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Foreign presence and efficiency in transition economies

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Abstract This paper presents empirical evidence on the role of foreign presence in the performance of domestic manufacturing firms in five Central and Eastern European countries. Data Envelopment Analysis (DEA) was used to estimate a frontier for each sector with similar technology common for five transition countries in the sample – Bulgaria, Estonia, Hungary, Poland and Romania. Following Simar and Wilson (J Econom 136(1):31–64, 2007), this study applies a truncated regression and bootstrap technique in a second stage post-DEA analysis. Some evidence is found to support the hypothesis that foreign presence has an overall positive spillover effects on the performance of domestic firms.

Keywords FDI · DEA · Bootstrap · Transition economies

JEL Classifications F21 · C34 · O33

At the outset of the transition from the planned to the market economy the hope was that foreign direct investment (FDI) would improve economic outcomes in Central and Eastern Europe both directly and indirectly. Given the relatively low levels of domestic investment and weak marketing capabilities of most transition economies, FDI was expected to boost economic growth and employment by accelerating investment, transferring new technologies and bringing up-to-date organizational and marketing skills to the host economies. It has been difficult, however, for researchers to evaluate whether such expectations have been borne out by experience. Studies on the impact of FDI have employed various econometric techniques and yielded mixed results.

Following Hirschberg and Lloyd's (2002) criticisms of the *parametric* methods traditionally used to measure the indirect impact of FDI empirically, a *non-parametric* technique, Data Envelopment Analysis (DEA), is used in this paper to compute a single efficiency score for each observation. Additionally, we apply a methodological alternative in the post-DEA analysis developed by Simar and Wilson (2007). Truncated regression is used in combination with a bootstrap procedure to estimate confidence intervals in a test for various intra-industry spillover effects in this study.

Foreign firms are found to be more scale efficient than domestic firms, but there is no strong evidence that foreign firms are more technically efficient than their domestic counterparts. Thus, the average technical efficiency of foreign firms is found to be higher than the average efficiency of their domestic counterparts only in four out of ten sectors. This fact provides some support to the existing argument that foreign firms are not automatically more efficient than domestic firms but that they are guided by the economic environment in which they operate. Therefore, in the second stage of the analysis some environmental characteristics have been identified.

In this study, foreign firms are found to be more efficient than domestic counterparts in Hungary and Poland and less efficient in Bulgaria, Romania and Estonia. These findings arguably reflect some differences in local economic conditions. Furthermore, the results of post-DEA analysis

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suggest an overall positive effect from foreign presence on the technical efficiency of domestic firms in all five countries. While foreign multinational companies typically have the option to employ modern and highly efficient technologies in their foreign subsidiaries, they sometimes select older and less efficient technologies that do not give them any clear efficiency advantages above local firms. This is most likely to occur when there is limited competition, when technology transfer costs are high, or when uncertainty is large due to institutional problems.

The structure of the paper is as follows. Section 1 presents a brief overview of the FDI spillover literature, discussing its implications for transition economies and methodological discussion. Section 2 describes the data used. In Sect. 3, the empirical model and the results on technical efficiency as well as scale efficiency are presented, followed by an analysis of the main determinants of efficiency in Sect. 4. The main conclusions are drawn in the final section.

1 FDI spillovers: main determinants, methodology and empirical evidence from studies on transition economies

The studies on FDI spillover effects are heterogeneous in many respects, both considering the variables included as determinants of spillovers, the countries, industries and time periods that are analyzed, as well as the findings of the analyses.

The existence, dimension, and size of spillover effects are generally believed to depend on three categories of determinants: (1) multinational company and foreign affiliate characteristics, (2) local firm and economy characteristics and (3) institutional parameters, e.g. intellectual property rights, infrastructure, etc. (Table 1).

Previous studies showed that host country conditions are crucial in determining the behavior of foreign firms (Kokko 1994). The level of competition, presence of educated human resources (Blomstrom et al. 1995; Sjoholm 1999), the gap between the productivity of foreign and domestic firms (Wang and Blomström 1992; Perez 1997), infrastructure (Kinoshita 2001) and the institutional set up for intellectual property right protection (Smarzynska Javorcik 2004b) are among the most important host country characteristics identified in the literature.

Although they do not show a clear-cut, systematic pattern, most recent studies on developed countries find positive evidence of spillover effect from foreign companies' presence (Haskel et al. 2002; Keller and Yeaple 2003), while studies on developing countries find negative or no spillover effects (Aitken and Harrison 1999; Blomstrom and Sjoholm 1999).

Transition economies are distinct from both groups of countries and characterized by relatively developed human capital but poor infrastructure and weak market institutions. The relative abundance of human capital, which sets the transitions economies apart from developing countries at large, is likely to promote learning and spillovers of knowledge from foreign to local firms. However, human capital alone may not be sufficient for positive spillover effects to take place.

As Kogut and Zander (1993) put it, "… multinational corporation arises not out of the failure of markets for the buying and selling of knowledge but out of its superior efficiency as an organizational vehicle by which to transfer this knowledge across borders". However, intra-MNC technology transfer costs "derived from the efforts to codify and teach complex knowledge to recipient" (Kogut and Zander 1993) are usually underestimated and likely to be substantial (Teece 1981). In transition economies low levels of competition and weak intellectual property

Table 1 Main determinants of FDI spillover effect[a]

Local firm/economy characteristics	Foreign investor (MNC) characteristics	Other environmental characteristics
Absorptive capacity	Nationality in terms of levels of protection and sector structure	Distance/space—transport costs
Technological gap	Entry mode—M&A versus greenfield	***Product and technology differentiation***
Export capacity	***Degree of foreign ownership***	Social, cultural and legal differences
Size of the local firms	Trade policy of MNC	IPR
Competition	Training received by workers at MNC	
Overall country development	Wage differential – labor mobility	
Linkages with local suppliers and producers	Working contract conditions – labor mobility	
	Motivation	
	Innovative level of technology	

[a] Table is based on Crespo and Fontoura (2005) literature survey. In bold italic are the variables considered in this paper

protection regimes amplify the cost of knowledge transfers and reduce the motivation of foreign firms to transfer technologies in high-tech industries.

