approach with control for selection and simultaneity problem.

The main novelty of this paper is the explicit control for firm heterogeneity when accounting for different effects of FDI on firm performance. This results in some contrasting results to the previous empirical work in the field. We find that horizontal spillovers have become increasingly important over the last decade and might become even more important than vertical spillovers. Furthermore, these results show that the heterogeneity of firms, in terms of absorptive capacity, size, productivity and technology level, significantly affects the results. These findings suggest that both direct effects from foreign ownership as well as the spillovers from foreign firms do substantially depend on the absorptive capacity and productivity level of individual firms.

Another interesting result is the finding that both horizontal and vertical spillovers from FDI seem to be less frequent for foreign affiliates than for domestic firms. We argue that this may indicate that foreign affiliates are not fully integrated into the local environment and may depend more on direct links with their parent companies. Our data, however, do not allow us to study this interesting feature in more depth. Such a study would require a detailed survey of the demand-supply links of both domestic firms and foreign affiliates.

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Tables to be included into text

Table 1: Basic characteristics of the dataset

country		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	#Firms	#Effective obs.
BG	N(for)	31	94	48	59	284	325	387	151	148	100	76	9,549	24,809
	N(dom)	1,301	2,958	1,483	1,482	7,025	8,032	9,162	3,252	3,156	2,624	2,019		
	N(f)/N(d)	0.024	0.032	0.032	0.040	0.040	0.040	0.042	0.046	0.047	0.038	0.038		
	VA(f)/VA(d)	0.015	0.022	0.036	0.042	0.045	0.047	0.053	0.054	0.063	0.050	0.072		
CZ	N(for)	87	95	100	140	161	200	217	239	244	238	137	8,496	19,940
	N(dom)	933	996	1,052	1,543	1,877	2,374	3,022	5,074	7,075	8,258	3,367		
	N(f)/N(d)	0.093	0.095	0.095	0.091	0.086	0.084	0.072	0.047	0.034	0.029	0.041		
	VA(f)/VA(d)	0.171	0.183	0.188	0.201	0.239	0.248	0.244	0.236	0.211	0.219	0.223		
EE	N(for)			71	89	110	133	139	156	145	153	148	4,145	13,935
	N(dom)			1,086	1,433	2,753	3,100	3,109	3,519	3,833	3,992	2,484		
	N(f)/N(d)			0.065	0.062	0.040	0.043	0.045	0.044	0.038	0.038	0.060		
	VA(f)/VA(d)			0.190	0.211	0.200	0.197	0.192	0.198	0.177	0.197	0.190		
HR	N(for)	0	8	15	59	64	78	80	84	88	91	95	3,179	18,817
	N(dom)	3	112	246	2,711	2,856	2,934	2,989	3,004	3,102	3,088	3,004		
	N(f)/N(d)	0.000	0.071	0.061	0.022	0.022	0.027	0.027	0.028	0.028	0.029	0.032		
	VA(f)/VA(d)	0.000	0.127	0.092	0.067	0.072	0.088	0.094	0.095	0.105	0.114	0.118		
LT	N(for)		3	5	7	8	16	15	36	49	48	23	1,567	4,080
	N(dom)		112	192	226	293	350	398	984	1,518	1,278	661		
	N(f)/N(d)		0.027	0.026	0.031	0.027	0.046	0.038	0.037	0.032	0.038	0.035		
	VA(f)/VA(d)		0.066	0.051	0.054	0.050	0.055	0.055	0.080	0.074	0.075	0.076		
LV	N(for)	0	6	13	21	24	28	37	43	47	49	25	723	3,176
	N(dom)	20	137	219	283	314	350	454	552	676	641	374		
	N(f)/N(d)	0.000	0.044	0.059	0.074	0.076	0.080	0.081	0.078	0.070	0.076	0.067		
	VA(f)/VA(d)	0.000	0.077	0.062	0.087	0.095	0.103	0.115	0.106	0.120	0.123	0.156		
PL	N(for)	97	442	497	601	688	701	770	868	809	576	144	6,074	12,059
	N(dom)	478	2,265	2,386	3,129	3,966	4,197	4,780	5,311	5,629	5,498	1,470		
	N(f)/N(d)	0.203	0.195	0.208	0.192	0.173	0.167	0.161	0.163	0.144	0.105	0.098		
	VA(f)/VA(d)	0.269	0.297	0.289	0.303	0.320	0.331	0.316	0.314	0.315	0.267	0.288		
RO	N(for)	131	926	1,094	1,368	1,667	2,070	2,318	2,542	3,170	3,696	3,554	48,495	171,270
	N(dom)	1,920	16,053	18,272	20,378	22,273	24,965	25,637	27,207	34,578	42,103	44,941		
	N(f)/N(d)	0.068	0.058	0.060	0.067	0.075	0.083	0.090	0.093	0.092	0.088	0.079		
	VA(f)/VA(d)	0.128	0.094	0.099	0.124	0.138	0.152	0.171	0.188	0.205	0.205	0.211		
SI	N(for)	121	200	217	230	239	252	268	264	285			3,829	27,908
	N(dom)	2,756	2,964	3,090	3,311	3,464	3,536	3,406	3,539	3,544				
	N(f)/N(d)	0.044	0.067	0.070	0.069	0.069	0.071	0.079	0.075	0.080				
	VA(f)/VA(d)	0.060	0.097	0.128	0.134	0.170	0.196	0.214	0.224	0.236				
UA	N(for)				0	10	17	44	50	53	55	56	5,446	18,750
	N(dom)				1	1,131	2,920	5,158	5,275	5,393	5,198	5,010		
	N(f)/N(d)				0.000	0.009	0.006	0.009	0.009	0.010	0.011	0.011		
	VA(f)/VA(d)				0.000	0.015	0.015	0.013	0.016	0.018	0.018	0.020		
Total													91,503	314,744

