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Foreign Direct Investment and Productivity Spillovers in the Central and Eastern European Countries

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Abstract

The paper discusses the inflows of foreign direct investment into the Central and Eastern Europe (CEE) countries and focuses on analysis of productivity spillovers. Overview of the relevance of foreign firms in the CEE economies is presented. Using firm-level data on manufacturing industries for the period 2000–2005, total factor productivity of domestic firms is estimated using Petrin and Levinsohn (2003) method and subsequently related within a panel data model to foreign presence in the same industry and in the industries linked via production chain. Presence of productivity spillovers is tested across several breakdowns to detect possible conditionalities.

Keywords: foreign direct investment; productivity; spillovers
JEL: F21, D24, L60

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1. Introduction

Over the past years, economic growth in the CEE countries has been rather impressive.[2] Baltic countries stand out as top performers, with average annual real growth rates of more than 7% since 1999, but also other countries of the Central and Eastern Europe have been growing relatively fast, on average by around 4%.

The increased productivity has been usually identified as the main driver of economic growth in the CEE countries. Using the growth accounting approach, Schadler et al. (2006) estimated that the increase in total factor productivity has accounted for between 50% and 75% of the average GDP growth between 1995 and 2004. The second most important driver of growth was capital accumulation, while the contribution of labour input was assessed as either very small or negative. Also Arratibel et al. (2007) find that total factor productivity was the most important driver of growth in 8 CEE countries, while the contributions of capital and in particular labour were much smaller or negative.

Foreign direct investment (FDI) is often mentioned as an important driver of productivity, investment and economic growth. In general, FDI typically supports the internationalisation of production and thus spurs trade openness of an economy, which is believed to have a positive impact on growth[3]. FDI increases competitive pressures in markets and stimulates technology and knowledge transfers and innovation. In this respect, FDI supports a better diffusion of foreign technology. Furthermore, FDI can provide financial sources which may sometimes be scarce in the recipient countries and thus ease credit constraints that may limit investment. Altogether, these aspects of FDI are likely to improve the host country's long-term growth prospects (see for example Lim, 2001 and OECD, 2002).

The CEE countries have been attracting FDI successfully during 1990s, given the privatization in these countries, the lack of domestic capital needed for economic transition and EU accession prospects. Differences in the timing of privatisation and the degree of openness to foreign investment help to explain country-specific differences in FDI inward stock positions. More recently, other determinants of FDI, such as cost factors, the size and location of the market and FDI policies have gained in importance. Since 2000, the intense inward FDI has continued, averaging to 5% of the GDP.

As discussed, FDI brings substantial benefits to the host economy (see also Jones and Colin, 2006). Looking at the firms level, a foreign-owned company,

[2] In this note, the CEE (Central and Eastern European) countries include the Czech Republic, Hungary, Poland, Slovakia, Slovenia, Estonia, Lithuania, Latvia, Bulgaria and Romania.

[3] For instance, Frankel and Romer (1999) find empirical evidence of this effect, but some controversies with regard to its significance and magnitude exist in the literature – see, for example, Rodrik *et al.* (2004)

usually being part of a multinational enterprise, is larger, more capital intensive, has more skilled labour, higher technological knowledge and a greater productivity level compared to domestic companies. In addition, foreign firms have usually better access to financing, either from the parent company or from the banks given their superior performance. Thus, attracting FDI brings benefits for the host economy in terms of higher investment, employment and output of these firms, with resulting effect on the overall GDP growth (so-called direct effects).

Next to these direct effects, FDI can have indirect effects on the host economy, mainly through technology or productivity spillovers from foreign-owned firms to domestic firms (Blomstrom and Kokko 1998). These spillovers can take place both within an industry (horizontal spillovers), for example, via imitation of foreign company's technology by domestic firms, or across industries (vertical spillovers), via technology transfer to domestic sub-suppliers or customers in the production chain. Through productivity spillovers, FDI can have multiplier effect and increase overall productivity of the host economy. Empirical studies show that a substantial part of the increase in productivity levels in the CEE countries can be attributed to direct effects of FDI, but some indirect effects might have played a role as well. [4]

In this paper, we focus on the role of indirect effects of FDI in the CEE countries in terms of productivity spillovers to domestic companies. The main reason to analyse the spillovers is that the direct effects last only if the foreign companies stay in the host economy. Given that a number of firms invested in the CEE countries to relocate production to a country with lower labour costs (as opposed to the servicing-the-market motive), the investment may be again relocated to other countries after the current host country loses the comparative advantage. If the FDI also indirectly contributed to improved productivity of domestic firms, the effect of the liquidation of the FDI would not be that adverse.

In line with the recent literature, the analysis of productivity spillovers is done using firm-level data. We estimate total factor productivity of the domestic firms, which is subsequently related to foreign presence by using the Levinsohn and Petrin (2003) methodology that controls for endogeneity of input selection. In order to detect on what are spillovers conditional upon, we split the sample to sub-samples using several breakdowns and investigate whether the potential for spillovers differs across different groups of firms (depending on specified conditions). We analyse manufacturing firms only, mainly due to two reasons: first, manufacturing sector received high volume of FDI over the past years (around 40% of existing FDI stock in the CEE countries) and, second, the risk of liquidation of FDI due to further relocation is more severe in the manufacturing rather than in

[4] A recent study has found that FDI has generated, on average, three quarters of the economic growth registered in 13 Central and Eastern European countries during the period 1994–2002 (see Deutsche Bank Research, EU Monitor, Reports on European Integration No. 26/2005).

services, financial intermediation or other sectors where the servicing-the-market motive prevails.

In comparison with recent research in this area, represented mainly by Merlevede and Schoors (2005, 2006), Javorcik (2004), Javorcik and Spatareanu (2003), and Javorcik et al. (2004), this paper provides value added in two areas: first, it analyses the recent data over the period 2000–2005, while most of the last literature focused on the late 1990s. Second, we focus on all ten CEE countries, while the other literature usually focuses only on one selected country. The last overview study of all ten CEE countries was done by Damijan et al. (2003) who concentrated on the period 1995–1999.

The paper is structured as follows: Section 2 provides an overview of the FDI inflows and FDI inward positions in the CEE countries. Section 3 reviews the channels through which spillovers from FDI to productivity of domestic firms can work and discusses several conditions that can influence the emergence of spillovers. Section 4 analyses the foreign presence in the manufacturing sectors of these countries using the micro-level data. Section 5 describes the estimation strategy. Section 6 presents the estimation results and section 7 concludes.

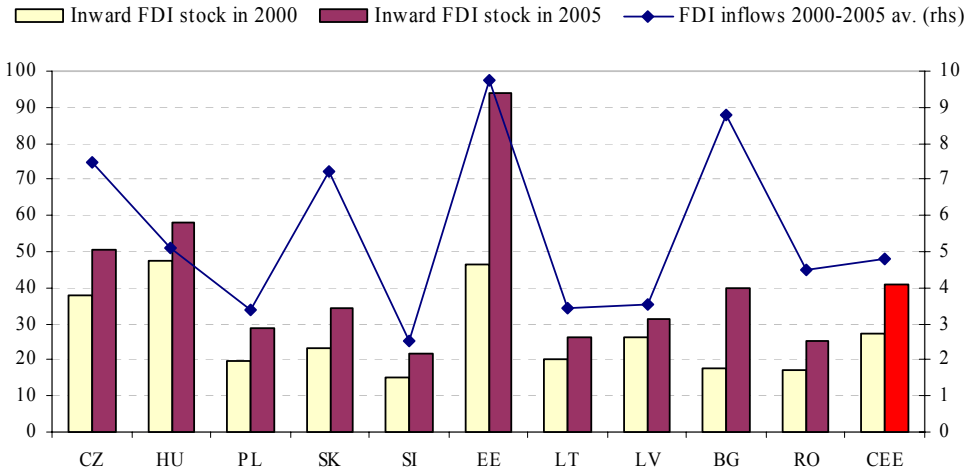
2. Foreign Direct Investment Inflows to the CEE Countries

The CEE countries have been successful at attracting FDI, which is reflected in strong FDI inflows and high inward FDI positions.

Since the early stages of their transition, the CEE countries have received substantial FDI inflows, which continued in the first half of 2000s. Annual FDI inflows have averaged around 5% of GDP between 2000 and 2005 although the pattern varied strongly across countries, with the highest being in Estonia, Bulgaria, the Czech Republic and Slovakia (chart 1). In 2005, FDI inflows in the CEE amounted to 33 billion euro, while since 2000 they accumulated to 150 billion euro.

Overall, FDI inflows as share of GDP remained broadly stable since 2000 and in line with strong FDI inflows, FDI inward positions have been growing fast in most CEE countries (chart 1). FDI inward stock in the CEE grew to 41% of GDP in 2005 from 27% of GDP in 2000. In 2005, Estonia had the highest accumulation of FDI (around 95% of GDP), followed by Hungary and the Czech Republic. In all other countries, FDI inward stock as percentage of GDP was below the CEE average, with the lowest being in Slovenia (22% of GDP in 2005). In absolute terms, the Czech Republic, Hungary and Poland accumulated about 70% of total inward FDI stock in EU10.

Chart 1: FDI Net Inflows and Inward FDI Stock, % of GDP



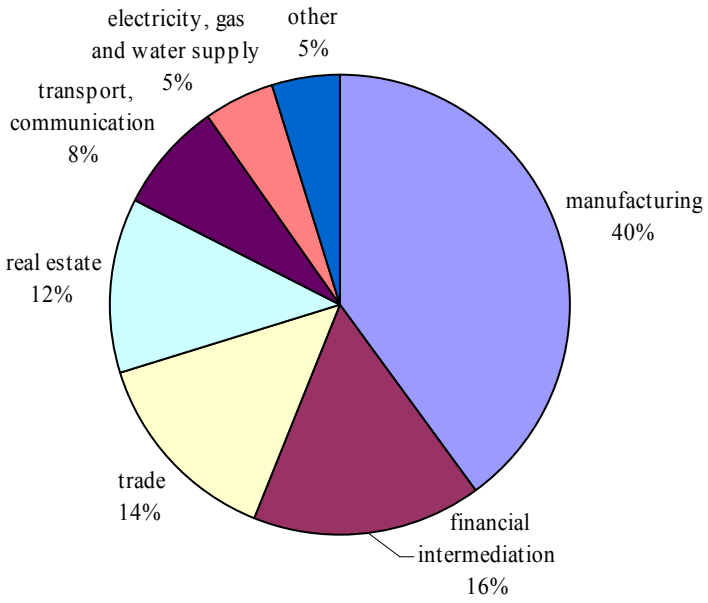
Note: The ordering of countries here and further in the paper is as follows: Visegrad countries (i.e. central Europe CZ, HU, PL, SK ordered alphabetically + SI), Baltic countries (EE, LT, LV) and the 2007 EU entrants (BG, RO).