However, in the new market-oriented environment, it has not been easy to efficiently utilize the resources accumulated before transition by technologically intensive domestic firms. Some studies suggest that slow privatization is one of the factors that has caused inefficiency in the transition economies in general, and in high-tech industries in particular (Adamchik and Bedi 2000). The planned economy era left many outdated institutions in its wake, mutually embodied in organizations and 'rules of the game' (North 1990). The attitude of traditional domestic firms to the competitive pressures exerted by foreign firms, and therefore the impact of foreign presence, is largely determined by the degree of adjustment or reform of the institutional framework. Unfortunately, assessing the quality and impact of a country's institutions poses formidable methodological challenges: there is no readily available way to quantify and measure such variables empirically.

Empirical studies on spillover effects in transition economies are not numerous, and those that exist provide divergent results. Djankov and Hoekman (2000) find a statistically significant negative intra-industry spillover effect of foreign participation on domestic firms in the Czech Republic from 1992 to 1996. This finding is consistent with the results found by Konings (2001) investigating Bulgaria and Romania, where foreign firms on average do not even perform better than their domestic counterparts. By contrast, in Poland foreign firms are more productive than domestic firms, but no evidence of spillover effects to domestic firms is found.

Various studies looking at determinants of FDI spillovers other than horizontal linkages in transition economies come up with contrasting results. Yudaeva et al. (2003) find that, in Russia, the stock of human capital in regions where foreign firms operate is one of the factors that help domestic firms to benefit from the entry of foreign firms. They also find that there are positive spillovers from foreign-owned firms to domestic firms in the same industry but negative effects on domestic firms that are vertically related to foreign-owned firms. The opposite holds for Lithuania (Smarzynska Javorcik 2004a). Here positive productivity spillovers from FDI taking place through contacts between foreign affiliates and their local suppliers in upstream sectors, while horizontal spillovers are insignificant. Mode of entry is also found to be important: spillovers are associated with projects with shared domestic and foreign ownership but not with fully owned foreign investments.

Sinani and Meyer (2004) look at the role of size, trade orientation and ownership structure of domestic firms in Estonia in determining spillover effects from technology transfers from abroad. Finding a positive spillover effect of significant magnitude, they conclude that small, non-exporting and outsider-owned firms benefit more from spillovers than do other types of domestic firms.

While the quality of the data, identified determinants and conclusions on FDI spillovers are diverse, the methodology used in these studies varies little. This study holds that some of the difficulties in capturing spillover effects econometrically may lie in the methodology commonly employed to measure the performance of firms.

The most accepted approach to measure spillover effect is the parametric estimation of production functions (largely Cobb-Douglas functions) with different proxies added to capture the spillover effect. The favored proxy is the foreign share of production, employment, or capital, as in Caves (1974) and Blomström, Haddad and Harrison (1993). However, finding a correlation between the foreign share of an industry and the productivity level or growth rate of domestic firms does not prove spillovers: the causal links are unclear and there may be endogeneity problems. These two main problems have been tackled differently in different econometric studies on spillovers. Spillovers were identified not merely by foreign share, but by correlation with the presence of multinationals in downstream sectors or upstream industries, namely vertical and horizontal spillovers (Smarzynska Javorcik 2004a). Different tools were employed to control for fixed and random effects (Konings 2001), and the semi parametric estimation method suggested by Olley and Pakes (1996) was implemented to account for endogeneity of input demand and corrected to take into account the fact that the measures of potential spillovers are industry specific while the observations in the data set are at the firm level (Smarzynska Javorcik 2004a).

The parametric techniques used in these studies are based on the assumption that all firms in the sample are efficient. Efficiency and scale are usually held constant so a change in TFP reflects a corresponding change in technology. Yet, in reality, productivity varies as a result of differences in production technology, differences in the technical efficiency of the organization, and the external operating environment in which production occurs. To the best of our knowledge, Hirschberg and Lloyd (2002) was the first spillover study attempting to take this into account, although their methodology was dubious as discussed by Simar and Wilson (2007). Here, we use the Simar and Wilson (2007) approach in the second stage bootstrap procedure (see Sect. 4 for more details on methodology). Efficiency is viewed as the best indicator reflecting the influence of foreign presence in transition economies. This is due to the assumption that organizational knowledge of foreign firms is superior to the state of existing knowledge of domestic firms, which used to operate in planned economy. This knowledge is not always tacit and can easier spill over to domestic firms, in contrast to codified knowledge on technology that may be well protected by patents and licenses.

The possibility for cross country comparison with DEA models was first proposed by Caves et al. (1982) "allowing utilities from different countries to support the DEA envelope" and applied in a number of recent studies, including Kumar and Russell (2002), Edvardsen and Forsund (2003), Jamasb and Pollitt (2001). International comparisons are often restricted to comparison of operating costs because of the heterogeneity of input costs. As a precondition for international comparisons they focus on improving the quality of the data collection process, auditing, and standardization within and across countries. Our data were taken from international standard accounting reports made by companies at the end of each year. This source has been used by other authors for cross-countries comparison—see Konings (2001) and Damijan et al. (2003).

