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Foreign Direct Investment and Productivity Spillovers: Updated Evidence from Central and Eastern Europe

Adam Geršl, Ieva Rubene and Tina Zumer *

Abstract

The paper discusses the inflows of foreign direct investment into the CEE countries and focuses on analysis of productivity spillovers. An 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, the total factor productivity of domestic firms is estimated using the Petrin and Levinsohn (2003) method and subsequently related within a panel data model to foreign presence in the same industry and in industries linked via the production chain. The presence of productivity spillovers is tested for across several sub-samples to detect possible conditionalities.

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Nontechnical Summary

The paper discusses the inflows of foreign direct investment into the CEE countries and focuses on analysis of productivity spillovers. Using firm-level data from the Amadeus database and techniques that control for simultaneity bias due to the effect of unobservable productivity shocks on the level of input choice (Levinsohn and Petrin, 2003), we recover the total factor productivity of domestic firms and link it to foreign presence in the same sector (horizontal spillovers) and in sectors linked via the production chain (vertical spillovers). In order to detect what the spillovers are conditional upon, we split the sample into sub-samples using several breakdowns and investigate whether the potential for spillovers differs across different groups of firms (depending on specified conditions).

We find that the vertical effects tend to be higher and thus economically much more important than the horizontal effects, which is in line with previous studies. In addition, we find that in many cases the spillovers are negative, thus foreign presence might also have some adverse impact on the productivity of local firms, for example via the brain drain or market stealing effects. We also find strong non-linearities in the effect of foreign presence on local firms' productivity. The spillovers depend on a number of industry and firm-level characteristics, including the relative technological level vis-à-vis foreign firms (absorptive capacity), export orientation and firm size.

1. Introduction

Over recent years, economic growth in the CEE countries has been rather impressive.[1] The Baltic countries stand out as the top performers, with average annual real growth rates of more than 7% since 1999, but the other countries of Central and Eastern Europe have also been growing relatively fast, on average by around 4%.

Increased productivity has usually been 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 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 being either very small 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 the trade openness of an economy, which is believed to have a positive impact on growth.[2] FDI should increase competitive pressures in markets and stimulate technology and knowledge transfers and innovation. In this respect, FDI supports 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, 2003).

The CEE countries were successful at attracting foreign direct investment (FDI) during the 1990s, given the privatisation 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 inward FDI 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 5% of GDP.

As discussed, FDI brings substantial benefits to the host economy (see also Jones and Colin, 2006). Looking at the firm level, a foreign-owned company, usually being part of a multinational enterprise, is larger and more capital intensive and has more skilled labour, greater technological knowledge and a higher productivity level compared to domestic companies. In addition, foreign firms usually have better access to financing, either from the parent company or from banks, given their superior performance. Thus, attracting FDI brings benefits to the host economy in terms of higher investment, employment and output of these firms, with a resulting effect on overall GDP growth – the so-called direct effects (also called the batting average effect in the literature).[3]

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

[2] 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).

[3] In the paper we use the term "direct effects". One should not, however, confuse these direct effects with the primary (direct) transfer of technology between a foreign investor and its subsidiary in the host country, which is sometimes also labelled the "direct effect".

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 (Blomström and Kokko, 1998). These spillovers can take place both within an industry (horizontal spillovers), for example via imitation of a foreign company's technology by domestic firms, or across industries (vertical spillovers), via technology transfer to domestic suppliers or customers in the production chain.[4] Through productivity spillovers, FDI can have a multiplier effect and increase the 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 the direct effects of FDI, but some indirect effects might have played a role as well.[5]

In this paper, we focus on the role of the indirect effects of FDI in the CEE countries in terms of productivity spillovers to domestic companies. The main reason for analysing these 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 their 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 its comparative advantage. If the FDI also indirectly fostered 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 uses firm-level data. We estimate the total factor productivity of domestic firms, which is subsequently related to foreign presence using the Levinsohn and Petrin (2003) methodology, which controls for endogeneity of input selection. In order to detect what the spillovers are conditional upon, we split the sample into 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 for two reasons: first, the manufacturing sector has received a high volume of FDI over past years (around 40% of the existing FDI stock in the CEE countries) and, second, the risk of liquidation of FDI due to further relocation is more severe in manufacturing than in services, financial intermediation or other sectors, where the servicing-the-market motive prevails.