Source: WIIW (Wiener Institut für Internationale Wirtschaftsvergleiche).

Turning now to the sectoral developments, the majority of FDI in the CEE went into the services sector, while manufacturing comprises around 40% of inward FDI stock by the end of 2004 (chart 2).

Among the services sectors financial intermediation, trade, real estate and transport are the largest receivers, with around 50% of the total FDI inward stock. As mentioned before, FDI in the service sector is usually motivated by market seeking and supplying cost optimisations, even though outsourcing and FDI in export oriented services seem to have become an important factor recently. The bulk of FDI in services can be associated with privatisation in these countries, as for example foreign investors took over a large proportion (in some countries majority) of the banking sector and telecommunications during the 1990s.

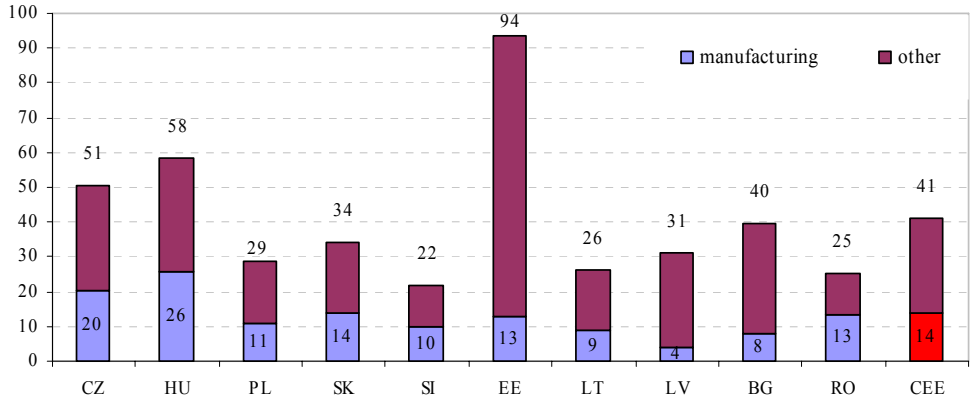
Chart 2: Inward FDI Stock in the CEE by Economic Activities (End of 2004)



Source: WIIW.

FDI in manufacturing, on the other hand, is usually motivated by low input costs and production cost economisation. However, as FDI in manufacturing has also been driven by privatisation, the motivation often was first to serve the domestic market, but may have afterwards led to expanding business activity of investing firms due to cost-savings and increased competitiveness. The accumulated inward FDI stock in manufacturing varies across CEE countries (chart 3).

Chart 3: Inward FDI Stock in Manufacturing Sector Relative to the Other Sectors in 2005, % of GDP



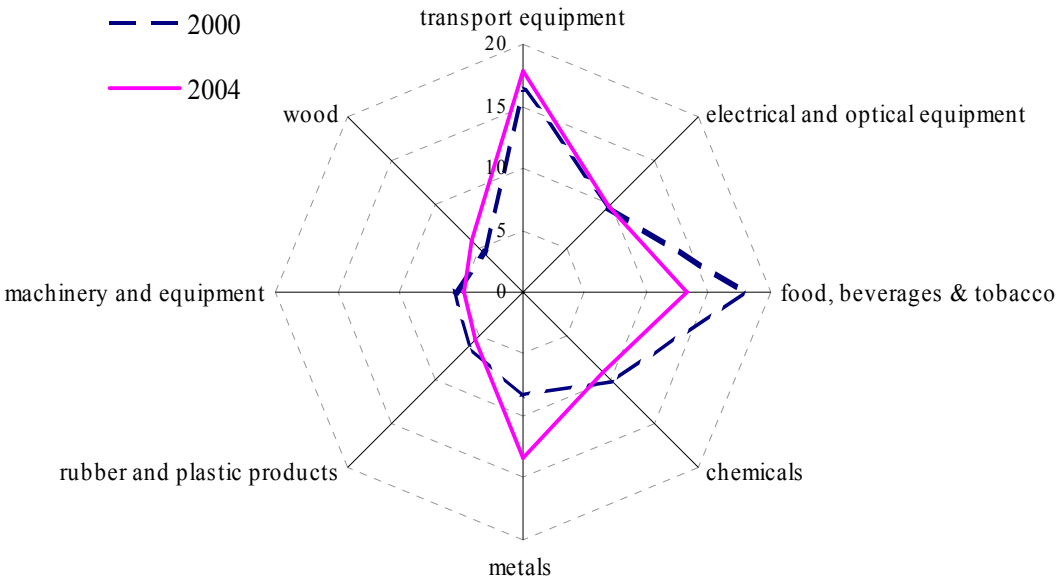
Source: WIIW.

On average, manufacturing sector had accumulated around 35% of total inward FDI stock in CEE by the end of 2005. Highest share of FDI stock in manufacturing sector by the end of 2005 was in Romania (52%) followed by Slovenia, Hungary, Czech Republic and Slovakia (on average 40%). Smallest share of inward FDI stock in manufacturing in Latvia and Estonia, 2.5% and 13.6%. of to the total inward FDI stock respectively.

Available data suggest that in the manufacturing sector foreign investors' activity has been concentrated in a few industries, notably, transport equipment, food, metals, electrical and optical equipment, which have received about 65% of the total FDI in manufacturing (chart 4).

Looking over the period 2000–2005, metal industry has gained in importance, while FDI in the food industry has become relatively less important, as this has mostly related to privatisation and the buying of existing firms and less to relocation.

Chart 4: Inward FDI Stock in the CEE by Manufacturing Industry



Source: WIIW.

3. Spillovers of Foreign Direct Investment on Productivity of Local Firms

There are several channels through which FDI can influence productivity of local firms when there is interaction between foreign and domestic firms in the host economy. As mentioned earlier, we differentiate between direct effects of FDI and indiriect effects. These indirect effects of foreign presence are called spillovers (Merlevede and Schoors, 2005). Two main kinds of spillovers are usually discussed in the literature: productivity spillovers (i.e. transfer of technology in a broader sense, including organizational and managerial practices and know-how) and market access spillovers (i.e. possibility for local firms to access new markets via marketing and business networks of foreign companies with which local firms interact). Clearly, the latter spillover may reinforce the former, as the chance to compete in the foreign markets puts pressure on the local firms to increase productivity. However, in our paper, we focus on the productivity spillovers only.

Two types of productivity spillovers are usually identified in the literature (Javorcik, 2004): when local firms benefit from the presence of foreign companies in their sector, we refer to horizontal spillovers, while if local firms benefit from interaction with foreign firms upstream or downstream in the production chain, we refer to vertical spillovers. In this sense, backward spillovers denote spillovers from the foreign firm to its local sub-supplier (upstream in the production chain), while forward spillovers refer to the spillovers from foreign firms to their local customers (downstream in the production chain).

As regards horizontal spillovers, three main channels through which horizontal spillovers may run are demonstration channel, labour market channel and competition channel (Kokko, 1992). Within the demonstration channel, local firms may try to imitate foreign firm's technology. Of course, informed foreign companies will try to prevent technology leakage to the local competitors, so that the potential for the spillover running via this channel may be limited. Another strategy of foreign firms to prevent imitation by local competitors is not to bring their state-of-the-art technologies, but those technologies that are only slightly more advanced than those of the local firms (Glass and Saggi, 1998). This would also adversely affect the potential for horizontal spillovers. The labour market channel works via labour turnover from foreign firms' trained workers to local firms (Fosfuri et al., 2001). However, foreign presence can have also detrimental effect on the local firms through this channel, as it can brain drain local talents from the local firms to the foreign affiliates (Balock and Gertler, 2004). Within the competition channel, entry of foreign firms increases competition in the host economy and forces local firms to use existing resources more efficiently and to adopt better technologies (Blomstrom and Kokko, 1998). On the other hand, if the competition induced by the entry of foreign firms is too high, less productive local firms may be driven out of the market (market stealing effect, see Aitken and Harrison, 1999).

To turn now to vertical spillovers, backward vertical spillovers emerge when foreign firms intentionally assist local sub-suppliers to deliver high-quality inputs and share with them superior technology. There are two conditions under which the incentive to help local sub-suppliers exists: first, the transportation costs between the home and the host country must be rather high so that the foreign firm does not have incentive to source its inputs in its home country. Second, the foreign firm must refrain to induce sub-suppliers from its home country to invest in the host country as well, as this would create an isolated enclave of mutually linked foreign firms with limited interaction with the local firms and thus limited potential for spillovers. Being a sub-supplier to a foreign firm provides the local firm with a stable demand for inputs and allows the local firm to invest into appropriate physical capital, build up a stock of experienced workers and accumulate necessary experience, all prerequisites for increased productivity via usage of advanced technology (Merlevede and Schoors, 2005). However, if local sub-suppliers are not

able to maintain the quality standards for the inputs as required by the foreign customer, backward vertical spillovers may also be negative, as the foreign firm may turn back to its home country sub-suppliers.

Forward vertical spillovers appear when higher quality inputs produced by foreign firms are used in the production chain by the local firms. In principle, forward vertical spillover may be also negative. For example, if the inputs produced by foreign companies are more expensive and not adapted to the local conditions, in which case they are used only by more productive foreign enterprises that are better equipped to handle the high-quality inputs. This would increase the productivity difference between local and foreign companies.[5]

Given the possible ambivalent net effect of horizontal and vertical productivity spillovers, some studies assume that the spillovers may be non-linear, meaning that the net effect on domestic companies' productivity changes with the degree of foreign presence (Damijan et al., 2003; Merlevede and Schoors, 2005, 2006). For example, relatively moderate presence of foreign companies may induce positive horizontal spillovers via demonstration channel, but further substantial increase of foreign presence may trigger brain drain and lead to market stealing effect, driving local companies out of the market, meaning negative horizontal spillovers. In other words, foreign presence contributes to an increase in domestic productivity, but if foreign presence increases beyond some threshold, its impact on local productivity turns negative.

Recent literature also focuses on conditions or characteristics that make domestic companies sensitive to spillovers, so-called conditional spillovers (Schoors and van der Tol, 2002; Javorcik and Spatareanu, 2003; Javorcik, 2004; Merlevede and Schoors 2005, 2006). Main characteristics of a firm or industry that affect the conditional spillovers are: absorptive capacity of a firm, export orientation, import competition, sectoral competition, firm size and the level and origin of foreign ownership.