Notes: N(for) and N(dom) is number of foreign and domestic owned firms in the dataset, respectively. N(f)/N(d) and VA(f)/VA(d) are shares of foreign firms in the total number of firms and in the total value added of the whole sample of firms.

BG = Bulgaria, CZ = Czech Republic, EE = Estonia, HR = Croatia, LT = Lithuania, LV = Latvia, PL = Poland, RO = Romania, SI = Slovenia, UA = Ukraine.

Source: Amadeus database (Bureau van Dijk), except for Slovenia (SORS).

**Table 2: Direct effects from FDI – Impact of foreign ownership on firm TFP growth
[OLS on first differenced log TFP]**

	No dum.	Year dum.	Year & Region dum.	Firms by size classes				Firms by quintiles of productivity					Gap of domestic vs. foreign firms in productivity			No. obs.
				Micro	Small	Medium	Large	Q1	Q2	Q3	Q4	Q5	Gap1	Gap2	Gap3	
BG	0,067 [1.26]	0,046 [0.86]	0,046 [0.87]	0,231 [1.83]*	0,062 [0.70]	-0,094 [0.87]	-0,041 [0.23]	0,399 [1.66]*	0,013 [0.09]	0,041 [0.40]	0,083 [0.82]	0,011 [0.09]	0,077 [0.65]	-0,058 [0.45]	0,056 [0.71]	24.809
CZ	0,090 [2.73]***	0,089 [2.72]***	0,090 [2.74]***	0,171 [1.39]	0,137 [2.72]***	0,037 [0.84]		0,002 [0.02]	0,076 [1.10]	0,139 [2.09]**	0,047 [0.70]	0,04 [0.55]	0,111 [2.32]**	0,108 [1.42]	0,03 [0.45]	19.940
HR	0,049 [1.15]	0,051 [1.18]	0,055 [1.28]	-0,022 [0.23]	0,066 [0.83]	0,02 [0.27]	0,111 [0.80]	-0,021 [0.18]	0,091 [0.96]	0,033 [0.17]	0,005 [0.05]	0,09 [0.93]	0,046 [0.53]	0,019 [0.26]	0,009 [0.09]	13.935
EE	0,082 [1.18]	0,081 [1.18]	0,083 [1.19]	0,228 [0.98]	0,085 [0.88]	-0,087 [0.94]	0,027 [0.08]	-0,414 [0.99]	0,439 [1.37]	-0,026 [0.16]	0,104 [0.70]	0,075 [0.76]	0,062 [0.76]	-0,003 [0.01]	0,252 [1.20]	18.817
LT	0,009 [0.13]	0,004 [0.05]	0,004 [0.05]	0,44 [0.45]	0,042 [0.22]	0,078 [0.89]	0,063 [0.46]	-0,055 [0.05]	-0,173 [0.17]	0,048 [0.18]	0,262 [1.34]	-0,095 [0.71]	-0,035 [0.38]	-0,309 [0.35]	0,166 [0.86]	4.080
LV	0,067 [1.50]	0,071 [1.60]*	0,072 [1.61]*	0,072 [1.61]*	-0,147 [0.16]	-0,122 [0.93]	0,094 [1.65]*	-0,043 [0.33]	-0,022 [0.17]	-0,033 [0.22]	0,327 [1.82]*	0,025 [0.16]	0,048 [0.62]	0,096 [1.37]	0,029 [0.11]	3.176
PL	-0,015 [0.38]	-0,005 [0.14]	-0,009 [0.25]	-0,072 [0.20]	-0,002 [0.02]	-0,019 [0.33]	-0,015 [0.27]	0,146 [1.31]	0,02 [0.20]	0,017 [0.22]	-0,163 [2.09]**	0,051 [0.66]	-0,008 [0.14]	-0,169 [1.93]*	0,088 [1.04]	12.059