In comparison with recent research on CEE countries in this area, represented mainly by Kolasa (2007), Vacek (2007), Gorodnichenko et al. (2006), Merlevede and Schoors (2005, 2006), Javorcik (2004), Javorcik and Spatareanu (2003), Torlak (2004), Damijan et al. (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 previous literature focused on the late 1990s. One can argue that the data from the late 1990s may have been less reliable given the structural changes in the economy, new investments and privatisation. Our assumption is that since 2000 the CEE economies have reached relatively sustained and stable economic development. Moreover, foreign firms entering the region as of 2000 were largely motivated by cost factors within the relocation of production processes, thus it is important to analyse to what extent spillovers emerge within the current globalisation of production. Second, we focus on all ten CEE countries, while the other literature usually focuses on only one

[4] Horizontal and vertical spillovers are not to be confused with horizontal and vertical FDI. Horizontal FDI occurs when the multinational undertakes the same production activities in multiple countries. Vertical FDI takes place when the multinational fragments the production process internationally, locating each stage of production in the country where it can be done at the lowest cost (see Aizenman and Marion, 2001).

[5] A recent study has found that FDI 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).

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 main value added in providing updated evidence on all CEE countries lies in an analysis of differences in the nature of the interaction between foreign and local firms in countries that are usually treated as very similar.

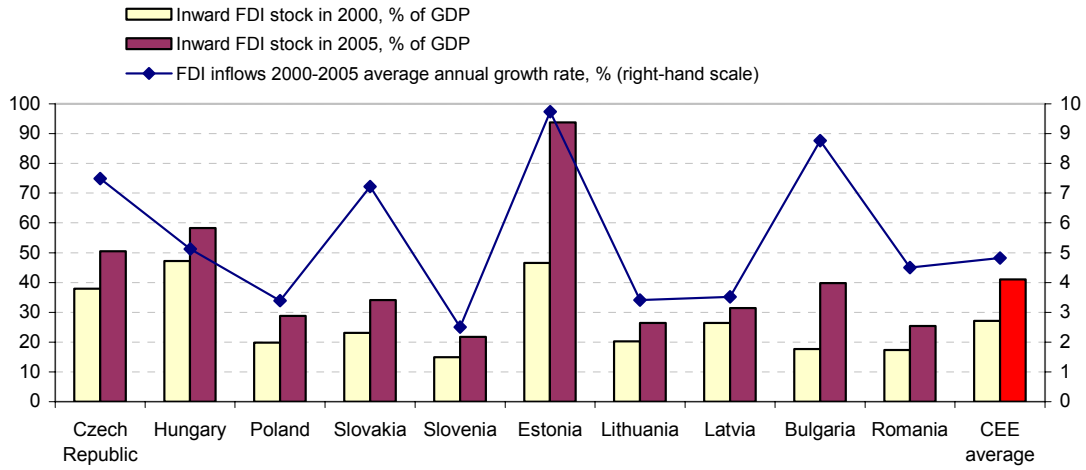
The paper is structured as follows: Section 2 provides an overview of the FDI inflows and inward FDI positions in the CEE countries. Section 3 reviews the channels through which spillovers from FDI to productivity of domestic firms can work and discusses several conditions that can influence the emergence of spillovers. Section 4 analyses the foreign presence in the manufacturing sectors of these countries using micro-level data. Section 5 describes the estimation strategy. Section 6 presents the estimation results and section 7 shows some robustness checks. Section 8 concludes.

2. Foreign Direct Investment Inflows to the CEE Countries

The CEE countries have been successful at attracting FDI, as 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 the 2000s. Annual FDI inflows averaged around 5% of GDP between 2000 and 2005, although the pattern varied strongly across countries, with the highest inflows being in Estonia, Bulgaria, the Czech Republic and Slovakia (Figure 1). In 2005, FDI inflows into CEE amounted to €33 billion, while since 2000 they had accumulated to €150 billion.

Figure 1: FDI Net Inflows and Inward FDI Stock



Source: Wiener Institut für Internationale Wirtschaftsvergleiche (WIIW) database „Countries in transition", own calculations.