A number of studies showed that absorptive capability of local firms is high if the technological gap vis-à-vis foreign firms is small (Blomstrom, 1986; Kokko et al., 1996). Thus, the level of technology of local firms in comparison to the level of technology of foreign firms is often used as a proxy for absorptive capacity. Indeed, if a local firm has well developed human capital and the technology gap is small, it can better handle and implement the advanced technology brought by foreign affiliates. If the technology gap is large and human capital low, the absorptive capacity is low, as the foreign technology might not be relevant for the

[5] Merlevede and Schoors (2006) introduce another spillover, following the theoretical model of Markusen and Venables (1999), namely the supply-backward spillover, arguing that foreign presence in downstream sectors may cause local sub-suppliers to increase their productivity and provide high-quality inputs that may positively influence also the productivity of their local customers

local firms or too difficult to implement.[6] However, taking into account nonlinearities when investigating the effect of absorptive capacity on productivity spillovers, firms both too close to and too far from the foreign technology frontier will benefit least from foreign presence, as firms with low technology level will lack resources to absorb new technologies (negative spillovers), while for firms with advanced technology level the potential to gain from spillovers is rather limited. The highest potential for spillovers hence exists for firms with medium technological level.

Similarly, export orientation of industries or firms has been found to affect the sensitivity of local companies to spillovers in both ways (Schoors and van der Tol, 2002; Sinani and Meyer, 2004). On the one hand, export-oriented firms are used to higher competition on foreign markets, are usually more productive than firms serving only local markets and, thus, may be better prepared to adapt advanced technologies. On the other hand, exporters may already be at a technology frontier that is comparable to the one of the foreign companies, reducing the potential for spillovers. Additionally, the export orientation of an industry, even if only foreign firms are exporting, creates a possibility for the market access spillovers. If, for example, a local firm is able to hire workers previously employed by a foreign company, it can use his or her knowledge about the foreign markets and increase the share of exports, which in turn puts pressure on productivity improvements. As a result, we do not have a clear guidance ex ante on whether we should expect export-oriented firms to benefit more from foreign presence.

Import competition arises when imported products are similar to those produced in the local economy. Consequently, competition in the market is higher in the sectors with high import competition compared to the sectors with lower import competition (Sjoholm, 1999). This can have two opposite effects on the potential for spillovers. On the one hand, competition forces domestic firms to produce more efficiently and increase their productivity, thus being more sensitive also to potential spillovers from foreign firms. On the other hand, if the competition from imports is too high, local firms may encounter problems to sell their products in local markets and suffer losses, a situation that decreases sensitivity to productivity spillovers. The effect of import competition on existence of spillovers has not been empirically tested enough to have a clear empirical evidence about the sign and size of this effect.

The effect of sectoral competition on the sensitivity to spillovers is similar to the effect of import competition, with most studies finding positive impact of competition on productivity (Kokko, 1994, 1996; Sjoholm, 1999).

[6] Some studies also use the level of R&D as a proxy for absorptive capability, arguing that it stimulates innovation and increases firm's ability to adapt to advanced technologies (Cohen and Levinthal 1989; Kinoshita 2001; Sinani and Meyer 2004).

Regarding the firm size, larger firms have greater resources, thus they are more capable to exploit innovative opportunities and benefit more from adapting advanced technology (Merlevede and Schoors, 2006). On the other hand, small and medium-sized companies are more flexible to adapt to new organizational and managerial practices and are an important source of innovations (Sinani and Meyer 2004). Thus, we cannot ex ante predict what type of firms will be more prone to spillovers.

Some studies investigated whether the degree of foreign ownership in firms defined as foreign (i.e. minority, majority or 100% ownership) and origin of foreign investors affects spillovers (Javorcik and Spatareanu, 2003; Javorcik 2004, Merlevede and Schoors, 2006). Local participation means higher potential for technology leakages and thus positive horizontal spillovers, but this in turn prevents foreign firms to bring the state-of-the-art technology, reducing the scope for spillovers.

In sum, the complexity of the channels trough which spillovers could arise, together with the uncertainty about their direction and possible non-linearities in the relationships make the estimation of spillovers very difficult.[7] In this paper, we focus on three selected conditions, namely absorptive capability, export orientation and the firm size.

4. Data Description and Analysis of Foreign Presence in the Manufacturing Sector

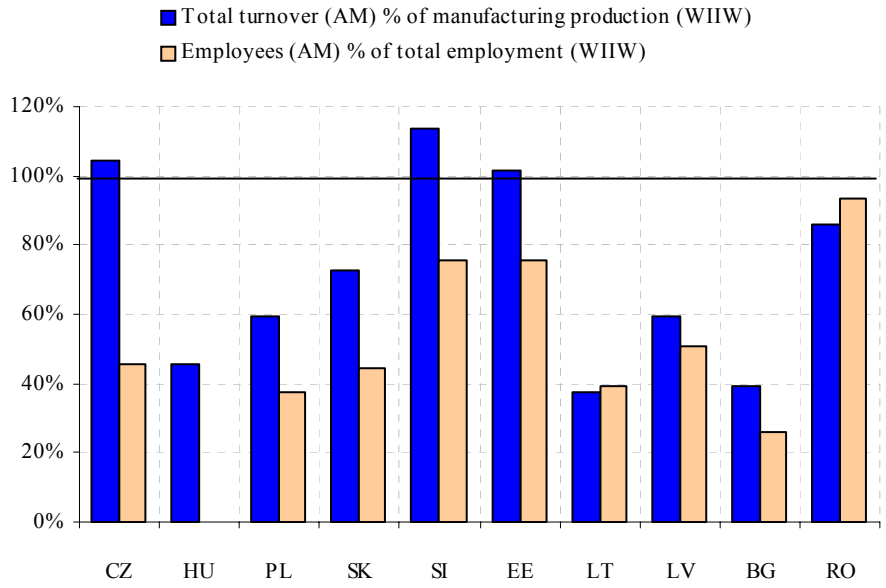
Database "Amadeus" provided by Bureau van Dijk (September 2006 release) is used as a source of firm-level data on CEE corporate sector. The data on companies' balance sheet items, profit and loss account and ownership constitute an unbalanced panel over the period 2000–2005.[8] We focus on manufacturing companies (NACE Rev. 1.1 2-digit industries 15–36) with minimum of 10 employees and fixed assets and turnover of at least 10,000 USD. The coverage of firms in Amadeus database differs across countries, with the firms' aggregated turnover representing between 40% and 100% of total manufacturing sector's production and between 30% and 90% of total manufacturing sector's employment (see chart 5).[9]

[7] Merlevede and Schoors (2005, 2006) explore the effect of interaction of different conditions on the existence of spillovers.

[8] Unfortunately, a given release of the Amadeus database does not include history of ownership information, thus the most recent information about the ownership status is used (i.e. as of September 2006) and assumed to be valid over the whole period of analysis.

[9] Figures higher than 100% are possible as the industrial manufacturing production in WIIW database includes only sales of goods classified as manufacturing, while the

Chart 5: The Coverage of Firms in Amadeus Database



Note: The chart shows total turnover and employment compared with WIIW database (in %)

Source: Amadeus, WIIW database.

In the countries with the best coverage in terms of manufacturing turnover (the Czech Republic, Slovenia, Estonia and Romania), the distribution of turnover according to the Amadeus data by individual NACE sectors is almost identical to the distribution reported by WIIW for aggregate figures (see table A1 in Appendix A). Furthermore, distributions of Amadeus and WIIW data are also comparable in the remaining countries, thus the used sample from Amadeus database is relatively representative of the actual manufacturing industries in the CEE countries.

Foreign companies are our proxy for FDI, despite the methodological difference (FDI is traditionally defined as a share of at least 10% of company's capital hold by non-residents). The Amadeus database allows defining foreign companies in many different ways. For the scope of this note, we define foreign company as a company with the global ultimate owner from a country outside the host country, or with immediate shareholders of the company from countries outside the host country which have a share of at least 51% of company's capital. The main reason to use the majority-ownership definition as a proxy for FDI is that most of the FDI

turnover data for firms in Amadeus represent total turnover, including also revenues from sales of non-manufacturing products and services.

related to relocation of production are majority-owned foreign companies and that the probability of technology transfer from foreign parent company to its subsidiary is higher if the parent company holds control over its subsidiary.

The number of foreign companies covered in our sample varies across the countries (table 1). Foreign firms represent from around 1% (Slovenia) to around 70% (Bulgaria) of the number of firms in the new EU countries.

Table 1: Relevance of Foreign Companies (in 2004)

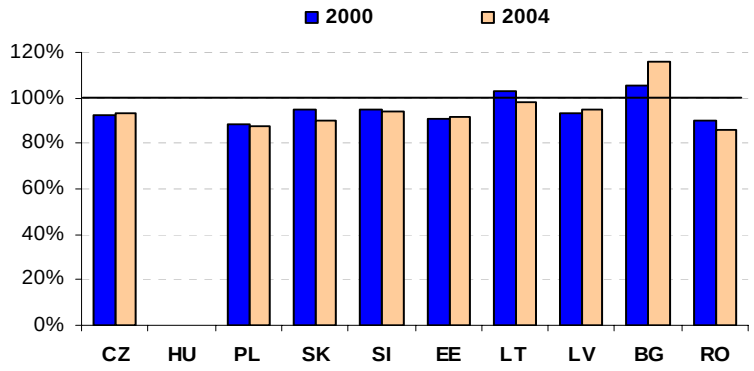
			% of foreign firms (2004) in:			
	No. of firms	of which: foreign firms	number of firms	total assets	turnover	employment
CZ	5011	618	12.3	38.9	37.1	23.4
HU	1625	57	3.5	26.7	29.2	n.a.
PL	5035	1131	22.5	56.4	56.8	35.1
SK	767	35	4.6	59.7	57.7	19.7
SI	1215	15	1.2	8.3	10.2	3.9
EE	1762	885	50.2	73.5	72.0	66.6
LT	921	584	63.4	71.2	73.5	67.7
LV	580	79	13.6	31.5	25.5	18.6
BG	1338	929	69.4	46.2	45.9	50.3
RO	13108	6053	46.2	78.0	75.0	65.1

Source: Amadeus.

In terms of total assets, the share of foreign firms is higher (between 8% in Slovenia and 78% in Romania in 2004) than in the number of firms and the same holds for the share of total turnover, employment and stock of investment, indirectly indicating that foreign firms are on average larger than domestic firms. However, over the period 2000–2004, foreign companies did not considerably increase their shares in total assets, turnover, employment or investment in many countries. This might indicate that domestic firms were able to compete or co-operate within the production chain with the foreign firms (charts A1 in Appendix A).

When comparing the average size of domestic and foreign firms in terms of total assets, stock of investment, employment and turnover, foreign companies are on average bigger, have more fixed assets, employ more people, and produce more (table A2 in Appendix A). This holds for all countries except Bulgaria, where the number of foreign firms as share in total number of firms is the highest. In most countries (except Slovakia, Slovenia and Romania), foreign companies are also more profitable (table A2).