RO	0,033 [1.95]*	0,025 [1.58]*	0,024 [1.51]	-0,009 [0.29]	0,018 [0.75]	0,025 [0.77]	0,093 [1.84]*	0,04 [0.55]	0,03 [0.69]	0,017 [0.47]	-0,004 [0.14]	0,044 [1.65]*	0,033 [1.53]	0,002 [0.08]	0,07 [1.19]	171.270
SI	0,068 [2.16]**	0,066 [2.12]**	0,066 [2.12]**	0,064 [0.84]	0,057 [1.18]	0,113 [2.44]**	0,068 [1.13]	-0,037 [0.31]	0,101 [1.43]	0,039 [0.57]	0,106 [1.67]*	0,088 [1.68]*	0,053 [1.02]	0,073 [1.59]*	0,035 [0.29]	27.908
UA	0,061 [0.46]	0,06 [0.45]	0,06 [0.45]	0,704 [0.58]	0,134 [0.43]	0,027 [0.11]	0,003 [0.01]	-0,545 [0.12]	0,017 [0.03]	0,003 [0.01]	-0,029 [0.08]	0,158 [0.72]	0,11 [0.45]	0,141 [0.31]	-0,034 [0.18]	18.750
sig	3	4	3	2	1	3	1	2	0	2	2	2	2	2	0	314.744

Notes: Results from the full specification of the model (11). t-statistics in brackets. ***, ** and * indicate significance at 1, 5 and 10 per cent, respectively.

BG = Bulgaria, CZ = Czech Republic, EE = Estonia, HR = Croatia, LT = Lithuania, LV = Latvia, PL = Poland, RO = Romania, SI = Slovenia, UA = Ukraine.

**Table 3: Direct effects from FDI – Impact of foreign ownership on firm TFP growth
[ATT effects with nearest neighbor matching]**

year after the change in ownership		<i>t+1</i>	<i>t+2</i>	<i>t+3</i>	<i>t+4</i>	<i>t+5</i>	No. obs. Treated/non-treated
BG	ATT	-0.008	-0.028	0.118	0.272	0.424	248/38
	<i>t</i>	<i>-0.07</i>	<i>-0.24</i>	<i>0.88</i>	<i>1.55*</i>	<i>1.81*</i>	
CZ	ATT	0.205	0.287	0.270	0.373	0.453	267/77
	<i>t</i>	<i>2.79***</i>	<i>3.40***</i>	<i>2.84***</i>	<i>3.37***</i>	<i>3.33***</i>	
EE	ATT	0.181	0.197	0.108	0.082	-0.104	134/54
	<i>t</i>	<i>1.59*</i>	<i>1.49</i>	<i>0.78</i>	<i>0.52</i>	<i>-0.59</i>	
HR	ATT	0.041	0.108	0.185	0.044	0.113	77/55
	<i>t</i>	<i>0.45</i>	<i>1.75*</i>	<i>2.86***</i>	<i>0.60</i>	<i>1.27</i>	
LT	ATT	0.053	0.082	0.049	-0.034	-0.026	193/13
	<i>t</i>	<i>0.62</i>	<i>1.43</i>	<i>0.96</i>	<i>-0.52</i>	<i>-0.32</i>	
LV	ATT	0.147	0.064	-0.015	0.059	0.223	283/73
	<i>t</i>	<i>2.44**</i>	<i>1.27</i>	<i>-0.32</i>	<i>1.13</i>	<i>4.25***</i>	
PL	ATT	0.121	0.028	0.050	0.272	0.222	391/70
	<i>t</i>	<i>1.56*</i>	<i>0.28</i>	<i>0.38</i>	<i>1.57*</i>	<i>0.96</i>	
RO	ATT	-0.009	-0.017	-0.052	0.332	0.016	1951/944
	<i>t</i>	<i>-0.19</i>	<i>-0.43</i>	<i>-1.26</i>	<i>5.76***</i>	<i>0.45</i>	
SI	ATT	0.286	0.440	0.403	0.389	0.489	150/95
	<i>t</i>	<i>3.05***</i>	<i>4.09***</i>	<i>3.72***</i>	<i>3.24***</i>	<i>4.31***</i>	
UA	ATT	0.167	-0.496	0.067	0.028	-0.353	47/11
	<i>t</i>	<i>0.72</i>	<i>-2.52***</i>	<i>0.35</i>	<i>0.10</i>	<i>-1.89*</i>	