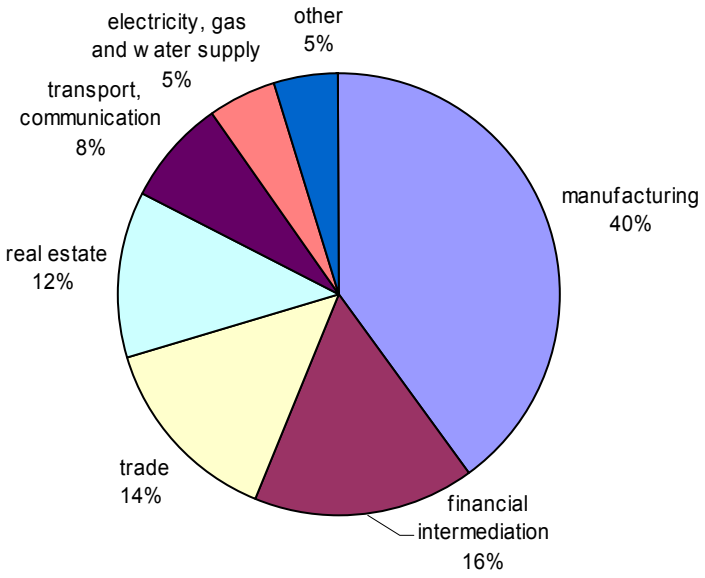
Note: The ordering of countries here and further in the paper is as follows: Visegrad countries (i.e. central Europe CZ, HU, PL, SK ordered alphabetically + SI), Baltic countries (EE, LT, LV) and the 2007 entrants (BG, RO).

Overall, FDI inflows as a share of GDP remained broadly stable between 2000 and 2005, and inward FDI positions grew fast in most CEE countries (Figure 1). The inward FDI stock in 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, the inward FDI stock as a 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 had accumulated about 70% of the total inward FDI stock in the EU10.

Turning now to sectoral developments, the majority of the FDI in CEE went into the services sector, while manufacturing accounted for around 40% of the inward FDI stock by the end of 2004 (Figure 2).[6]

Figure 2: Inward FDI Stock in CEE by Economic Activity (end of 2004)



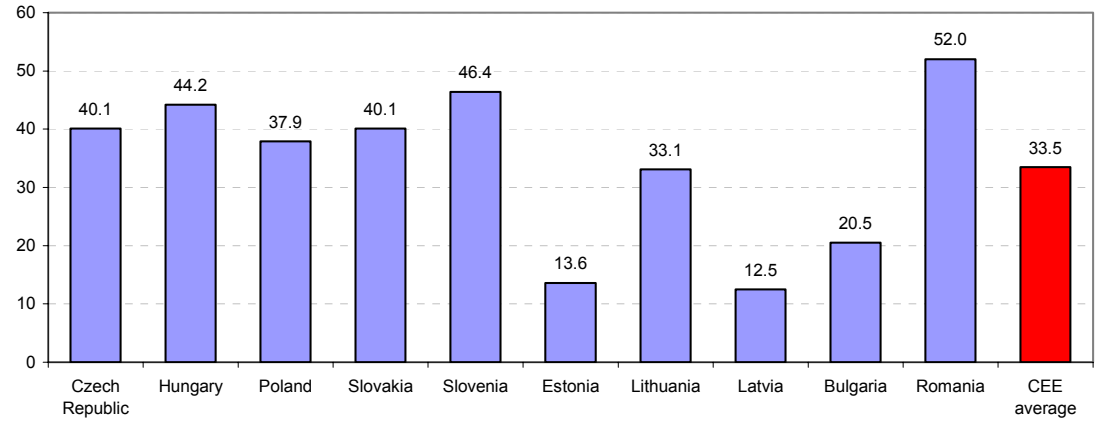
Source: WIIW, own calculations.

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

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, often the motivation was initially to serve the domestic market, but the investing firms may have later expanded their business activity due to cost-savings and increased competitiveness. The accumulated inward FDI stock in manufacturing varies across the CEE countries (Figure 3).

[6] The sectors 'mining and quarrying' and 'construction' have received comparatively little FDI; in Figure 2, they are included in the item 'Other', and their combined share in the total inward FDI stock is just around 1.5% on average in the CEE countries.

Figure 3: Share of Inward FDI Stock in Manufacturing in Total Inward FDI Stock in 2005 (%)