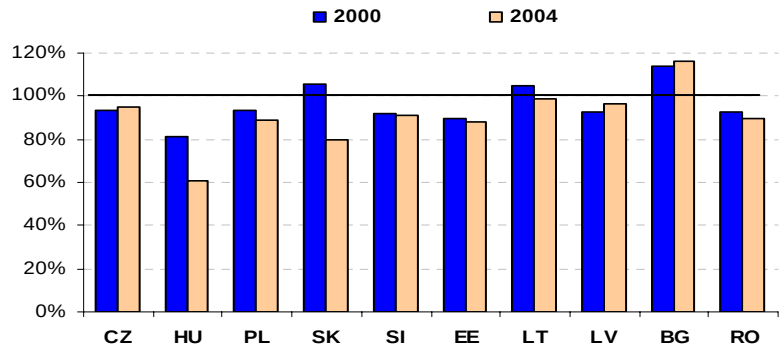
Chart 6: Average Labour Productivity of Domestic Firms (in % of Average Labour Productivity of Foreign Firms)



Note: Labour productivity for HU is missing due to insufficient coverage of data for employees in the Amadeus database.

Source: Amadeus.

Chart 7: Average Total Factor Productivity of Domestic Firms (in % of Average Total Factor Productivity of Foreign Firms)



Note: TFP = ln (total factor productivity) computed via Levinsohn and Petrin (2003) technique for individual industries or groups of industries for all firms.

Source: Amadeus.

Moreover, in most of the countries foreign companies have on average higher labour and total factor productivity (charts 6–7).

Tables A3 and A4 in Appendix A provide a detailed overview of manufacturing production across industries (14 NACE 2-digit sectors) and foreign versus domestic ownership of the firms. According to these tables almost all industries have foreign penetration. However, while foreign companies drive almost all industries' output in Estonia, Lithuania, Poland and Romania, domestic companies dominate in almost all industries' turnover in Czech Republic, Latvia, Hungary, and Slovenia. In Slovakia and Bulgaria some sectors are dominated by foreign whereas some are dominated by domestic companies.

As mentioned in Section 3 the role of export orientation of firms or industry is a factor that may contribute to higher sensitivity of domestic firms to spillovers. Table 2 highlights five most important industries in terms of exports. According to table 2, industries with higher value added and level of technology (such as machinery and equipments, electrical and optical equipment or transport equipment) belong to the most important exporters in the most countries. In these industries, stronger potential for spillovers exists. Nevertheless, in some countries the low-value-added industries are also important exporters.

Table 2: Exports by Manufacturing Industries (as % of Total Manufacturing Export to the EU-25 in 2004)

	CZ	EE	LV	LT	HU	PL	SK	SI	BG	RO
DA Food products, beverages and tobacco	3.1	6.5	**6.2**	**9.4**	4.3	7.1	2.8	1.2	**6.2**	1.3
DB Textiles and textile products	5.3	**10.1**	**7.7**	**15.9**	3.9	5.6	4.1	4.3	**28.9**	**31.3**
DC Leather and leather products	0.5	1.0	0.3	0.5	0.9	0.7	2.2	1.3	5.4	**11.0**
DD Wood and wood products	1.5	**10.5**	**24.3**	5.8	0.8	3.2	1.8	2.2	1.9	3.6
DE Pulp, paper and paper products; publishing and printing	3.2	1.4	1.4	0.9	1.3	3.1	3.3	3.3	1.1	0.5
DF Coke, refined petroleum products and nuclear fuel	1.1	**11.8**	**29.2**	**25.1**	1.6	2.8	**6.8**	0.1	2.1	2.4
DG Chemicals, chemical products and man-made fibres	**5.8**	4.5	4.8	**8.7**	**5.4**	5.6	5.7	8.4	5.4	2.8
DH Rubber and plastic products	5.3	2.1	1.5	3.3	2.8	4.4	4.1	4.0	1.4	2.5
DI Other non-metallic mineral products	3.1	1.6	1.4	0.8	1.2	2.3	2.1	2.1	2.1	1.4
DJ Basic metals and fabricated metal products	**13.6**	**10.3**	**10.3**	6.6	**6.0**	**13.2**	**14.8**	**14.3**	**26.1**	**10.2**
DK Machinery and equipment n.e.c.	**12.7**	4.1	2.5	2.3	**7.7**	**7.1**	**7.4**	**13.7**	**7.9**	6.3
DL Electrical and optical equipment	**21.4**	**22.5**	4.1	**9.5**	**40.4**	**13.2**	**13.2**	**10.5**	**6.4**	**13.3**
DM Transport equipment	**19.6**	8.0	1.9	3.7	**22.1**	**22.9**	**29.4**	**25.7**	1.4	**6.8**
DN Manufacturing n.e.c.	3.7	5.6	4.3	7.3	1.7	**8.8**	2.3	**8.9**	3.6	6.6
Total	100	100	100	100	100	100	100	100	100	100

Note: Shadow indicates top five industries in terms or export share in total manufacturing exports to the EU-25.

Source: WIIW.

5. Estimation Strategy

Estimating direct effects of FDI is not easy as we lack the data on past ownership of firms to test the additional effect of foreign entry into domestic market. In addition, foreign firms are usually targeting larger and more productive firms, thus a selection bias arises when just comparing the performance of foreign versus domestic firms[10]. Thus, in line with the objective of this paper stated in the beginning, we focus on indirect effects only.

Traditional approach when analyzing productivity is to estimate a production function and use the residuals not explained by the input factors (capital, labour) as a proxy for total factor productivity (Solow residuals). However, as Levinsohn and Petrin (2003) point out, when estimating the production function, one must account for the correlation between input levels and productivity, as profit-maximizing firms respond to increase in productivity by increase of usage of factor inputs. Thus, methods that ignore this endogeneity such as OLS or the fixed-effects estimator inevitably lead to inconsistent estimates of the parameters of the production function.

In line with recent literature, we employ a semi-parametric approach suggested by Olley and Pakes (1996) and modified by Levinsohn and Petrin (2003). This method allows for firm-specific productivity differences that exhibit idiosyncratic changes over time. The technique is described in detail in Appendix B. Using this technique, we estimate a log-linear transformation of a Cobb-Dougals production function:

$$va_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \varepsilon_{it} \quad (1)$$

where va_{it} is log of value added of a firm i, l_{it} is log of labour input, k_{it} is log of capital. The estimation is done for each manufacturing sector j (at a 2-digit NACE level) separately, using a sample of domestic firms only.[11] Value added enters the equation as real value added, computed as real turnover minus real material costs.[12] The data on operating turnover were deflated by the producer price index for the corresponding 2-digit NACE sector, while material costs were deflated by

[10] Some studies use Heckman-correction model to account for the selection bias (Damijan et al., 2003) or have information on past ownership (Arnold et al., 2006).

[11] Following Arnold et al. (2006), we group similar 2-digit sectors together to get a larger number of observations. For CZ, HU, PL, SI, LT and RO 15 manufacturing sectors were constructed (NACE 15+16, 20+21+36, 23+24, 30+31, 32+33 and 34+35 were grouped), while for SK, EE, LV and BG 7 manufacturing sectors were constructed (NACE 15+16, 17+18+19, 20+21+22+36, 23+24+25+26, 27+28, 30+31+32+33 and 29+34+35 were grouped).

[12] In SI and LT, the data on material costs were not available, thus a proxy for material costs was used: for SI, the proxy was computed as operating turnover minus EBIT minus depreciation minus costs of employees, while for LT the proxy "costs of goods sold" was used.

unweighted average of total manufacturing producer price index and import price index. Labour input refers to number of employees.[13] For capital input, the stock of fixed assets was used, deflated by the average of the deflators for the following NACE sectors: machinery and equipment (29), office machinery and computing (30), electrical machinery and apparatus (31), motor vehicles, trailers and semi-trailers (34) and other transport equipment (35).[14]

A measure of log of total factor productivity tfp_{it} is obtained as the difference between log of value added and log of capital and log of labour, multiplied by their estimated coefficients:

$$tfp_{it} = va_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it\,t} \tag{2}$$

In the second step, we relate total factor productivity to foreign presence variables (horizontal, backward and forward) and other control variables (Herfindahl index as a proxy for the level of concentration and thus competition within the sector and year and firm fixed effects), estimating an unbalanced panel of local firms via fixed-effects estimator.[15]

$$tfp_{ijt} = \alpha_0 + \alpha_1 horizontal_{jt} + \alpha_2 backward_{jt} + \alpha_3 forward_{jt} + \\ + hhi_{jt} + \alpha_i + \alpha_t + \varepsilon_{ijt} \tag{3}$$

While the estimation of *tfp* is done on sectoral level, the fixed-effects estimation of spillovers is done on the level of the entire sample of domestic firms.

The $horizontal_{jt}$ variable is a proxy for foreign presence in the same sector and is defined as the share of foreign firms' output in total sector output:

$$horizontal_{jt} = \frac{\sum_{i \in j} foreign_{it}\, x\ turnover_{it}}{\sum_{i \in j} turnover_{it}} \tag{4}$$

The variable *foreign* is a dummy variable that equals 1 if the company *i* is a foreign company, and 0 otherwise. The higher the value of output produced by foreign

[13] In HU, the data on number of employees was missing, thus the costs of employees deflated by CPI was used instead, an approach followed for example by Arnold et al. (2006).

[14] This approach follows Javorcik (2004). Alternatively, then capital could be deflated using the GDP deflator, see Damijan et al. (2003), or even capital stock deflator if available, see Arnold et al. (2006).

[15] Most studies on spillovers use fixed effects estimator, both due to economic reasoning (heterogeneity among firms due to managerial skills etc.) and econometric assumptions (possible correlation between regressors and firm effects). A notable exception is Jarolím (2000) who uses random effects model. However, the Hausman test showed that in our case the hypothesis of no correlation between regressors and individual effects can be rejected, thus fixed-effects model is appropriate.

firms and the higher the number of foreign firms in the sector *j*, the higher is the variable *horizontal* and thus the potential for horizontal spillovers.

The variables $backward_{jt}$ and $forward_{jt}$ are proxies for the potential for vertical spillovers. The variable *backward* stands for foreign presence in linked downstream sectors (to which a local company supplies its inputs). Ideally, one would need the share of firm's output sold to foreign firms. As this information is not available, we use input-output tables to trace inter-industry supply linkages and proxy the share of firm's output sold to foreign companies by the share of sector's output for intermediate consumption within the domestic economy sold to foreign companies in downstream sectors. The input-output tables reveal the information about the amount supplied by the sector *j* to its sourcing sector *k*. In addition, we employ the information about the foreign presence in sector *k* (the variable *horizontal*). Thus, variable $backward_{jt}$ is defined as

$$backward_{jt} = \sum_{k\ if\ k \neq j} \gamma_{jkt} horizontal_{kt} \tag{5}$$

where γ_{jkt} is the proportion of sector *j*'s output supplied to sourcing sectors *k* and is calculated using the input-output table for domestic intermediate consumption (i.e. excluding imports).[16] In addition, intra-industry supplies are not accounted for, as this effect is captured by the variable *horizontal*.