Notes: *t*-statistics in italics. ***,** and * indicate significance at 1, 5 and 10 per cent, respectively.

BG = Bulgaria, CZ = Czech Republic, EE = Estonia, HR = Croatia, LT = Lithuania, LV = Latvia, PL = Poland, RO = Romania, SI = Slovenia, UA = Ukraine.

**Table 4: Horizontal spillover effects from FDI with NACE-2 digit sectors
[OLS on first differences after Olley-Pakes]**

		All	Micro	Small	Medium	Large	Q1	Q2	Q3	Q4	Q5	G1	G2	G3
BG	hs	0,012	-0,040	0,019	-0,033	-0,020	-0,047	-0,037	0,015	-0,078	0,036	-0,028	-0,049	0,018
	hsw	-0,021	0,264	0,089	-0,046	0,079	0,321	0,341	0,034	0,520	-0,019	0,351	0,827	-0,050
	hsf	-0,164	0,230	-0,187	-0,150	0,102	-0,118	-0,196	-0,153	-0,007	-0,198	-0,121	0,050	-0,146
	hsfw	0,073	-0,146	0,086	0,148	0,012	-0,182	0,172	0,071	0,036	0,057	0,032	0,067	0,084
CZ	hs	-0,003	-0,012	-0,024	-0,009	0,000	-0,032	-0,048	-0,005	-0,030	0,011	0,001	-0,035	0,010
	hsw	0,007	0,016	0,033	0,020		0,094	0,073	0,007	0,030	0,005	-0,001	0,047	0,003
	hsf	0,310	0,375	0,218	0,547		-0,256	0,472	-0,130	0,672	0,261	0,312	0,110	-0,526
	hsfw	-0,018	-0,025	-0,015	-0,046		0,209	-0,074	0,023	-0,050	-0,023	-0,010	-0,024	0,121
EE	hs	-0,014	-0,023	-0,032	-0,032	-0,035	0,039	-0,025	-0,032	-0,042	-0,014	-0,032	-0,019	-0,002
	hsw	0,035	0,017	0,076	0,076	-0,015	-0,193	0,105	0,085	0,077	0,025	0,076	0,026	0,008
	hsf	-0,006	0,022	0,005	-0,004	0,045	0,071	-0,143	0,522	0,088	-0,059	-0,006	-0,005	0,078
	hsfw	0,003	-0,030	-0,046	0,020	0,025	0,122	0,087	-0,078	-0,123	0,046	-0,019	-0,001	-0,172
HR	hs	-0,075	-0,083	-0,033	-0,050	-0,128	-0,038	-0,035	-0,041	-0,036	0,012	-0,063	0,052	0,233
	hsw	0,023	0,046	0,070	0,000	0,056	0,038	0,097	0,080	0,086	0,015	0,030	0,038	-0,004
	hsf	0,368	0,900	0,189	-0,029	-0,076	-0,073	0,059	0,042	0,043	0,071	-0,063	0,209	0,203
	hsfw	-0,025	0,109	-0,118	-0,017	-0,065	0,463	-0,159	0,086	-0,079	-0,012	-0,002	0,009	-0,047
LT	hs	0,007	0,203	0,043	-0,009	-0,036	-0,024	0,039	-0,010	0,016	0,012	0,100	-0,666	0,070
	hsw													
	hsf	-0,035	-1,597	-0,230	-0,019	0,066	-0,456	0,361	-0,748	0,099	-0,038	-0,080	0,106	-0,309
	hsfw													
LV	hs	0,006	-0,083	0,005	0,012	0,040	0,058	-0,003	0,008	0,003	0,007	0,033	0,000	-0,017