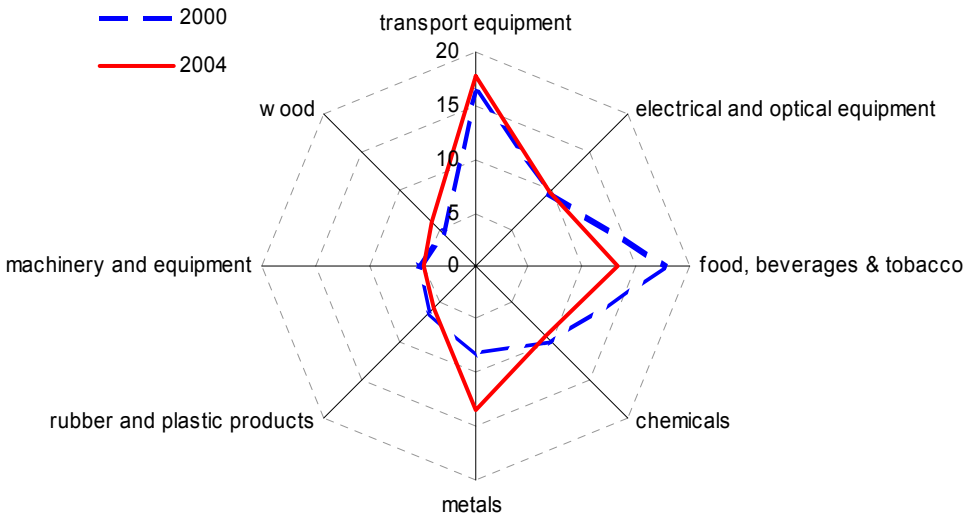


Source: WIIW, own calculations.

On average, the manufacturing sector had accumulated around 34% of the total inward FDI stock in CEE by the end of 2005. The highest share of FDI stock in the manufacturing sector by the end of 2005 was in Romania (52%), followed by Slovenia, Hungary, the Czech Republic and Slovakia (40% on average). The smallest shares of inward FDI stock in manufacturing were in Latvia and Estonia, with 2.5% and 13.6% of the total inward FDI stock respectively.

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

Figure 4: Inward FDI Stock in CEE by Manufacturing Industry (% of total manufacturing FDI stock)



Source: WIIW, own calculations.

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

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

There are several channels through which FDI can influence the productivity of local firms when there is interaction between foreign and domestic firms in the host economy. As mentioned earlier, we differentiate between the direct effects and indirect effects of FDI. These indirect effects of foreign presence are called spillovers (Blomström and Kokko, 1998; 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 organisational and managerial practices and know-how) and market access spillovers (i.e. the possibility for local firms to access new markets via the marketing and business networks of foreign companies with which local firms interact).[7] The latter spillover may reinforce the former, as the chance to compete in foreign markets puts pressure on local firms to increase their productivity. However, in our paper we focus on productivity spillovers only.

3.1 Horizontal versus Vertical Productivity Spillovers

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 other words, backward spillovers denote spillovers from the foreign firm to its local supplier (upstream in the production chain), while forward spillovers refer to spillovers from foreign firms to their local customers (downstream in the production chain).

As regards horizontal spillovers, there are three main channels through which horizontal spillovers may run: the demonstration channel, the labour market channel and the competition channel (Kokko, 1992). Within the demonstration channel, local firms may try to imitate the foreign firm's technology. However, informed foreign companies may try to prevent technology leakage to local competitors, so that the potential for spillover running via this channel might be limited. Another strategy of foreign firms for preventing imitation by local competitors is to bring not their state-of-the-art technologies, but those technologies which are only slightly more advanced than those of local firms (Glass and Saggi, 1998). This would also adversely affect the potential for horizontal spillovers. The labour market channel works via labour turnover of trained workers from foreign to local firms (Fosfuri et al., 2001). However, foreign presence can also have a detrimental effect on local firms through this channel, as it can brain drain local talent from local firms to foreign affiliates (Blalock and Gertler, 2003). Within the competition channel, the 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 (the market stealing effect – see Aitken and Harrison, 1999).

[7] Aitken et al. (1997), for example, analysed export spillovers in Mexico.

Turning now to vertical spillovers, backward vertical spillovers emerge when foreign firms intentionally assist local suppliers to deliver high-quality inputs and share with them superior technology. Merlevede and Schoors (2005, p. 8) identify two conditions under which the incentive to help local 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 an incentive to source its inputs in its home country. Second, the foreign firm must refrain from inducing 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 local firms and thus limited potential for spillovers.[8] Being a supplier to a foreign firm provides the local firm with stable demand for inputs and allows the local firm to invest in appropriate physical capital, build up a stock of experienced workers and accumulate necessary experience, all prerequisites for increased productivity via the use of advanced technology (Merlevede and Schoors, 2005). However, if local suppliers are not able to maintain 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 suppliers.