Similarly, the variable $forward_{jt}$ captures the potential for forward vertical spillovers to local firms that buy inputs from foreign firms and is defined as

$$forward_{jt} = \sum_{l\ if\ l \neq j} \delta_{jlt} horizontal_{lt} \tag{6}$$

where δ_{jlt} is the proportion of sector *j*'s inputs purchased from upstream sectors *l*. Nor in this case is it accounted for intra-industry supplies, as this effect is captured by the variable *horizontal*. Note that for both cases, the weights γ_{jkt} and δ_{jlt} are calculated using the proportion in total output for intermediate consumption (or total input used), not only the output (input) supplied to (bought from) the manufacturing sectors (thus, the sum of γ_{jkt} or δ_{jlt}, respectively, is not equal to 1).

To capture possible non-linear impact of all three variables representing foreign presence in the economy, we in addition include squared *horizontal*, *backward* and *forward*:

[16] Ideally, one would need a series of I-O tables to capture the dynamics of inter-industry trade. Due to data limitation, we employ the last available I-O table for domestic intermediate consumption (CZ 2003, HU 2000, PL 2000, SI 2001, EE 2000, LT 2000) or – if only the use tables including imports are available – the use tables (SK 2000, BG 2001, RO 2003). For LV, I-O tables after 2000 were not available, thus the I-O table for domestic intermediate consumption for the last available year 1998 was used.

$$tfp_{ijt} = \alpha_0 + \alpha_1 horizontal_{jt} + \alpha_2 horizontal_{jt}^2 + \alpha_3 backward_{jt} + \\ + \alpha_4 backward_{jt}^2 + \alpha_5 forward_{jt} + \alpha_6 forward_{jt}^2 + hhi_{jt} + \alpha_i + \alpha_t + \varepsilon_{ijt} \quad (7)$$

6. Estimation Results

As we have seen above, foreign firms outperform local firms in productivity levels, so there is some potential for spillovers we are interested in within our analysis.

Table 3 presents the results of estimation of equation (3). First, the vertical effects tend to be higher and thus economically much more important than horizontal effects. This is similar to findings by Merlevede and Schoors (2005, 2006) or Javorcik (2004).

Table 3: Horizontal and Vertical Spillovers (Linear Effects)

	CZ	HU	PL	SK	SI	EE	LT	LV	BG	RO
horizontal	-0.285**	-0.040	0.347**	-0.046	0.119	0.141	-1.030***	0.156	-0.480**	-0.855***
backward	-0.272	1.446	0.283	0.609	1.071***	4.326**	1.616	-11.344***	-0.911	2.547*
forward	0.219	-4.151***	-1.587	-0.729	-22.584***	0.162	-0.579	0.882	-0.905	0.478
hhi	0.107	-0.061	-0.172	0.202	-0.060	-0.233	-1.048**	0.315	-0.487	-1.665***
Obs.	11386	6864	10267	1772	4667	3580	1177	2186	2075	31831
Firms	3850	2581	3159	641	1287	898	444	575	428	7143
R-squared	0.10	0.01	0.03	0.01	0.11	0.00	0.08	0.07	0.02	0.01

*Note: Dependent variable: ln TFP; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects.*

Second, horizontal effects seem to be negative in a number of countries (the Czech Republic, Lithuania, Bulgaria and Romania,). They are found to be positive only in Poland, while in other countries they are insignificant. This is contrary to the findings by Damijan et al. (2003) who found rather positive albeit small horizontal spillovers when analyzing these countries in the late 1990s.[17] Our findings indicate a potential for the market stealing effect after 2000 and some crowding-out of the domestic firms, but they might also be reflecting continued FDI inflow in these countries (i.e. purchases of more productive local firms by foreign companies). Furthermore, it is interesting to note that horizontal spillovers turned significant in the Czech Republic, Poland, Lithuania, Bulgaria, Romania, i.e. countries where the potential for horizontal spillover is higher (i.e. countries with the largest number of

[17] However, it is in line with Torlak (2004) who found small and negative horizontal spillovers as well in the late 1990s for the Czech Republic and Romania.

foreign firms and highest share of foreign firms' turnover), with exception being Estonia, and to a lesser extent Slovakia (which also have relatively large potential).

Third, we find that backward spillovers tend to be positive (if they are significant as is the case in Slovenia, Estonia and Romania), while forward spillovers tend to be negative (significant in Hungary and Slovenia). This finding corresponds to finding by Damijan et al. (2003), who also found positive backward and negative forward spillovers to domestic companies, although for partly different countries than we did (both positive backward spillovers and negative forward spillovers were found for the Czech Republic, Poland and Slovenia, for other countries the vertical effects were insignificant). In line with the theoretical reasoning underlying the spillover channels, our findings suggest that being a sub-supplier to foreign companies has a beneficial effect on a firm's productivity development. On the other hand, larger foreign presence in upstream sectors affects negatively the productivity of local firms, suggesting that inputs produced by foreign companies are probably mostly used by foreign companies, thus the gap in total factor productivity between local and foreign firms may increase. This might be also in line with some anecdotic evidence from these countries in some supply networks such as automotive or ICT industries (European Commission, 2003).

Concentration as measured by Herfindahl index in our results is significant only for Lithuania and Romania, with the effect of concentration on productivity being negative, suggesting that less concentrated sectors (i.e. sectors with more competition) benefit more in terms of productivity increases.

Table 4 presents the results with non-linear effects. The findings can be summarized as follows: first, if horizontal spillovers exist, they tend to be highly non-linear. Interestingly, in the Czech Republic the effect is positive up to a certain level of foreign ownership, but turns negative after the foreign presence exceeds a certain threshold (around 50%). In other countries (Hungary, Bulgaria and Romania), the effect is just opposite: it starts negative, eventually turning positive with an increasing level of foreign presence. For Romania, the result is in line for late 1990s by Merlevede and Schoors (2005).

Table 4: Horizontal and Vertical Spillovers (Non-Linear Effects)

	CZ	HU	PL	SK	SI	EE	LT	LV	BG	RO
horizontal	0.721**	-0.967**	0.534	0.037	-0.235	-1.201	0.874	-0.068	-2.583***	-2.625***
horizontal^2	-1.468***	1.033**	-0.214	-0.075	0.413	1.077	-1.515	0.772	2.431***	1.337*
backward	4.188**	0.993	2.433	0.333	2.195	2.819	-18.591	-33.968***	4.798	-53.211***
backward^2	-10.976**	13.184	-4.935	0.604	-2.035	2.356	30.114*	125.548**	-12.454	96.549***
forward	1.851*	-3.767**	-6.410*	1.105	23.114**	-0.630	-12.096*	6.747*	-2.627	9.352***
forward^2	-5.973*	-0.666	14.377	-3.633	5.892	2.106	23.530*	-18.039	3.043	-5.759
hhi	0.642***	-0.159**	-0.146	0.226	-0.135	-0.475	-1.013**	0.145	-1.078**	-1.394***
Obs.	11386	6864	10267	1772	4667	3580	1177	2186	2075	31831
Firms	3850	2581	3159	641	1287	898	444	575	428	7143
R-squared	0.03	0.01	0.07	0.06	0.13	0.00	0.00	0.06	0.01	0.01

*Note: Dependent variable: ln TFP; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects.*

Second, for the backward spillovers, we find opposite effects for the Czech Republic compared to Latvia and Romania. In the Czech Republic, backward spillovers are again positive up to a certain threshold of foreign presence in downstream sector (around 40%) after which the effect turns into negative. In Latvia and Romania, on the contrary, the effect starts as negative, turning into positive after a certain threshold (in Latvia around 30% and in Romania of around 50%). Third, in those countries where the forward spillovers are non-linear (the Czech Republic, Lithuania) the effect again differs. In the Czech Republic, spillovers are first positive and then turn negative with an increasing foreign presence in the upstream sectors. In Lithuania, on the other hand, the effect first is negative and then turns positive when foreign presence is higher. In most countries, however, forward effects are found to be just linear and rather negative than positive (with exception of Romania).

Interestingly, in this specification the effect of concentration is positive for the Czech Republic (i.e. lower competition is beneficial for productivity) while for four other countries it is negative (i.e. higher competition is beneficial).

In the following three estimations (results presented in tables A5 – A10 in Appendix A), we split the sample by a certain characteristic in order to detect differences in the pattern of spillovers across different groups of firms (so-called conditional spillovers). We employ the breakdown by absorptive capability, export orientation, and firm size. We always estimate the equation (3) with linear effects only in order to make interpretation easier.

We define absorptive capability in terms of relative productivity performance of domestic companies vis-à-vis foreign companies in the same sector. Following

Merlevede and Schoors (2005), we apply the Levinsohn and Petrin (2003) technique on the whole sample of firms (including foreign firms) and retrieve the total factor productivity for individual firms. Again, this estimation is done by industries (in the same grouping of industries as in the estimation done on domestic companies only). The absorptive capability AC_{ijt} for a firm *i* and the year *t* is then defined as the distance between firm's *i* total factor productivity in the year *t-1* (to avoid endogeneity) and the "foreign productivity frontier" that is defined as the 90 percentile productivity of foreign firms in the sector *j* and time *t-1*.

We split the sample into three groups by the absorptive capability. In the group with low *AC*, firm-years were placed with *AC* below 25 percentile of average *AC* distribution across all firms. Medium *AC* group contains firm-years with *AC* between 25 and 75 percentile, while high *AC* group includes firm-years with *AC* above the 75 percentile.

Tables A5 and A6 present the results. Again, the results are rather mixed across countries. According to theory, we expected some positive spillovers in the group of firms with medium absorptive capability, as these have most probably a productivity gap to fill and at the same time some basic level of technology that enables them to adapt to better technologies. In five out of the ten countries, we indeed find positive spillovers, in Romania both horizontal and vertical, while in other countries just some of them. Negative or insignificant spillover effects were expected in the groups with both low and high absorptive capability, a fact only partly confirmed by the results. However, there are also many negative spillovers in all groups of firms, including those with high absorptive capability, suggesting that some "brain drain" effects are likely to be taking place.

Tables A7 and A8 present the results by export orientation of sectors. As low export orientation industries are identified those NACE 2-digit sectors with exports to EU-25 as a share of sectoral output below 25 percentile of export share. Sectors with medium export orientation have export shares between 25 and 75 percentile, while sectors with high export orientation have export shares above 75 percentile.

Following the theoretical reasoning, we expected firms in more export-oriented sectors to be more prone to positive spillovers. However, the results support this hypothesis only in the Czech Republic, and partly in Estonia. In most other countries, negative spillovers are detected also for the sectors with high exports. This seems to indicate that exports are largely driven by foreign rather than domestic companies, and, as a result, the productivity gap between domestic and foreign firms increases with higher export orientation of the industry.