	hsw													
	hsf	-0,023	0,000	-0,042	-0,013	-0,084	-0,157	-0,421	-0,330	-0,030	-0,007	-0,028	-1,047	-0,045
	hsfw													
PL	hs	0,008	-0,941	-0,258	0,199	-0,001	-0,002	0,707	-0,055	0,091	-0,119	0,127	0,052	-0,012
	hsw	0,003	0,007	0,019	-0,020	0,008	0,020	-0,101	-0,004	-0,003	0,005	-0,009	0,006	0,002
	hsf	0,022	0,257	0,079	0,009	0,029	0,059	-0,160	-0,064	-0,034	0,020	-0,011	-0,039	0,099
	hsfw	-0,016	-0,059	-0,036	0,011	-0,041	-0,135	0,323	0,097	0,082	-0,017	-0,001	0,027	-0,087
RO	hs	-0,006	-0,010	-0,010	-0,009	-0,018	-0,032	-0,047	-0,040	-0,025	-0,005	0,001	-0,031	-0,004
	hsw	0,024	0,014	0,027	0,043	0,021	0,180	0,192	0,121	0,081	0,017	0,023	0,032	0,041
	hsf	0,061	0,016	0,051	0,007	0,117	-0,018	0,055	-0,101	-0,003	0,049	-0,038	0,158	0,082
	hsfw	-0,010	0,048	0,010	-0,015	-0,013	-0,008	0,026	0,191	0,059	-0,005	-0,011	-0,011	0,019
SI	hs	-0,023	-0,019	-0,035	-0,022	-0,054	-0,001	-0,050	-0,056	-0,050	-0,029	-0,004	-0,046	-0,074
	hsw	0,015	0,013	0,020	0,017	0,039	0,002	0,033	0,035	0,027	0,015	0,012	0,020	0,020
	hsf	0,042	0,025	0,053	0,019	0,044	-0,124	0,145	-0,016	0,120	0,057	0,021	0,052	0,263
	hsfw	-0,022	-0,027	-0,025	-0,013	-0,031	0,113	-0,094	0,012	-0,068	-0,026	-0,019	-0,024	-0,089
UA	hs	-0,161	-0,187	-0,104	-0,078	-0,205	-0,294	-0,085	-0,182	-0,051	-0,241	-0,206	0,177	-0,119
	hsw	0,116	0,892	0,124	0,113	0,116	0,776	0,135	0,212	0,210	0,076	0,220	0,072	0,115
	hsf	0,297	0,000	-0,173	0,161	0,576	-0,418	0,931	0,975	0,602	-0,133	0,241	-0,109	-0,650
	hsfw	-0,225	0,000	-0,688	-0,691	-0,075	0,126	-0,639	-0,150	-0,947	-0,204	-0,763	0,148	0,406
pos.	D	0	0	0	1	0	0	1	0	0	0	2	0	0
	Dw	6	5	7	3	5	4	4	4	7	5	5	6	2
neg.	D	4	4	4	1	3	4	4	3	5	1	2	3	1
	Dw	1	0	0	2	0	0	1	0	0	1	1	0	1

Notes: Results from the full specification of the model (11). t-statistics are omitted from the results due to space limitations. Shadowed results indicate that the coefficient is significant at 10 per cent at the least. Full results are available from the authors at request.

BG = Bulgaria, CZ = Czech Republic, EE = Estonia, HR = Croatia, LT = Lithuania, LV = Latvia, PL = Poland, RO = Romania, SI = Slovenia, UA = Ukraine.