Forward vertical spillovers appear when higher quality inputs produced by foreign firms are used in the production chain by local firms. In principle, forward vertical spillover may also be 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.[9]

Given the possible ambivalent net effect of horizontal and vertical productivity spillovers, some studies assume that the spillovers may be non-linear: 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, a relatively moderate presence of foreign companies may induce positive horizontal spillovers via the demonstration channel, but a further substantial increase in foreign presence may trigger a brain drain and lead to the market stealing effect, driving local companies out of the market, meaning negative horizontal spillovers. In other words, foreign presence fosters an increase in domestic productivity, but if it increases beyond some threshold, its impact on local productivity turns negative.

3.2 Conditions Influencing the Magnitude of Spillovers

Recent literature also focuses on the 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). The main characteristics of a firm or industry that affect the conditional spillovers are: the absorptive capacity of the firm, export orientation, import competition, sectoral competition, firm size and the level and origin of foreign ownership.

[8] For a discussion of the conditions under which vertical spillovers may exist, see also Rodriguez-Clare (1996).

[9] 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 suppliers to increase their productivity and provide high-quality inputs that may positively influence the productivity of their local customers as well.

A number of studies show that the 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 local firms or too difficult to implement.[10] However, taking into account non-linearities 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 a low technology level may lack the resources to absorb new technologies (negative spillovers), while for firms with an already advanced technology level the gain from spillovers may be rather limited. The highest potential for spillovers hence exists for firms with a medium technological level.

Similarly, the export orientation of industries or firms may 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 the 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 that of foreign companies, reducing the potential for spillovers. Additionally, the export orientation of an industry, even if only foreign firms are exporting, creates a possibility of market access spillovers. If, for example, a local firm is able to hire workers previously employed by a foreign company, it can use their knowledge about foreign markets to increase its share of exports, which in turn exerts pressure for productivity improvements. As a result, there is no clear guidance ex ante on whether to expect export-oriented firms to benefit more from foreign presence.

Another firm characteristic influencing the size of productivity spillovers is import competition, which arises when imported products are similar to those produced in the local economy. Consequently, competition in the market is higher in sectors with high import competition compared to sectors with lower import competition (Sjöholm, 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 they are also more sensitive to the potential spillovers from foreign firms. On the other hand, if the competition from imports is too high, local firms may encounter problems with selling their products in the local market and suffer losses, a situation that decreases the possibility of productivity spillovers. Although several studies find a positive effect of import competition on productivity spillovers, the effect of import competition on the existence of spillovers has not been empirically tested enough for there to be clear empirical evidence about the sign and size of this effect.

As regards the effect of sectoral competition on the sensitivity to spillovers, most studies find a positive impact of competition on productivity (Kokko, 1994, 1996; Sjöholm, 1999).

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

Regarding firm size, larger firms have greater resources, thus they are more capable of exploiting innovative opportunities and benefit more from adapting advanced technologies (Merlevede and Schoors, 2006). Moreover, larger firms can utilise economies of scale and enjoy greater benefits from more advanced foreign technology than smaller firms. On the other hand, small and medium-sized companies are more flexible to adapt to new organisational and managerial practices and are an important source of innovation (Sinani and Meyer, 2004). Thus, we cannot predict ex ante what type of firms will be more prone to spillovers.

Some studies investigate whether the degree of foreign ownership in firms defined as foreign (i.e. minority, majority or 100% ownership) and the origin of foreign investors affect spillovers (Javorcik and Spatareanu, 2003; Javorcik, 2004, Merlevede and Schoors, 2006). The findings are inconclusive: local participation means higher potential for technology leakages and thus positive horizontal spillovers, while this in turn may also prevent foreign firms bringing in state-of-the-art technology and thus reduce the scope for spillovers.

To sum up, the complexity of the channels through which spillovers can arise, together with the uncertainty about their direction and possible non-linearities in the relationships, make the estimation of spillovers very difficult.[11] In this paper, we analyse how productivity spillovers vary with absorptive capability, export orientation and firm size.