Tables A9 and A10 present the results by the firm size. We differentiate between small firms (up to 50 employees), medium-sized firms (between 50 and 250 employees) and large firms (more than 250 employees).[18] We expected medium-sized companies to be able to benefit most from spillovers. This

[18] For Hungary, reliable data on number of employees were not available.

hypothesis is supported only partly for the Czech Republic, Poland, Slovakia and Romania, while in other countries the pattern of spillovers across firm sizes differs.

7. Conclusions

In this paper, we discussed the inflow of foreign direct investment into the CEE countries and analysed indirect effects of FDI on productivity, so-called productivity spillovers from foreign to domestic firms. Using firm-level data and techniques that control for simultaneity bias due to the effect of unobservable productivity shocks on the level of input choice, we recovered total factor productivity of domestic firms and linked it to foreign presence in the same sector (horizontal spillovers) and in the sectors linked via production chain (vertical spillovers).

We find that vertical effects tend to be higher and thus economically much more important than horizontal effects, which is in line with previous studies. In addition, we found that in many cases the spillovers are negative, thus foreign presence might have also some adverse impact on productivity of local firms, for example via brain drain or market stealing effects.

Furthermore, we found strong nonlinearities in the effect of foreign presence on local firms' productivity. In addition, we found that spillovers depend on number of industry and firm-level characteristics including the relative technological level vis-à-vis foreign firms (absorptive capacity), export orientation, or firm size. Theory and anecdotic evidence often support both positive and negative effect of horizontal and vertical spillovers. However, according to our results the existence of horizontal and vertical spillovers using different breakdowns according to characteristics differ across CEE countries, and no common pattern was detected. While some part of the difference might be due to different quality of the data and the degree of coverage, some economic and institutional variables may still play a role in explaining these differences. Additionally, the definition of the foreign company is very narrow in our study and further investigation by expanding sample including companies with smaller than 51% foreign ownership would shed additional light on the issue.

This study, focusing on the period after 2000, further supports the mixed evidence on spillovers discussed in the literature focusing on the 1990s. The CEE countries, now members of the EU, have been successful in attracting FDI at least over the past decade and experienced surprisingly positive economic developments since 2000. However, the effects of foreign firms on the host economies and indirect effects on the local firms are different across countries and depend also on other conditions and characteristics on the firm-, industry- and national level as well on the nature of FDI, issues that have to be analysed more thoroughly.

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Appendix A

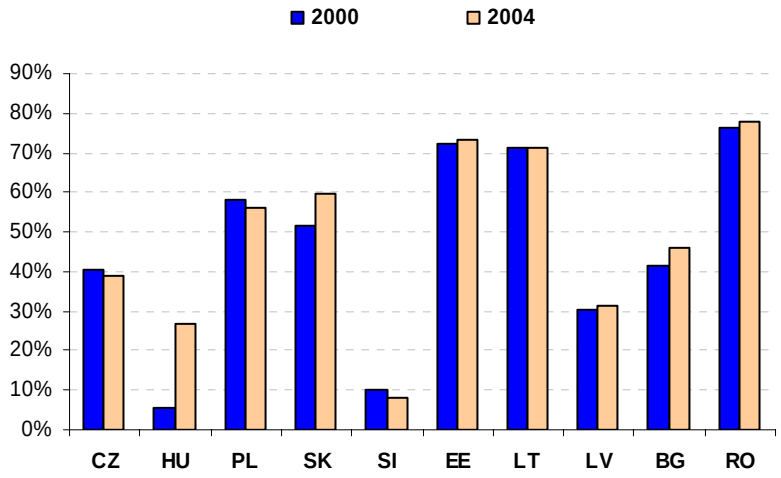
Table A1: Distribution of Manufacturing Turnover by NACE Sectors in 2004

	CZ		HU		PL		SK		SI		EE		LT		LV		BG		RO	
	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI
DA	14.4	11.5	13.7	14.1	25.8	20.2	8.1	9.0	10.3	10.8	18.5	17.2	28.2	19.3	32.8	24.8	16.8	19.2	20.8	19.1
DB	2.5	2.8	2.0	2.3	2.4	3.5	1.6	2.0	6.6	4.8	9.5	8.9	7.5	10.6	8.4	6.2	7.5	9.7	8.1	7.9
DC	0.1	0.2	0.2	0.4	0.3	0.6	1.1	1.4	2.0	1.5	0.5	0.6	0.5	0.3	0.1	0.1	0.8	0.9	2.1	2.2
DD	1.5	1.9	0.5	1.1	3.0	3.6	0.7	1.3	2.0	2.7	15.6	16.7	9.0	6.3	19.2	23.4	2.2	2.2	3.5	3.7
DE	4.5	4.1	3.9	3.6	5.7	6.0	6.0	4.5	5.8	6.6	5.7	6.3	6.0	4.1	5.3	6.5	9.7	4.3	3.5	3.1
DF	4.3	2.8	0.0	5.0	1.9	5.9	16.3	8.1	0.1	0.1	1.0	0.0	0.4	25.4	0.0	0.0	0.0	14.4	6.7	11.7
DG	6.4	5.9	6.1	7.0	7.3	7.1	3.1	3.9	12.9	12.4	5.6	4.9	4.2	5.3	2.4	2.8	6.2	6.4	5.9	7.4
DH	6.7	6.2	17.5	3.6	4.7	5.5	6.5	4.3	6.5	5.4	4.4	3.9	7.8	3.9	4.1	3.1	3.5	2.9	4.3	3.1
DI	5.4	5.3	3.8	2.6	4.2	4.8	2.8	4.0	3.5	4.0	5.1	5.3	4.3	2.9	5.7	4.1	4.4	5.1	4.6	4.3
DJ	10.9	15.3	6.4	8.7	8.6	12.6	14.6	15.5	15.2	14.9	9.3	9.0	6.2	3.4	7.9	4.5	35.8	19.0	17.8	16.7
DK	7.7	7.8	2.9	5.2	7.3	5.4	4.2	7.3	10.8	12.2	3.1	3.3	3.2	2.6	1.9	3.1	3.1	7.2	5.1	4.1
DL	15.8	15.1	36.0	30.4	7.9	7.2	5.0	10.9	10.6	9.0	10.1	9.9	14.0	7.8	5.0	3.1	7.7	4.6	6.2	4.3
DM	17.2	17.7	5.7	14.8	17.5	12.2	28.1	24.5	10.1	10.6	4.5	5.3	3.4	2.1	2.6	3.3	0.9	1.7	7.7	7.0
DN	2.6	3.4	1.5	1.1	3.3	5.4	1.8	3.2	3.7	4.9	7.2	8.7	5.3	6.1	4.5	15.0	1.4	2.4	3.8	5.2
Average absolute difference	0.9		3.0		2.0		2.2		0.8		0.7		4.3		2.6		3.7		1.2	

Note: In % of total manufacturing turnover; Amadeus versus WIIW.

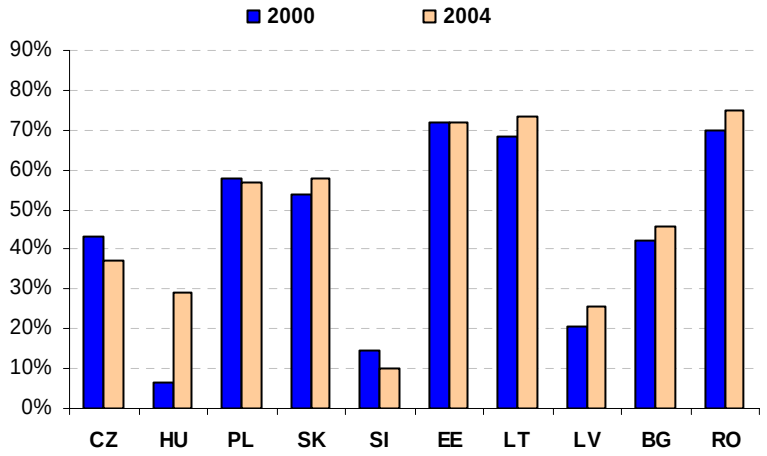
Source: WIIW, Amadeus.

Chart A1: Share of Foreign Firms in Total Assets (in %)



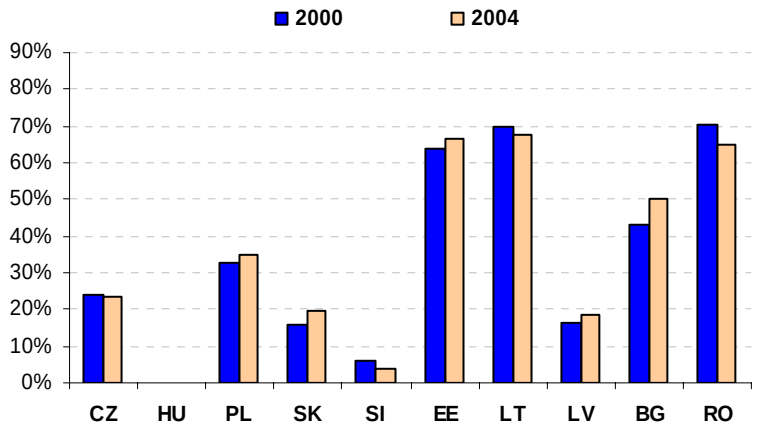
Source: Amadeus.

Chart A2: Share of Foreign Firms in Total Turnover (in %)



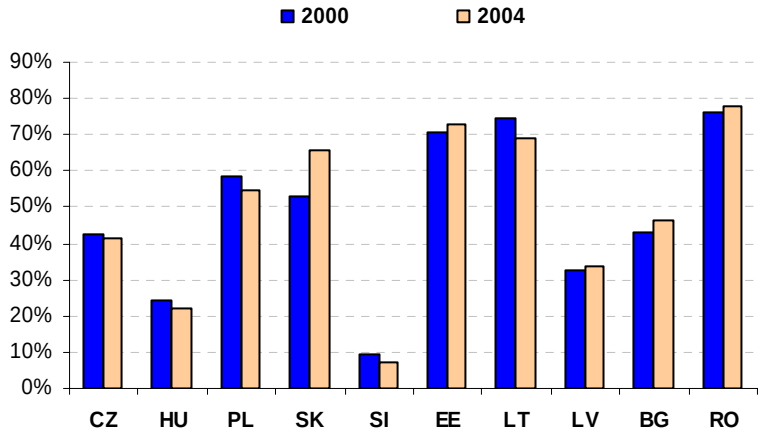
Source: Amadeus.

Chart A3: Share of Foreign Firms in Employees (in %)



Source: Amadeus.

Chart A4: Share of Foreign Firms in Fixed Assets (in %)



Source: Amadeus.