2 Data description

Firm level data for 1998 was obtained for five transition economies—Bulgaria, Estonia, Hungary, Poland, and Romania—from the Amadeus database.[1] Table 2 outlines the share of foreign investment enterprises (FIEs) of the total number of firms in our dataset for each country. Foreign investment enterprise is defined as an economic unit that has at least a 10% share of foreign capital.

In order to carry out the DEA analysis, firms were divided into peer groups with identical economic activities identified by the NACE rev.1 standard industry classification. This enables us to estimate efficiency scores based on comparable inputs and outputs. To obtain a feasible production plane, where output quantities can be produced from the associated input quantities, three inputs were specified—capital, number of employees and materials. Total sales were taken as a desirable output for all firms.

Some governments in Central and Eastern Europe tried to set wages while taking into account many factors, including marginal productivity, compensating wage differentials, social factors, and other considerations such as effort. However, as distorted prices made it difficult to measure output, wages bore almost no relation to differences in productivity or skills (Jackman and Rutkowski 1994). In order to eliminate possible cross-country

Table 2 Descriptive statistics on the foreign presence *by country*

	Bulgaria	Estonia	Hungary	Poland	Romania
No. of all firms	514	88	64	335	736
No. of FIEs	57	6	7	10	196
FIEs in no. of firms (%)	11.09	6.82	10.94	2.99	26.63
FIEs in employment (%)	17.78	36.89	3.97	15.62	33.57
FIEs in sales (%)	19.92	28.41	9.07	27.28	30.32
FIEs in tangible assets (%)	28.11	40.01	5.65	17.72	25.14
FIEs in materials (%)	21.43	18.00	10.23	27.94	26.68

differences in wage mechanism the number of employees was taken as a proxy for human capital.

While the relation between wages and productivity may still be weak in some countries of our sample, the privatization process has been important to improve the organization, productivity, and efficiency of existing firms in transition economies. As Sachs (1997) remarks, "the pattern and speed of privatization of state enterprises will affect the speed of adjustment of the pre-existing enterprises". To capture possible organizational differences private and public ownership a dummy has been constructed using information from Amadeus firm-level data on the type of ownership.

Prices on the inputs are assumed to not vary greatly among five countries: Bulgaria, Estonia, Poland, Hungary and Romania and between two types of firms—foreign and domestic. Therefore, the technology available to a firm at a given point in time (1998) defines which input-output combination is feasible. It is assumed that a firm does not influence its own output and that sales are consequently determined exogenously by the market. However, firms can minimize inputs to obtain a given output. In the absence of market prices, DEA endogenously generates "shadow prices" of inputs and outputs for aggregation. In the second stage of the analysis 2-digit industry data was obtained from the WIIW dataset on transition countries. All variables expressed in national currency were converted into current US dollar term.

The deterministic assumption used in DEA models that all observed units belong to the attainable set requires a robust procedure for outliers detection (Simar 2003). Since envelopment estimators are very sensitive to extreme observations they can behave dramatically in the presence of super-efficient firms, which can be viewed as outliers. An exploratory data analysis procedure, recently proposed by Simar (2003), which is more robust to the super-efficient observations and does not envelope all data points, was used. It was found that the distribution is qualitatively

[1] The data are available on the Amadeus CD-ROM (June 2000), a Pan European database, provided by Bureau van Dijk Electronic Publishing SA.

similar among the ten industries, albeit it is more extreme in some industries like "Sawmilling of wood, manufacture of semi-finished wood products, etc." and "Wooden and upholstered furniture" (see Column (5) of Table 3), where few super-efficient observations and relatively many extremely inefficient firms are observed. Since the situation where many firms have not adapted to the market economy is very close to the reality of transition economies, the outliers were identified simply by calculating two standard deviations from the mean of three ratios—sales per labor, capital (tangible assets) per labor and materials per labor. This procedure allowed excluding only observations with extraordinary size, firm that experience an individual shock at that particular point of time and allowed to avoid possible errors in the recording information. In total, 1,910 observations in all five countries remained, including 299 FIEs. On average the number of FIEs in each country account for about 10% of the total number of firms, but their share varies in the contribution to employment, capital, sales and materials (Table 2).

3 First stage: efficiency results

An efficiency score is estimated for each firm j out of the sample of n firms separately for each industry, but for a common frontier across all five countries. Therefore, ten models for each sector, where firms are grouped by similar technology and validate the common technological frontier are estimated. Since the manufacturing industry in transition economies presented in the sample are traditional industries and do not easily expand in terms of output, the Farrell (1957) input oriented technical efficiency measure is used:

$$D_i(y,x) \equiv \max_{\theta}\{\theta : (x/\theta, y) \in T_s\} \tag{1}$$

where T_s is a technology set in each sector. Therefore ten separate input-oriented models were estimated for each industry, where technical efficiency estimates are reciprocals of Farrell-type efficiency scores:

$$\overline{TE}_i \equiv \frac{1}{D_i(x,y)}, \in [0,1] \tag{2}$$

Table 3 First stage: technical and scale efficiency score for the domestic and foreign firms in 10 manufacturing sectors