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

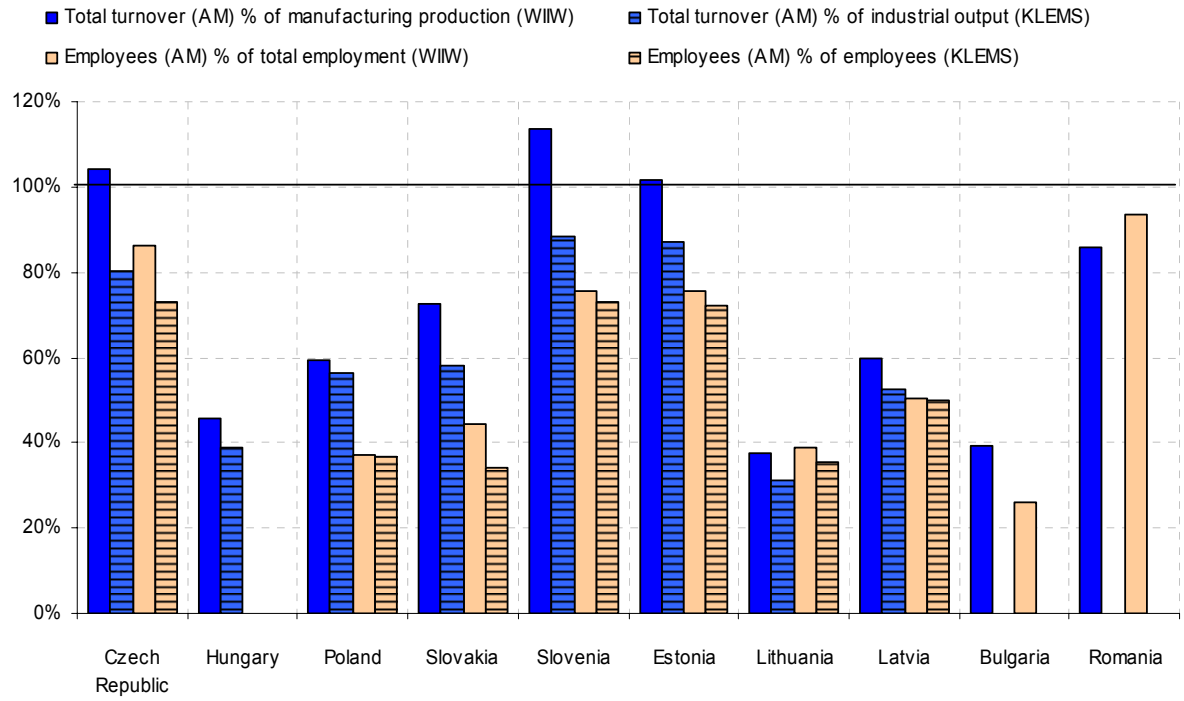
The "Amadeus" database provided by Bureau van Dijk (September 2006 release, "All companies" set) is used as a source of firm-level data on the CEE corporate sector. The data on companies' balance sheet items, profit and loss accounts and ownership constitute an unbalanced panel over the period 2000–2005.[12] We focus on manufacturing companies (NACE Rev. 1.1, 2-digit industries 15–36) with a minimum of 10 employees and fixed assets and turnover of at least $10,000. The coverage of firms in the Amadeus database differs across countries, with the firms' aggregated turnover representing between 40% and 100% of the total manufacturing sector's production and between 30% and 90% of the total manufacturing sector's employment (see Figure 5).[13]

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

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

[13] Figures higher than 100% are possible, as industrial manufacturing production in the WIIW and KLEMS databases includes only sales of goods classified as manufacturing, while the turnover data for firms in Amadeus represent total turnover, including revenues from sales of non-manufacturing products and services.

Figure 5: Coverage of Firms in the Amadeus Database: Total Turnover and Employment Compared with WIIW and EU KLEMS Databases (%)



Source: Amadeus, WIIW, European Commission (EU KLEMS), own calculations.

There are differences between the coverage of firms when using total turnover versus number of employees (see Figure 5). This is mainly related to the fact that in the Amadeus database, the number of employees may not be very reliable, since it is not always officially reported (unlike the balance sheet and profit and loss accounts) and in those cases it is estimated by the database providers.

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 very similar to the distribution reported by WIIW for aggregate figures (see Tables A1–A4 in the Appendix).[14] Furthermore, the distributions of the Amadeus and WIIW data are also comparable in the remaining countries, thus the sample used from the Amadeus database is relatively representative of the actual manufacturing industries in the CEE countries. This is confirmed by the comparison of the Amadeus data with the EU KLEMS database.[15]

Foreign companies are our proxy for FDI. The Amadeus database allows a foreign company to be defined in several ways. For the scope of this note, we define a foreign company as a company with a 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

[14] WIIW is an internationally acknowledged source of comparable aggregate data on the industrial structure of the CEE countries and thus an ideal benchmark for assessing the representativeness of the Amadeus dataset. The aggregate industrial data of the WIIW comes predominantly from the national statistical offices.