Table A2: Descriptive Statistics by Ownership Status (in National Currency or %, as of 2004)

	CZ	HU	PL	SK	SI	EE	LT	LV	BG	RO
average total assets domestic	195.4	1989.1	22.8	261.7	2908.5	16.2	7932.6	1596.5	12.4	3.2
average total assets foreign	886.6	16211.8	101.7	8108.6	21100.1	44.5	11338.9	4674.1	4.7	13.3
domestic as % of foreign	22.0%	12.3%	22.4%	3.2%	13.8%	36.3%	70.0%	34.2%	262.2%	24.3%
average stock of investment domestic	92.3	487.9	11.3	139.4	1670.7	8.6	4633.3	796.5	7.0	1.8
average stock of investment foreign	462.5	3054.8	47.4	5581.4	10425.4	23.2	5921.0	2549.7	2.7	7.1
domestic as % of foreign	20.0%	16.0%	23.8%	2.5%	16.0%	37.1%	78.3%	31.2%	258.5%	24.8%
average employment domestic	155.3	184.7	162.3	253.9	140.1	39.7	83.0	126.8	190.1	69.0
average employment foreign	335.4	2913.4	292.6	1023.9	447.2	84.3	100.5	184.5	84.8	150.5
domestic as % of foreign	46.3%	6.3%	55.5%	24.8%	31.3%	47.1%	82.5%	68.7%	224.1%	45.8%
average turnover domestic	320.9	2850.7	37.7	400.4	3063.5	25.0	8.6	2.5	12.6	4.5
average turnover foreign	1347.7	32415.5	171.6	11403.0	27768.2	63.6	13.8	5.4	4.7	15.8
domestic as % of foreign	23.8%	8.8%	22.0%	3.5%	11.0%	39.2%	62.4%	46.0%	267.3%	28.6%
average ROE domestic	19.4	12.9	21.9	12.3	11.2	6.0	11.9	15.2	10.5	44.6
average ROE foreign	23.9	38.2	29.8	3.3	10.4	11.5	16.7	41.6	21.0	40.0
domestic as % of foreign	81.3%	33.7%	73.7%	369.1%	107.8%	52.2%	71.3%	36.5%	50.0%	111.5%

Note: ROE = return on equity; for SI, RO computed using P/L for period, otherwise P/L before tax is used.

Source: Amadeus.

Table A3: Total Turnover – Domestic versus Foreign Ownership Breakdown across Industries (2004, : D = domestic firms, F = Foreign Firms)

	CZ			HU			PL			SK			SI		
	Total	of which:		Total	of which:		Total	of which:		Total	of which:		Total	of which:	
		D	F		D	F		D	F		D	F		D	F
DA	14.4	67.4	32.6	13.7	77.1	22.9	25.8	53.9	46.1	8.1	85.3	14.7	10.3	95.6	4.4
DB	2.5	83.9	16.1	2.0	39.2	60.8	2.4	72.6	27.4	1.6	100.0	0.0	6.6	94.4	5.6
DC	0.1	96.3	3.7	0.2	100.0	0.0	0.3	73.6	26.4	1.1	90.2	9.8	2.0	100.0	0.0
DD	1.5	95.8	4.2	0.5	98.0	2.0	3.0	62.9	37.1	0.7	100.0	0.0	2.0	100.0	0.0
DE	4.5	67.2	32.8	3.9	98.2	1.8	5.7	41.2	58.8	6.0	89.9	10.1	5.8	88.1	11.9
DF	4.3	90.2	9.8	0.0	100.0	0.0	1.9	33.8	66.2	16.3	0.0	100.0	0.1	100.0	0.0
DG	6.4	77.0	23.0	6.1	69.1	30.9	7.3	46.3	53.7	3.1	65.1	34.9	12.9	89.7	10.3
DH	6.7	54.4	45.6	17.5	97.4	2.6	4.7	40.6	59.4	6.5	99.9	0.1	6.5	99.3	0.7
DI	5.4	54.2	45.8	3.8	58.8	41.2	4.2	47.5	52.5	2.8	76.6	23.4	3.5	96.5	3.5
DJ	10.9	70.1	29.9	6.4	89.8	10.2	8.6	64.3	35.7	14.6	35.6	64.4	15.2	96.0	4.0
DK	7.7	82.3	17.7	2.9	94.8	5.2	7.3	49.6	50.4	4.2	87.5	12.5	10.8	100.0	0.0
DL	15.8	70.3	29.7	36.0	53.7	46.3	7.9	27.0	73.0	5.0	86.8	13.2	10.6	87.5	12.5
DM	17.2	26.0	74.0	5.7	38.8	61.2	17.5	12.6	87.4	28.1	8.5	91.5	10.1	48.0	52.0
DN	2.6	60.7	39.3	1.5	100.0	0.0	3.3	49.4	50.6	1.8	23.6	76.4	3.7	100.0	0.0
Total	100.0	62.9	37.1	100.0	70.8	29.2	100.0	43.2	56.8	100.0	42.3	57.7	100.0	89.8	10.2

Source: Amadeus.

Table A4: Total Turnover – Domestic versus Foreign Ownership Breakdown across Industries (2004, : D = domestic firms, F = Foreign Firms)

	EE			LT			LV			BG			RO		
	Total	of which:		Total	of which:		Total	of which:		Total	of which:		Total	of which:	
		D	F		D	F		D	F		D	F		D	F
DA	18.5	34.9	65.1	28.2	28.6	71.4	32.8	81.0	19.0	16.8	59.9	40.1	20.8	34.0	66.0
DB	9.5	17.4	82.6	7.5	23.9	76.1	8.4	79.7	20.3	7.5	62.6	37.4	8.1	29.6	70.4
DC	0.5	38.3	61.7	0.5	35.8	64.2	0.1	100.0	0.0	0.8	69.7	30.3	2.1	24.4	75.6
DD	15.6	32.8	67.2	9.0	19.2	80.8	19.2	59.2	40.8	2.2	85.9	14.1	3.5	37.0	63.0
DE	5.7	42.0	58.0	6.0	29.6	70.4	5.3	83.1	16.9	9.7	60.6	39.4	3.5	29.4	70.6
DF	1.0	67.4	32.6	0.4	0.0	100.0	0.0	n.a.	n.a.	0.0	0.0	100.0	6.7	2.7	97.3
DG	5.6	7.2	92.8	4.2	19.1	80.9	2.4	85.3	14.7	6.2	68.1	31.9	5.9	18.6	81.4
DH	4.4	30.8	69.2	7.8	41.7	58.3	4.1	78.8	21.2	3.5	32.6	67.4	4.3	29.4	70.6
DI	5.1	40.8	59.2	4.3	27.9	72.1	5.7	25.5	74.5	4.4	31.0	69.0	4.6	22.3	77.7
DJ	9.3	25.7	74.3	6.2	26.1	73.9	7.9	87.7	12.3	35.8	48.7	51.3	17.8	17.5	82.5
DK	3.1	37.9	62.1	3.2	54.4	45.6	1.9	58.8	41.2	3.1	51.1	48.9	5.1	27.2	72.8
DL	10.1	12.5	87.5	14.0	12.0	88.0	5.0	84.4	15.6	7.7	54.2	45.8	6.2	27.7	72.3
DM	4.5	19.1	80.9	3.4	23.2	76.8	2.6	88.4	11.6	0.9	70.1	29.9	7.7	19.6	80.4
DN	7.2	28.0	72.0	5.3	35.4	64.6	4.5	87.5	12.5	1.4	31.4	68.6	3.8	36.9	63.1
Total	100.0	28.0	72.0	100.0	26.5	73.5	100.0	74.5	25.5	100.0	54.1	45.9	100.0	25.0	75.0

Source: Amadeus.

Table A5: Spillovers by Absorptive Capability

	CZ			HU			PL			SK			SI		
	low ac	medium ac	high ac	low ac	medium ac	high ac	low ac	medium ac	high ac	low ac	medium ac	high ac	low ac	medium ac	high ac
horizontal	-0.759	-0.467*	-0.267	5.418	1.151	-0.046	0.739*	0.048	0.558	0.407	-0.239	-0.282	-6.065***	1.736***	0.614
backward	-3.016	-0.787	-1.822	-9.807	2.177	1.196	10.546**	-1.074	0.867	-10.607	1.701	0.491	-67.009**	-1.569	0.658
forward	1.812	1.636***	0.071	-21.777***	-5.998	-4.728***	-3.562	-3.105*	0.420	-10.712	-307	-0.241	-23.645	4.764	-28.381***
hhi	1.251*	0.414	-0.206	-22.737**	-1.459	-0.079	-1.262**	-0.085	-0.756	1.297**	0.156	0.118	-3.429***	0.357	0.054
Observations	1683	3409	6294	396	910	5558	1874	3550	4843	181	366	1225	276	646	3745
Firms	1034	1946	3850	322	695	2581	1013	1770	3159	126	237	641	178	345	1287
R-squared	0.08	0.18	0.01	0.02	0.02	0.01	0.01	0.03	0.03	0.01	0.02	0.01	0.01	0.07	0.10

*Note: Dependent variable: ln TFP; ac = absorptive capability defined as industry-specific distance to foreign productivity frontier, estimated via Levinsohn and Petrin (2003) technique on previous years; low ac = firm-years with ac below 25 percentile of ac distribution; medium ac = firm-years with ac between 25 and 75 percentile; high ac = firm-years with ac above 75 percentile; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects.*

Table A6: Spillovers by Absorptive Capability

	EE			LT			LV			BG			RO		
	low ac	medium ac	high ac	low ac	medium ac	high ac	low ac	medium ac	high ac	low ac	medium ac	high ac	low ac	medium ac	high ac
horizontal	1.660	1.224***	-0.210	-1.648	-0.337	-1.050***	-0.115	-0.478	-0.258	0.374	0.238	-0.593	0.646	1.269***	-1.661***
backward	17.401***	5.348**	5.487	-13.557	-2.506	2.055	-13.208	-17.040***	-6.864*	-6.036	-6.054	3.709	-11.759*	6.478***	0.937
forward	38.551**	1.834	-2.888	2.816	-5.771	-2.440	4.449	6.362***	-4.840**	-2.658	0.067	-0.369	-1.921	2.781***	-0.807
hhi	3.164	0.076	-0.544	4.102	-3.958**	-0.873*	3.803	3.561***	0.032	-2.408*	0.211	-0.493	-1.594	-3.860***	-0.109
Observations	556	1316	1708	143	324	710	284	746	1156	364	799	912	5476	11457	14898
Firms	321	554	898	123	243	444	177	330	575	165	296	428	2694	4948	7143
R-squared	0.01	0.01	0.01	0.08	0.02	0.04	0.16	0.15	0.06	0.01	0.01	0.01	0.01	0.01	0.01