Industry	Technology Intensity Group	Type of ownership	Number of obs.	Weighted mean of TE	Weighted mean of SE	Share of firms operating at different scale, %		
						IRS[a]	DRS[b]	MPSS[c]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sawmilling of wood, manufacture of semi-finished wood products, etc.	Low-Tech	DEs	155	0.28	0.38	82.35	17.65	0
		FIEs	34	0.13	0.42	85.16	10.32	4.52
Clothing, hats, gloves, fur goods and household textile		DEs	165	0.28	0.38	67.74	29.03	3.23
		FIEs	31	0.41	0.50	76.97	21.21	1.82
Fish and meat industry		DEs	136	0.29	0.35	70.59	23.53	5.88
		FIEs	17	0.46	0.57	75	20.59	4.41
Structural clay products, cement, lime plaster and other building materials	Medium-Tech	DEs	126	0.23	0.37	96	4	0
		FIEs	25	0.28	0.27	98.41	0	1.59
Hand tools; metal furniture, table ware, packaging products and other finished metal goods		DEs	120	0.31	0.37	50	43.75	6.25
		FIEs	16	0.19	0.37	64.17	27.5	8.33
Printing and publishing		DEs	236	0.39	0.45	61.43	32.86	5.71
		FIEs	70	0.50	0.49	80.51	14.41	5.08
Wooden and upholstered furniture		DEs	82	0.07	0.31	38.46	61.54	0
		FIEs	13	0.05	0.45	37.8	59.76	2.44
Rubber and plastic products		DEs	109	0.41	0.42	85.71	9.52	4.76
		FIEs	21	0.39	0.48	84.4	9.17	6.42
Basic and specialized industrial chemicals	High-Tech	DEs	182	0.39	0.28	61.54	38.46	0
		FIEs	26	0.22	0.30	62.09	36.26	1.65
Basic electrical equipment		DEs	150	0.45	0.35	78.26	17.39	4.35
		FIEs	23	0.36	0.35	86.67	9.33	4

[a] IRS—Increasing returns to scale

[b] DRS—Decreasing returns to scale

[c] MPSS—Most productive scale size

The estimates of technical efficiency $\overline{TE}_i$ indicate the extent to which it is possible for a firm to reduce its inputs without reducing output and where 1 indicates the firm on the frontier with a maximum efficiency.

This model incorporates a dual approach with a correction for slacks (Coelli et al. 1998; Coelli 1996) and variable returns to scale (VRS), as suggested by Banker et al. (1984). Taking scale efficiency into account means that technical efficiency is estimated under the assumption that not all firms are operating at the optimal scale. The relationship between VRS and CRS can be expressed as:

$$\text{VRS Technical Efficiency Score} * \text{Scale efficiency} = \text{CRS Technical Efficiency Score} \quad (3)$$

Taking further into consideration the VRS efficiency score, we exclude the efficiency obtained to the scale. It is important for our analysis to leave out scale efficiency in order to give a representative comparison of two sets of firms—foreign and domestic. Further analysis of the scale efficiency alone for foreign and domestic firms yields information about the behavior of firms in transition economies (see columns 7–9 in Table 3).

Table 3 summarizes the results for each industry, where the scores for domestic enterprises (DEs) are reported in the first row and the following row contains the results for the foreign investment enterprises (FIEs). Table 3 (column 6) shows that foreign firms are on average more scale efficient than domestic firms, implying that domestic firms have better possibilities to improve their efficiency by scaling up their activity. At the same time there are more domestic than foreign firms operating on the most productive size scale. Table 3 (columns 7–9) also shows that most of the industries operate under increasing returns to scale, with the exception of "Printing and publishing" and "Rubber and plastic products". From a theoretical point of view, firms face diseconomies of scale for a number of reasons. Among them specific process within a plant may not be able produce the same quantity of output as another related process. Or alternatively, as output increases, the cost of transporting the good to distant markets can increase sufficiently to offset any economies of scale. More detailed industry-level study is needed to identify the factors causing the presented pattern of economies of scale.

Table 3 (columns 5–6) reports aggregated DEA scores proposed by Färe and Zelenyuk (2003) based on the "within-group" weights. The main idea of the method is to estimate weighted efficiency separately for a group of foreign firms in each sector:

$$\overline{TE}_f = \sum\nolimits_{n=1}^{N_f} \left(\overline{TE}_f^n * \frac{Y_f^n}{\sum\nolimits_{n=1}^{N_f} Y_f} \right) \quad (4)$$

and a group of domestic firms:

$$\overline{TE}_d = \sum\nolimits_{n=1}^{N_d} \left(\overline{TE}_d^n * \frac{Y_d^n}{\sum\nolimits_{n=1}^{N\_d} Y_d} \right) \quad (5)$$

The estimates of technical efficiency are weighted by the share of the individual output (sales in our case) of total output in the group of foreign and domestic firms (see Li and Cheng (2007) for further details on the interpretation of weighted means).

Column (5) in Table 3 shows that domestic firms in the sample obtain higher efficiency scores than their foreign counterparts in six out of 10 industries. At the same time foreign firms are more scale efficient in eight out of ten industries in a sample (column 6).[2] Due to the nature of the construction of the DEA frontier, only a few firms attain very high efficiency scores—see column (7) of Table 3. This pattern of allocation makes the examination of the distribution of scores industry by industry impractical. However, having built a common frontier for all countries in ten sectors separately, Kernel density estimation may be applied to picture the distribution of the efficiency scores (Fig. 1) country by country in all ten sectors taken together.

The plot "All observations" in Fig. 1 depicts the distribution of the efficiency scores of all firms across all sectors and all countries, in contrast to the normal distribution. DEA efficiency scores tend to have a bimodal distribution, as shown by the two peaks at about 0.2 and 0.95. It suggests that there are large numbers of firms with very low efficiency as well as with high efficiency in our sample. This may be an indication of a deep transitional structural change, where some firms adapt well to the changing environment while others, mainly traditional plants with outdated management, perform poorly.

Separate figures are built in order to investigate the country-specific distribution of efficiency and the position of foreign firms with respect to the common frontier. The cross-country plots suggest that there is a different pattern of behavior for foreign and domestic firms in different countries. It is only in Poland and Hungary where foreign firms relatively speaking outperform domestic ones. In Romania, Bulgaria and especially in Estonia, foreign firms are significantly less technically efficient.