**Table 5: Vertical spillover effects from FDI with NACE-2 digit sectors
[OLS on first differences after Olley-Pakes]**

		All	Micro	Small	Medium	Large	Q1	Q2	Q3	Q4	Q5	G1	G2	G3
BG	vs	-0,120	0,055	-0,237	-0,273	-0,157	-0,699	-0,221	-0,129	0,041	-0,130	0,058	-0,056	-0,349
BG	vsw	0,058	-0,014	0,103	0,109	0,046	0,509	0,115	0,042	-0,022	0,051	-0,048	-0,190	0,121
BG	vsf	-0,068	-1,652	0,084	-0,298	-0,780	-0,216	0,306	-0,523	0,592	-0,654	-0,734	-0,110	0,255
BG	vsfw	-0,036	0,400	-0,219	0,064	0,116	0,183	-0,090	0,138	-0,156	0,105	0,188	-0,404	-0,147
CZ	vs	-0,025	-0,013	0,005	-0,009		-0,084	0,042	0,006	0,044	-0,054	-0,039	0,046	-0,083
CZ	vsw	0,040	0,032	0,002	0,002		0,215	-0,046	-0,006	-0,039	0,032	0,055	-0,041	0,076
CZ	vsf	-0,040	-0,108	-0,011	-0,070		0,199	0,031	0,016	-0,201	-0,009	-0,005	-0,061	0,166
CZ	vsfw	0,002	0,059	-0,049	0,070		-0,606	-0,196	-0,049	0,162	0,014	-0,024	0,069	-0,363
EE	vs	0,027	0,048	0,063	-0,004	0,036	-0,044	0,069	0,057	0,035	-0,042	0,046	0,077	-0,023
EE	vsw	-0,048	-0,019	-0,149	-0,048	0,098	0,299	-0,215	-0,099	-0,051	0,000	-0,109	-0,077	0,023
EE	vsf	-0,091	-0,151	-0,171	0,124	-0,165	0,164	-0,248	-0,192	-0,297	0,181	-0,060	-0,135	-0,447
EE	vsfw	0,053	0,083	0,181	-0,108	-0,085	-0,297	0,616	0,268	0,314	-0,127	0,063	0,188	0,699
HR	vs	0,025	0,021	0,080	-0,067	0,096	-0,036	0,007	-0,004	0,078	0,063	-0,058	0,056	-0,034
HR	vsw	-0,022	0,030	-0,114	0,140	-0,140	0,243	-0,042	0,074	-0,089	-0,037	0,112	-0,068	0,176
HR	vsf	-0,163	0,198	-0,451	-0,110	-0,413	0,161	-0,396	-0,349	-0,257	-0,128	0,652	-0,205	-0,428
HR	vsfw	0,276	-0,127	0,452	0,124	0,904	-0,853	1,196	0,458	0,503	0,040	-0,201	0,306	1,255
LT	vs	-0,019	-0,969	-0,076	0,034	0,230	-0,087	-0,350	0,243	-0,042	0,118	-0,219	0,546	-0,259
LT	vsw													
LT	vsf	0,229	-4,384	0,421	0,038	-0,483	0,399	-0,525	0,135	-1,178	0,295	0,244	0,266	0,331
LT	vsfw													
LV	vs	-0,003	-0,034	-0,001	-0,019	-0,221	-0,329	0,010	-0,010	0,000	0,052	-0,046	0,000	-0,015
LV	vsw													
LV	vsf	-0,010	0,000	1,153	-0,023	0,312	0,121	0,262	0,208	0,355	-0,047	0,034	0,000	-0,079
LV	vsfw													
PL	vs	-0,031	0,168	-0,001	-0,078	-0,016	-0,031	-0,181	-0,092	-0,107	-0,018	-0,066	-0,038	-0,035
PL	vsw	0,013	0,003	-0,003	0,069	-0,002	0,096	0,237	0,158	0,068	0,002	0,054	0,010	0,004
PL	vsf	-0,009	-0,549	-0,095	0,026	-0,038	-0,171	0,314	0,253	0,112	-0,007	0,082	0,124	-0,142
PL	vsfw	0,031	0,147	0,061	-0,037	0,093	0,301	-0,604	-0,297	-0,091	0,039	-0,019	-0,043	0,135
RO	vs	-0,081	0,014	-0,239	-0,026	0,085	0,239	0,394	0,198	0,034	-0,053	-0,202	0,147	0,146
RO	vsw	0,067	0,029	0,429	-0,319	-0,018	-0,210	-0,187	-0,768	-0,347	0,113	0,364	-0,345	-0,369
RO	vsf	-0,197	-0,435	-0,371	-0,271	-0,371	-0,726	-0,116	-0,315	-0,124	-0,256	-0,067	-0,744	-0,148
RO	vsfw	-0,106	0,182	0,840	0,735	-0,094	0,527	0,505	0,975	-0,780	-0,172	-0,373	0,977	-0,477
SI	vs	0,026	0,019	0,033	0,041	0,054	-0,027	-0,065	0,032	0,031	0,039	0,014	0,045	0,104
SI	vsw	-0,013	-0,013	-0,015	-0,015	-0,028	0,229	0,054	-0,011	-0,013	-0,019	-0,021	-0,017	-0,025
SI	vsf	-0,080	-0,165	-0,008	-0,017	-0,090	0,916	-0,060	0,090	-0,245	-0,165	-0,037	-0,105	-0,348
SI	vsfw	0,046	0,096	0,014	0,028	0,019	-0,659	0,320	-0,061	0,154	0,070	0,054	0,049	0,212
UA	vs	0,100	0,091	0,110	0,059	0,115	-0,013	0,040	0,143	0,078	0,077	0,139	-0,033	0,057
UA	vsw	-0,325	-0,699	-0,336	-0,331	-0,287	-0,529	-0,152	-0,618	-0,072	-0,209	-0,836	0,081	-0,246
UA	vsf	-0,311	0,000	-0,403	-0,789	-0,235	0,443	-2,924	-0,125	-0,121	-0,214	-0,142	-0,281	0,090
UA	vsfw	0,104	0,000	0,304	0,293	-0,001	-0,138	0,196	0,198	0,140	0,111	0,361	0,188	-0,069
pos.	D	2	1	2	0	1	0	1	2	1	1	0	3	0
	Dw	3	0	2	3	0	4	1	1	1	2	3	0	3
neg.	D	4	0	2	3	0	2	2	0	1	0	4	0	1
	Dw	3	0	2	2	2	1	1	1	1	3	2	4	1