[15] The KLEMS dataset was created at the University of Groningen, Netherlands, and funded by a European Commission project aimed at creating a database on measures of economic growth, productivity, employment creation, capital formation and technological change at the industry level for all European Union member states from 1970 onwards.

least 51% of the company's capital. This contradicts the traditional methodology, where FDI is defined as a share of at least 10% of a company's capital held by non-residents. The main reason for using the majority-ownership definition as a proxy for FDI is that most of the FDI related to relocation of production is due to majority-owned foreign companies and that the probability of technology transfer from a 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 between around 1% (Slovenia) and around 70% (Bulgaria) of the number of firms in the new EU countries.[16]

Table 1: Coverage of Foreign Firms (in 2004)

			% of foreign firms (2004) in:			
	No. of firms	of which foreign firms	number of firms	total assets	turnover	employment
Czech Republic	5011	618	12.3	38.9	37.1	23.4
Hungary	1625	57	3.5	26.7	29.2	n.a.
Poland	5035	1131	22.5	56.4	56.8	35.1
Slovakia	767	35	4.6	59.7	57.7	19.7
Slovenia	1215	15	1.2	8.3	10.2	3.9
Estonia	1762	885	50.2	73.5	72.0	66.6
Lithuania	921	584	63.4	71.2	73.5	67.7
Latvia	580	79	13.6	31.5	25.5	18.6
Bulgaria	1338	929	69.4	46.2	45.9	50.3
Romania	13108	6053	46.2	78.0	75.0	65.1
CEE total/average*	31362	10386	33.1	49.0	48.3	38.9

Source: Amadeus, own calculations.

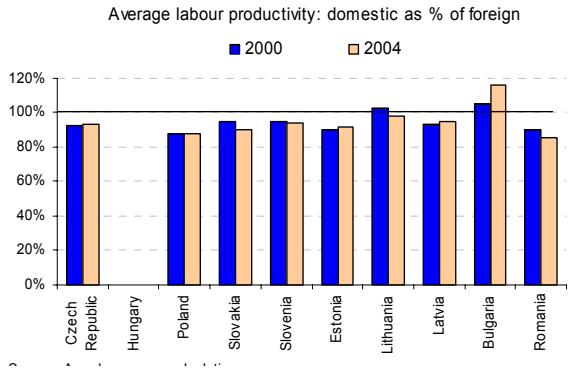
Note: Data on companies for which total turnover is available. * CEE total for number of firms, CEE average for shares of foreign firms in total assets, turnover and employment.

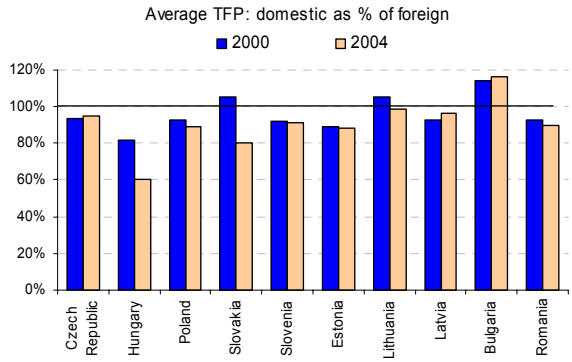
In terms of total assets, the share of foreign firms is higher (between 8% in Slovenia and 78% in Romania in 2004) than in the number of firms, and the same holds for the share of total turnover, employment and stock of investment, indirectly indicating that foreign firms are on average larger than domestic firms. However, over the period 2000–2004, foreign companies did not considerably increase their share 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 (Figures A1 in Appendix).

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 the Appendix). This holds for all countries except Bulgaria, where the number of foreign firms as a share of the total number of firms is the highest. In most countries (except Slovakia, Slovenia and Romania), foreign companies are also more profitable (Table A2). Moreover, in most of the countries foreign companies have on average higher labour and total factor productivity (Figures 6–7).

[16] Unfortunately, companies where the owner's name is known but his nationality (or country of residence) is not known are generally classified as foreign companies in the Amadeus database. This problem is of some relevance for the case of Romania, where numerous firms are owned by private persons with non-reported nationality. As probably a large number of the owners are Romanian citizens, the share of foreign-owned companies is overestimated in the Romanian sample.

Figures 6–7 Average Labour and Total Factor Productivity





Source: Amadeus, own calculations.
Note: TFP = ln (total factor productivity) computed using the Levinsohn and Petrin (2003) technique for individual industries or groups of industries for all firms. Labour productivity for HU is missing due to insufficient coverage of data for employees in the Amadeus database.