[2] The scale efficiency scores were as well aggregated as in Fare and Zelenyuk (2003) for foreign and domestic firms respectively: $\overline{SE}\_f = \sum\nolimits_{n=1}^{N-f} \left(\overline{SE}_f^n * \frac{Y_f^n}{\sum\nolimits_{n=1}^{N\_f} Y_f} \right)$, $\overline{SE}\_d = \sum\nolimits_{n=1}^{N-d} \left(\overline{SE}_d^n * \frac{Y_d^n}{\sum\nolimits_{n=1}^{N\_d} Y_d} \right)$

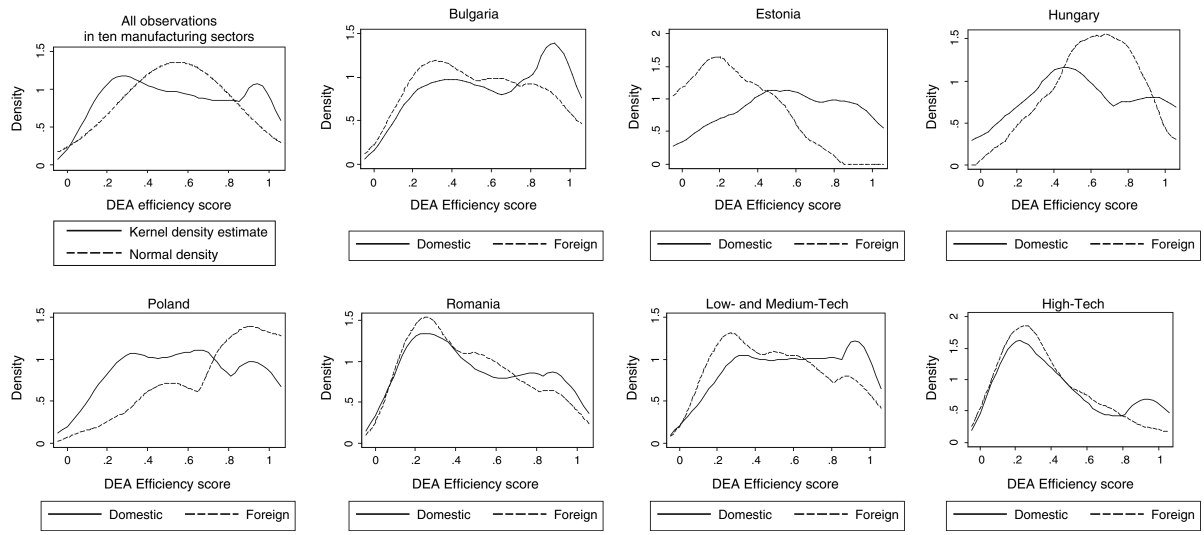

Fig. 1 Cross-country and cross-industry DEA technical efficiency score distribution illustrated using Kernel density estimates

On the one hand, foreign companies have the strongest advantages compared to domestic firms in relatively more backward countries like Romania and Bulgaria. Here, there would be no need for FIEs to transfer costly new technology to outcompete domestic firms. Nevertheless, foreign firms are found to be even less productive than their domestic counterparts in these countries. On the other hand, previous studies have shown that host country conditions are crucial in determining the behavior of foreign firms (Kokko 1994). The level of competition, the abundance of educated human resources, the gap between the productivity of foreign and domestic firms, infrastructure, institutional set up of intellectual property right protection, and the like (see part one for this paper for the references) are among the most important host country characteristics identified in the literature. It may be that this set of factors was more encouraging for foreign firms to be more efficient than their domestic counterparts in Poland and Hungary than in Romania and Bulgaria. It may also suggest that in the early stages of transition in Romania and Bulgaria the overall environment was not conducive for foreign firms to do better. The relatively small Estonia, unlike the rest of transition countries, relied heavily on FDI especially in the early stages of transition, since early 1990s. As a result, already by the late 1990s, domestic firms managed to close the efficiency gap with foreign firms.

Moreover, industry-specific features can determine the conduct of foreign subsidiaries' performance. In order to characterize the technological intensity of the industry, three subgroups were formed according to the taxonomy drawn from Hatzichronoglou (1997). Low- and medium-tech groups are represented in one plot, due to the similar pattern of distribution of efficiency scores in both groups (Fig. 1). Clear evidence of bimodality with different peaks for foreign and domestic firms suggests that in low- and medium-tech sectors there is a higher density of foreign firms with low efficiency. At the same time, there is comparable density of firms that are very close to the efficiency frontier and those that are very far from the frontier.[3] A different mode of distribution is observed in high-tech industries. A relatively high density of inefficient firms is evident both for foreign and domestic firms (Fig. 1).

The estimated technical efficiency score distribution of foreign firms is very similar to the distribution of the domestic firms in the high-tech sector, even with a lower density of highly efficient firms. Superior ability to transfer knowledge from headquarters is widely perceived to give a competitive advantage to foreign relative to purely domestic firms, but the cost of the transfer is sometimes largely underestimated.

It may also be pointed out that in the "Printing and publishing industry" both domestic and foreign firms enjoy the highest scale efficiency, while in the "Building materials" industry they enjoy the least. *Inter alia*, this is because building materials is one of the oldest and most traditional industries in transition economies. Most enterprises in the industry operate in mature markets with mature technology and old-fashioned management. By contrast, the printing and publishing sector is one of the most dynamic and open industries with a substantial share

[3] As suggested by Simar and Zelenyuk (2006), Schuster -Silverman reflection method can be used to provide consistent estimator in cases when the standard Kernel density estimators (KDE) are inconsistent at the boundary (e.g. in case when there are many observations at 0 and 1 points). In our case, the results of this test give qualitatively similar to standard KDE pattern of distribution between foreign and domestic firms and therefore are not reported in the paper.

of foreign presence. In order to identify other factors determining the difference in the efficiency performance of domestic and foreign firms, a post DEA regression analysis is carried out.