*Note: Dependent variable: ln TFP; ac = absorptive capability defined as industry-specific distance to foreign productivity frontier, estimated via Levinsohn and Petrin (2003) technique on previous years; low ac = firm-years with ac below 25 percentile of ac distribution; medium ac = firm-years with ac between 25 and 75 percentile; high ac = firm-years with ac above 75 percentile; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects.*

Table A7: Spillovers by Export Orientation

	CZ			HU			PL			SK			SI		
	low exp	medium exp	high exp	low exp	medium exp	high exp	low exp	medium exp	high exp	low exp	medium exp	high exp	low exp	medium exp	high exp
horizontal	0.083	-1.674***	1.178***	1.316*	0.440	0.597	-2.630	-0.994**	0.150	-0.110	-0.132	-0.617*	-13.371***	3.786**	-1.208*
backward	-6.751**	-4.451*	4.732***	221.099	-2.523	-0.508	-198.876**	-5.119	-7.419***	-4.436	-0.224	-3.259*	-34.785***	1.376***	7.127**
forward	1.999**	5.674***	-0.307	-137.813	-2.973***	3.269	89.123**	-8.575***	0.199	-0.511	0.224	-3.542*	-18.376	-57.672***	-22.075***
hhi	1.397***	-1.947***	1.259**	-1.907***	2.242***	-0.293	-1.825	-0.664	-0.985**	-1.210	0.07	2.152***	2.117***	-1.884**	1.776***
Observations	4212	4901	2273	1126	3839	1899	2749	4858	2660	763	567	442	1458	1678	1531
Firms	1962	2481	1473	775	1789	898	857	1675	1090	305	251	298	699	779	762
R-squared	0.02	0.17	0.03	0.00	0.17	0.09	0.01	0.02	0.15	0.05	0.01	0.07	0.19	0.11	0.05

*Note: Dependent variable: ln TFP; exp = export orientation defined as share of NACE 2-digit sectoral exports to EU-25 to its total turnover; low exp = year-sectors with exp below 25 percentile; medium exp = year-sectors with exp between 25 and 75 percentile; high exp = year-sectors with exp above 75 percentile; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects.*

Table A8: Spillovers by Export Orientation

	EE			LT			LV			BG			RO		
	low exp	medium exp	high exp	low exp	medium exp	high exp	low exp	medium exp	high exp	low exp	medium exp	high exp	low exp	medium exp	high exp
horizontal	1.844	-1.023	0.571	-0.191	-0.281	-4.938**	-0.055	0.371	-0.415	2.942	-1.838***	-0.580	1.047	-1.282***	-9.201***
backward	22.232*	2.319	6.237**	-44.419***	0.544	30.504		-22.021***	-8.461	5.572	-5.433	-2.101	-773.033***	25.667***	-53.530***
forward	-21.760	-6.761	-5.218	0.338	4.183	-16.917		-3.245	5.464	-1.969	-2.002	-2.777**	-30.095**	7.029***	0.187
hhi	-4.607*	-2.302*	0.239	-3.715	0.956	-3.513	2.490	-0.274	0.422	-5.230**	-0.993	-0.534	-2.114	-0.697	15.418***
Observations	1056	1513	1011	518	458	201	411	1218	557	527	868	680	6238	19033	6560
Firms	365	502	354	228	218	127	717	495	306	182	245	317	2087	5397	1658
R-squared	0.01	0.05	0.07	0.21	0.07	0.01	0.04	0.05	0.01	0.01	0.01	0.37	0.18	0.07	0.02

*Note: Dependent variable: ln TFP; exp = export orientation defined as share of NACE 2-digit sectoral exports to EU-25 to its total turnover; low exp = year-sectors with exp below 25 percentile; medium exp = year-sectors with exp between 25 and 75 percentile; high exp = year-sectors with exp above 75 percentile; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects.*

Table A9: Spillovers by Firm Size

	CZ			HU			PL			SK			SI		
	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large
horizontal	-0.118	-0.213	-0.353*				0.441	0.187	0.734**	0.660	0.167	-0.421	-0.449	0.419	0.101
backward	-0.279	-0.820	-0.004				-4.412	3.818*	1.675	-2.079*	0.883*	1.308*	1.335**	0.891	1.713
forward	-0.654	1.213**	0.426				-4.292	-0.752	-3.971**	0.913	-0.639	-1.359	-17.817***	-22.169***	-30.283***
hhi	0.260	0.047	0.197				-0.299	-0.193	0.350	0.648	0.168	0.23	-0.591*	-0.312	0.493
Observations	3985	5558	1843				2681	5491	2095	383	970	419	2148	1754	765
Firms	1712	1958	617				1001	1804	689	179	358	141	738	534	186
R-squared	0.01	0.12	0.11				0.01	0.01	0.06	0.01	0.01	0.05	0.20	0.06	0.10

*Note: Dependent variable: ln TFP; small firms = up to 50 employees; medium-sized firms = up to 250 employess; large firms = more than 250 employees; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects.*

Table A10: Spillovers by Firm Size

	EE			LT			LV			BG			RO		
	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large
horizontal	0.784**	-1.658**	-6.309**	-0.369	-0.988**	0.542	-0.574	0.566	1.116	-0.272	-0.190	0.600	-0.450	-1.389***	-1.771***
backward	4.335*	5.864	-15.307	-0.977	0.737	-18.613**	-12.358**	-8.378**	-29.133***	4.175	-1.204	0.354	0.826	3.943*	17.517***
forward	-2.759	6.279	-23.114	-0.504	-0.761	-12.532	-0.295	0.626	-4.951	-2.509***	0.078	-0.091	-0.356	2.181***	3.093**
hhi	-0.183	-1.059	-14.306*	-2.897***	-0.343	-2.901	0.152	-0.142	2.613***	-1.786**	0.352	1.854***	-2.629***	0.717	0.325
Observations	2851	667	62	578	531	68	850	1051	285	780	827	468	23157	7091	1583
Firms	754	215	22	268	206	27	297	301	80	208	225	122	5815	2202	453
R-squared	0.01	0.01	0.03	0.07	0.05	0.30	0.05	0.03	0.01	0.01	0.01	0.01	0.01	0.06	0.04

*Note: Dependent variable: ln TFP; small firms = up to 50 employees; medium-sized firms = up to 250 employess; large firms = more than 250 employees; * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects.*

Appendix B: The Levinsohn and Petrin (2003) Estimator of Productivity

The Levinsohn and Petrin (2003) technique assumes a Cobb-Douglas production technology:[1]

$$v_t = \beta_0 + \beta_l l_t + \beta_k k_t + \omega_t + \eta_t \quad \text{(B1)}$$

where v_t is log of value added, l_t is log of freely variable labour input, k_t is log of the state variable capital. The error has two components, the transmitted productivity component ω_t and an error term η_t that is uncorrelated with input choice. The key difference between ω_t and η_t is that the former is a state variable and thus impacts the firm's choice of inputs. As ω_t is not observed by the econometrician but is known to the firm, it leads to the simultaneity problem in production function estimation and yields inconsistent results.

Olley and Pakes (1996) developed an estimator that uses investment as a proxy for this unobservable shock. However, Levinsohn and Petrin (2003) argue that investment is very lumpy and thus the investment proxy may not smoothly respond to productivity shocks under substantial adjustment costs. Instead of investment, Levinsohn and Petrin (2003) suggested that intermediate inputs can better serve as a proxy for productivity shocks, as they are not typically state variables and are easily available from computation of value added (while investment is often truncated to zero in many datasets and thus not available).

Levinsohn and Petrin (2003) assume that the demand for the (log of) intermediate input, materials m_t, depends on the firm's state variables k_t and ω_t:

$$m_t = m_t(k_t, \omega_t) \quad \text{(B2)}$$

Making mild assumptions about the firm's production technology (Levinsohn and Petrin 2003, Appendix A), the demand function is monotonically increasing in ω_t. This allows inversion of the intermediate demand function, so ω_t can be written as a function of k_t and m_t:

$$\omega_t = \omega_t(k_t, m_t) \quad \text{(B3)}$$

[1] This part draws heavily from Levinsohn et al. (2003).

The unobservable productivity term is now expressed solely as a function of two observed inputs. Final identification restriction assumes that productivity follows a first-order Markov process:

$$\omega_t = E[\omega_t \mid \omega_{t-1}] + \xi_t \tag{B4}$$

where ξ_t is an innovation to productivity that is uncorrelated with k_t.
Thus, (1) can be rewritten as

$$v_t = \beta_l l_t + \phi_t(k_t, m_t) + \eta_t \tag{B5}$$

where

$$\phi_t(k_t, m_t) = \beta_0 + \beta_k k_t + \omega_t(k_t, m_t) \tag{B6}$$

By substituting a third-order polynomial approximation in k_t and m_t in place of $\phi_t(k_t, m_t)$, it is possible to consistently estimate parameters of the equation (1) using OLS as

$$v_t = \delta_0 + \beta_l l_t + \sum_{i=0}^{3}\sum_{j=0}^{3-i} \delta_{ij} k_t^i m_t^j + \eta_t \tag{B7}$$

where β_0 is separately identified from the intercept of $\phi_t(k_t, m_t)$. Out of this first stage of the estimation, an estimate of β_l and an estimate of ϕ_t (up to the intercept) are available.

The second stage of the estimation begins by computing the estimated value for ϕ_t using

$$\hat{\phi}_t = \hat{v}_t - \hat{\beta}_l l_t = \hat{\delta}_0 + \sum_{i=0}^{3}\sum_{j=0}^{3-i} \hat{\delta}_{ij} k_t^i m_t^j - \hat{\beta}_l l \tag{B8}$$

For any candidate value β^*_k, one can compute (up to a scalar constant) a prediction for ω_t for all periods t using

$$\hat{\omega}_t = \hat{\phi}_t - \beta_k^* k_t \tag{B9}$$

Using these values, a consistent (non-parametric) approximation to $E[\omega_t \mid \omega_{t-1}]$ is given by the predicted values from the regression

$$\hat{\omega}_t = \gamma_0 + \gamma_1 \omega_{t-1} + \gamma_2 \omega_{t-1}^2 + \gamma_3 \omega_{t-1}^3 + \varepsilon_t \tag{B10}$$

which will be called $\hat{E}[\omega_t \mid \omega_{t-1}]$. Given $\hat{\beta}_l, \beta_k^*$ and $\hat{E}[\omega_t \mid \omega_{t-1}]$, the estimate $\hat{\beta}_k$ is defined as the solution to minimization of squared sample residuals of the production function

$$\min_{\beta_k^*} \sum_t (v_t - \hat{\beta}_l l_t - \beta_k^* k_t - \hat{E}[\omega_t \mid \omega_{t-1}])^2 \tag{B11}$$

Standard errors are estimated via bootstrap procedure, but may be also derived analytically.[2]

[2] Levinsohn and Petrin (2003) methodology is available as an ado file for Stata program where a bootstrap technique is used to derive standard errors, see Levinsohn et al. (2003).