Notes: Results from the full specification of the model (11). t-statistics are omitted from the results due to space limitations. Shadowed results indicate that the coefficient is significant at 10 per cent at the least. Full results are available from the authors at request.

BG = Bulgaria, CZ = Czech Republic, EE = Estonia, HR = Croatia, LT = Lithuania, LV = Latvia, PL = Poland, RO = Romania, SI = Slovenia, UA = Ukraine.

**Table 6: Summary of results for domestic firms*
[Number of countries with significant spillovers]**

	All	Micro	Small	Medium	Large	Q1	Q2	Q3	Q4	Q5	G1	G2	G3
Direct effects													
Positive	3	2	1	3	1	2	0	2	2	2	2	2	0
Negative	0	0	0	0	0	0	0	0	0	0	0	0	0
Horizontal spillovers													
Positive spill.													
Nace-2	D	0	0	0	1	0	1	0	0	0	2	0	0
	Dw	6	5	7	3	5	4	4	4	7	5	6	2
Nace-3	D	1	0	0	0	0	1	2	0	1	0	0	1
	Dw	7	6	5	2	5	3	4	4	4	6	4	1
Negative spill.													
Nace-2	D	4	4	4	1	3	4	4	3	5	1	2	3
	Dw	1	0	0	2	0	0	1	0	0	1	1	0
Nace-3	D	5	3	5	2	1	0	4	3	4	1	5	2
	Dw	0	0	0	1	0	0	1	0	0	0	0	1
Vertical spillovers													
Positive spill.													
Nace-2	D	2	1	2	0	1	0	1	2	1	1	0	3
	Dw	3	0	2	3	0	4	1	1	1	2	3	0
Nace-3	D	2	0	2	0	1	1	1	0	1	4	2	1
	Dw	2	1	1	1	0	1	1	2	0	1	4	0
Negative spill.													
Nace-2	D	4	0	2	3	0	2	2	0	1	0	4	0
	Dw	3	0	2	2	2	1	1	1	1	3	2	4
Nace-3	D	2	0	0	1	0	1	2	2	1	0	1	0
	Dw	1	0	2	0	3	1	1	1	0	1	4	2

Note: Each cell gives a number of countries with a significant coefficient (at 10 per cent at the least).
* Foreign affiliates are excluded from the summary, except for direct effects.

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