4 Second stage: Determinants of efficiency and FDI spillover effects

In the second step, the efficiency score obtained from the DEA analysis described in the previous section are regressed on environmental variables. The purpose of this step is to account for exogenous factors (e.g. industry or country specific factors) that might affect firms' performance and cannot be directly taken into account in the first-step non-parametric model. The general model for the second stage can be specified as following:

$$\delta_j^* = Z_j\beta + \tau_j \tag{6}$$

where δ_j^* indicates the estimated technical efficiency score of each firm j. Since the estimates are bounded by unity in output-oriented models and both by zero and unity in input-oriented models, it is argued that DEA efficiency estimates are somehow truncated. In order to make a coherent account for truncating problem Simar and Wilson (2007) proposed an approach based on *truncated regression* where error term τ_j is identically, independently distributed for all j with $N(0, \sigma_\varepsilon^2)$. Further, Simar and Wilson (2007) point out that conventional approaches to inference employed in many studies, which rely on multi-stage approaches, are invalid due to complicated unknown serial correlation among the estimated efficiencies. The criticism applies equally to the use of naïve bootstraps, as in Hirschberg and Lloyd (2002). This method is shown to bring sound improvements to the estimates and was supported by the Monte Carlo experiment illustrations provided by the authors.

Following Simar and Wilson (2007) Algorithm 1 procedure, the method of maximum likelihood is used to obtain the estimate $\hat{\beta}$ of β as well as estimates $\hat{\sigma}_\varepsilon$ of σ_ε in the truncated regression of Eq. 6. The bootstrap estimates were obtained by following three steps in Simar and Wilson (2007) and the confidence interval was defined based on bootstrapped values of β and σ_ε.[4]

[4] The three steps used for a bootstrap procedure in Algorithm 1 (Simar and Wilson 2007) are: (1) For each $j = 1,..., n$, draw τ_j from the N(0, $\hat{\sigma}_\varepsilon^2$) distribution with left-truncation at $(1 - Z_j\hat{\beta})$. (2) Again for each $j = 1,..., n$, compute $\delta_j^* = Z_j\hat{\beta} + \tau_j$. (3) Use the maximum likelihood method to estimate the truncated regression of δ_j^* on Z_j, yielding estimates $(\hat{\beta}^*, \hat{\delta}_j^*)$. Then bootstrap simulation was repeated for these steps two thousand times for each model. The bootstrap values and original estimates of $\hat{\beta}$ are used to construct estimated confidence intervals reported in Table 4.

Among determinants of efficiency of the firms (Z_j) are: type of ownership, wage rate, age, absorptive capacity of the firm. It is particularly interesting to investigate the function of foreign presence in the industry as a whole on the efficiency of domestic firms, or the so called intra-industry spillover effect.

The more detailed empirical model can be described as following:

$$TE_{jic}^{dom} = f(\text{Age}_{jic}, \text{ Wage}_{jic}, \text{ Absorptive\_Capacity}_{jic}, \text{ Ownership Type}_{jic}, \text{ Foreign\_Presence}_{ic}, \text{ Technological\_Intensity}_{ic}) + \tau_{jic} \tag{7}$$

where j-firms, i-industry, c-country, τ- error term and TE_{jic}^{dom}—domestic firms' estimated technical efficiency score. Here, the frontier was estimated for each industry separately, for production possibility set, which initially contains observations of both domestic and foreign firms (see previous section for details). In this stage, only the technical efficiency of domestic firms is used as a dependent variable in order to capture the spillover effect foreign presence has on domestic firms.

Table 4 presents the results of truncated regression estimations of the determinants of technical efficiency of domestic firms in the five transition economies included in the study. Here, the bootstrap procedure described earlier was applied to estimate a confidence interval. The explanatory variables are grouped in three main categories:

- Firm level characteristics, such as age, wage rate, type of ownership dummy and firm-level absorptive capacity, which is proxied by the amount of intangible assets.
- Industry level characteristics reflecting the technological intensity and foreign presence.
- Country dummies.

Four main empirical models were constructed in order to test different proxies for FDI spillover effects. The definitions of all explanatory variables are presented in Appendix 1.

Among firm-level environmental characteristics taken into account, age tends to have a significantly negative effect on the technical efficiency of domestic firms in all four models (Table 4). This reflects the fact that older firms are less efficient in transition economies. The slow pace of changes in management style is thought to account for this. As a result, these firms find it difficult to sustain technical efficiency in comparison to newer firms in the same industry; they do not adjust easily to the new conditions of the market economy.

Wage rate, as a reflection of the quality of personnel, does not turn out to be significant in most of the models, and for that reason it was omitted in some of them. Only in

Table 4 Second stage: intra-industry spillover effect estimates results[a]

Group name	Variable	(1)	(2)	(3)	(4)
Environmental variables on the Firm-level	Age	−0.003***	−0.003***	−0.003***	−0.003***
	Wage			−0.022***	−0.022***
	Absorptive capacity	−0.045	−0.043	−0.034	
	Private Ownership	0.261***	0.257***	0.253***	0.254***
Technology intensity dummies	Medium-Tech	−0.083***	−0.090***	−0.094**	−0.095***
	High-Tech	−0.253***	−0.262***	−0.263***	−0.263***
FDI presence indicators on the Industry level	IA spill			0.168***	0.171***
	FSEmpl		0.590***		
	FSSales	0.471***			
Country dummies	Bulgaria	0.096	0.100	0.009	0.009
	Hungary	−0.037	−0.029	−0.024	−0.024
	Poland	−0.102	−0.080	−0.107	−0.110
	Romania	−0.194***	−0.193***	−0.242***	−0.243***
	Constant	0.464***	0.452***	0.842***	0.841***
	Number of obs.	1,439	1,439	1,433	1,435

[a] The dependent variable is a DEA efficiency score. Results of left-hand truncated regression with bootstrap procedure, where significance is 10, 5, and 1% levels denoted with ***, ** and *, respectively (two-tailed test). See Appendix 1 for definition of explanatory variables

models (3) and (4) wage has a negative effect on technical efficiency. This may be seen as a result of wages being imperfect proxy for the quality of labor in transition economies.

The results of our study suggest that private firms are more efficient than public ones, providing indirect empirical support calls to reform the public domain in transition economies as a way of increasing efficiency. The absorptive capacity of domestic firms, as measured by the intangible assets of the firm, does not turn out to be significant in any of the models considered in the study. It suggests that the requirement for absorptive capacity is not significant for domestic firms in transition economies.

Furthermore, as shown in the first stage of this analysis, domestic firms are more efficient than foreign firms in six out of 10 industries. At the same time, this result highlights the need for more accurate measurements of absorptive capacity that take into account not only the ‘input side’ of the learning process (measured by R&D expenditures or intangible assets) but also the ‘output side’, usually proxied by the number of patents, patent citations or sales of innovative products (Kinoshita 2001; Criscuolo et al. 2002).

The foreign direct investment spillover effect hypothesis was tested with a few alternative proxies for foreign presence.[5] In all models, foreign presence on the industry level has a significant positive effect on the performance of domestic firms. This result suggests that even though foreign firms are more efficient than domestic firms not in all sectors of the economy (see the first stage of the model, Sect. 3) their presence has a positive effect on the performance of domestic firms in the same sector. This result may reflect the facts that foreign firms are new to the market and do not quickly adjust. Unfortunately, the dynamic effect of foreign presence cannot be tested with the data available. However, the difference among the countries in the sample is not likely to be large, since foreign companies started operating only in the early 90s in most of the countries in the sample.

The intra-industry spillover effect, e.g. via competitive pressure and by using economies of scale more efficiently, can motivate domestic firms to perform better. Different

[5] Among not reported results are models using foreign share in total sales (SS), foreign share in total assets (SA), relative productivity (RP) and relative scale efficiency (RSE) variables (see Appendix 1 for the definition of variables). For variables SS and SA the data on foreign share in Bulgaria was missing, and for that reason some

Footnote 5 continued

observations had to be dropped and not reported in the table. Nevertheless, the positive relation of foreign share and the efficiency score of domestic firms holds. Also relative productivity variable RP constructed using industry data on from Germany as a baseline for comparison (Appendix 1). The variable takes a negative sign, suggesting that firms operating in transition economies are more efficient in those industries where local firms are relatively less productive than firms in the corresponding German industries. Relative scale efficiency (RSE) variable (Appendix 1) in the model is positively related with efficiency. This result suggests that the more scale efficient foreign firms are compared to domestic firms in the industry, the higher the technical efficiency of domestic firms. It supports the argument that the heightened competitive pressure that foreign firms bring into the industry generates positive spillover effect for domestic firms and forces them to be more efficient, even when foreign firms are less efficient than their domestic competitors. However, the coefficient for RSE variable is small.

proxies reflecting foreign presence were constructed in order to capture the influence of foreign firms on the efficiency of their domestic counterparts. In models presented in Table 4, variables relating to the activity of foreign firms were constructed from the initial firm-level dataset (see Appendix 1 for the definition of explanatory variables). In the models (1) and (2), foreign equity participation was averaged over all plants in a sector in a country, and then weighted by each plant's share of sectoral sales (1) and employment (2). Variables FSSales and FSEmpl increase as foreign share increases and sales (FSSales) and employment (FSEmpl) of foreign firms increase. The results suggest that a higher share of foreign sales and employment in the industry and country is positively related with better performance of domestic firms in those industries.

Similar proxies for foreign presence used in models (1) and (2) were constructed in previous studies by Aitken and Harrison (1999), Smarzynska Javorcik (2004a) and Caves (1974). Foreign share in the host-country's capital, employment and sales and its relation to the productivity of domestic firms in the sector is a traditional indication of intra-industry spillover effects.

Since knowledge-related assets have features of a 'public good' they have greater probability to spill over to domestic firms and increase their efficiency. This type of knowledge is related to innovative capabilities in research and development activities in foreign subsidiaries in transition economy. It can be expressed in many ways, including the amount of R&D expenditure of the subsidiary, patenting activity, or as a quantity of intangible assets that the firm acquires. In models (3) and (4), variable IAspill is constructed in order to capture the value of foreign knowledge existing in the industry in each country, which has a potential to spill over to domestic firms in this industry. As shown in columns (3) and (4) in Table 4, the IAspill variable is positive and significant, supporting the previous results. These results imply that industry share foreign knowledge expressed in the intangible assets of the firm has a positive relation with domestic firms' efficiency. Note that the IAspill variable should be interpreted with caution, because the amount of intangible assets that firm reports includes not only the value of R&D patents, but also trademarks, logos amongst others.

The argument that domestic firms in transition economies perform better in less productive industries is put forward with technology intensity dummies. The sign of the dummies suggest that domestic firms in the ten manufacturing industries in the sample are less efficient in high-tech and medium-tech industries than in low-tech industries. A possible explanation for this phenomenon is the fact that high-tech industries were highly subsidized before transition in most of planned economies. However, during the transition period, budget flows were minimized and most of the technology-intensive firms and plants, which worked for administratively planned demand, had to switch to less efficient production in order to sustain themselves under the new market conditions. It also bears mentioning that the positive influence of foreign presence does not change the sign of the technology dummies in all models. This outcome suggests that foreign direct investment has a positive impact mainly in low-tech industries.

Country dummies do not turn out to be significant, with the exception of Romania, where domestic firms are significantly less efficient than in the other countries. The insignificance of country dummies supports the idea that the five countries chosen were correctly pulled together to build a common frontier.

The results of the study should be treated with caution. The assumption used in the DEA model about equal input factor prices for foreign and domestic firms is strong for some transition economies, where capital is locally scarce. While local prices for capital might be initially higher, motivating foreign direct investment to take place, the cost of technology transfer from abroad and adjustment to local conditions also involves costs that should be taken into account. Hence, even if differences exist, they may not be large in the long run. The conclusions are also limited by the method's inability to demonstrate the dynamic mechanism that is thought to connect the influence of foreign presence with the efficiency of domestic firms. More detailed analysis of FDI spillover effects, including inter and intra industry effects using firm-level panel data, is needed.

5 Conclusions

This paper tests several hypotheses about the performance of foreign firms in transition economies and the effect of foreign direct investment (FDI) on domestically owned firms competing with foreign subsidiaries. Foreign investment enterprises (FIEs) may serve as effective generators of knowledge externalities and can work as a competitive force, reducing the excess profits earned by domestic competitors and improving efficiency. To find empirical evidence of such influence, and to overcome the shortcomings associated with traditional parametric methodologies, a two-stage semi-parametric model was employed.

In the first stage, the technical and scale efficiency of foreign and domestic firms were estimated using Data Envelopment Analysis (DEA) separately for ten manufacturing sectors. We conclude that the average efficiency of foreign firms shows a weak tendency to be higher than the technical efficiency of their domestic counterparts, but more scale-efficient, on average, than domestic firms in most of the industries considered. However, in more advanced countries like Poland and Hungary in our sample the difference of the average efficiency is in favor of foreign firms. These results provide a ground to conclude that while foreign firms have the strongest advantages compared to domestic firms in relatively less developed countries, the host country conditions are crucial in determining the behavior of foreign firms.

In the second stage, a truncated regression was used to analyze the main determinants of FDI spillover effects. The analysis shows that older domestic firms are less efficient than younger firms. Wage rates and intangible assets turn out to not be reliable proxies for the quality of personnel and absorptive capacity respectively in transition economies and do not prove to be significant in most of the models. The foreign direct investment spillover effect hypothesis was tested with several alternative proxies for foreign presence and turns out to be significantly positive in all models.

The results lead us to conclude that a large foreign presence is associated with improved performance for domestic firms. However, strong conclusions about spillover effects cannot be made with the data available in this study. Because of data limitations we are unable to demonstrate the dynamic mechanism that is necessary in order to more reasonably connect the foreign firms' presence with the efficiency of their domestic counterparts.

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Appendix

Variables definition[a]

Variable	Description	Formal definition
RSE	Relative scale efficiency. Ratio of average scale efficiency of foreign to domestic firms in the industry	$\text{RSE}_{\text{ic}} = \frac{\text{Mean}(\text{SE}_{\text{foreign}})_{\text{ic}}}{\text{Mean}(\text{SE}_{\text{domestic}})_{\text{ic}}}$
IA spill	Average share of foreign intangible assets in total amount of intangible assets in each industry of a country	$IA\_\text{spill}_{\text{ic}} = \frac{\text{Mean}(IA_{\text{foreign}})_{\text{ic}}}{\text{Mean}(IA_{\text{total}})_{\text{ic}}}$
FSEmpl	Foreign equity participation averaged over all plants in the sector, weighted by each plant's share in sectoral employment	$\text{FSE}_{\text{ic}} = \frac{\sum_{\text{for\_all\_j}\in\text{ic}} \text{For\_Share}_{\text{jic}} * \text{NO\_of\_Empl}_{jic}}{\sum_{\text{for\_all\_j}\in\text{ic}} \text{NO\_of\_Empl}_{\text{jic}}}$
FSSales	Foreign equity participation averaged over all plants in the sector, weighted by each plant's share in sectoral output measured by sales	$\text{FSS}_{\text{ic}} = \frac{\sum_{\text{for\_all\_j}\in\text{ic}} \text{Foreign\_Share}_{\text{jic}} * \text{Sales}_{\text{jic}}}{\sum_{\text{for\_all\_j}\in\text{ic}} \text{Sales}_{\text{jic}}}$
RP	Relative productivity as a ratio of value added per worker in transition economy to value added per worker in corresponding sector in Germany	$\text{RP}_{\text{ic}} = \frac{(\text{VA}/L)_{\text{ic}}}{(\text{VA}/L)_{i\text{Germany}}}$
Absorptive capacity	Amount of intangible assets in domestic firm's possession normalized by the average amount of intangible assets at the industry level in a country	$\text{Norm}IA_{\text{jic}} = \frac{\text{IntAssets}_{\text{jic}}}{\text{Mean}(\text{IntAssets})_{\text{ic}}}$
IndustryFS	Share of sales by foreign-owned companies in total sales at the industry level (obtained from the national statistical office in each country)	$SS_{\text{ic}} = \frac{\text{Sales\_of\_Foreign\_Firms}_{\text{ic}}}{\text{Total\_Sales}_{\text{ic}}}$
Age	Number of years from the date of establishment to 1998	
Wage	Wage rate in absolute value	
Private Ownership	Private/Public ownership Dummy according to AMADEUS dataset classification	

[a] *j*, firm; *i*, industry; *c*, country

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