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

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

Table 2: Exports by Manufacturing Industry
(as % of total manufacturing exports to the EU25 in 2004)

	Czech Republic	Hungary	Poland	Slovakia	Slovenia	Estonia	Lithuania	Latvia	Bulgaria	Romania
Food products, beverages and tobacco	3.1	4.3	7.1	2.8	1.2	6.5	**9.4**	**6.2**	**6.2**	1.3
Textiles and textile products	5.3	3.9	5.6	4.1	4.3	**10.1**	**15.9**	**7.7**	**28.9**	**31.3**
Leather and leather products	0.5	0.9	0.7	2.2	1.3	1.0	0.5	0.3	5.4	**11.0**
Wood and wood products	1.5	0.8	3.2	1.8	2.2	**10.5**	5.8	**24.3**	1.9	3.6
Pulp, paper and paper products; publishing and printing	3.2	1.3	3.1	3.3	3.3	1.4	0.9	1.4	1.1	0.5
Coke, refined petroleum products and nuclear fuel	1.1	1.6	2.8	**6.8**	0.1	**11.8**	**25.1**	**29.2**	2.1	2.4
Chemicals, chemical products and man-made fibres	**5.8**	**5.4**	5.6	5.7	8.4	4.5	**8.7**	4.8	5.4	2.8
Rubber and plastic products	5.3	2.8	4.4	4.1	4.0	2.1	3.3	1.5	1.4	2.5
Other non-metallic mineral products	3.1	1.2	2.3	2.1	2.1	1.6	0.8	1.4	2.1	1.4
Basic metals and fabricated metal products	**13.6**	**6.0**	**13.2**	**14.8**	**14.3**	**10.3**	6.6	**10.3**	**26.1**	**10.2**
Machinery and equipment n.e.c.	**12.7**	**7.7**	**7.1**	**7.4**	**13.7**	4.1	2.3	2.5	**7.9**	6.3
Electrical and optical equipment	**21.4**	**40.4**	**13.2**	**13.2**	**10.5**	**22.5**	**9.5**	4.1	**6.4**	**13.3**
Transport equipment	**19.6**	**22.1**	**22.9**	**29.4**	**25.7**	8.0	3.7	1.9	1.4	**6.8**
Manufacturing n.e.c.	3.7	1.7	**8.8**	2.3	**8.9**	5.6	7.3	4.3	3.6	6.6
Total	100	100	100	100	100	100	100	100	100	100

Source: WIIW database.
Note: Shading indicates top five industries in terms of export share in total manufacturing exports to the EU25.

5. Estimation Strategy

Estimating the direct effects of FDI is not easy as we lack data on the past ownership of firms to test for the additional effect of foreign entry into the domestic market. In addition, foreign firms usually target larger and more productive firms, thus a selection bias arises when one just compares the performance of foreign versus domestic firms.[17] Therefore, in this paper we focus on the indirect effects only.

The traditional approach to analysing 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-maximising firms respond to increasing productivity by increased use 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 the 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. In principle, the method

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

estimates a traditional Cobb-Douglas production function, taking into account that the error term has two components, of which one is correlated with the choice of inputs by the firm, but is not observable by the econometrician. The authors develop an estimator that uses a free variable such as intermediate inputs (material costs or fuel or electricity) as a proxy for this unobservable productivity shock. The details of the technique are described in Appendix 1.

Following the Levinsohn and Petrin (2003) technique, we estimate a log-linear transformation of a Cobb-Douglas production function:

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

where va_{it} is the log of the value added of a firm i, l_{it} is the log of labour input and k_{it} is the log of capital. The estimation is done for each manufacturing sector j (at the 2-digit NACE level) separately, using a sample of domestic firms only.[18] Value added enters the equation as real value added, computed as real turnover minus real material costs.[19] 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 the unweighted average of the total manufacturing producer price index and import price index. Labour input refers to number of employees.[20] For capital input, the stock of fixed assets was used, deflated by the average of the deflators for the following NACE sectors:[21] 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).[22] Within the technique applied, material costs were used as a proxy for the unobservable productivity shock.[23]

[18] 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).

[19] In Slovenia, Latvia and Lithuania, data on material costs were not available, thus a proxy for value added was used: for Slovenia, the proxy was computed as the sum of EBIT, depreciation and costs of employees, while for Latvia and Lithuania we had to use the only variable at least partly related to value added, namely gross profit. Thus, the results for Lithuania and Latvia must be interpreted with caution. However, as we do not compare the magnitude of the results across countries (the reason being also that the estimations are done in national currencies), the proxy used does not seriously hamper our analysis.

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

[21] The stock of fixed assets is given in the database at accounting (i.e. nominal) prices. When deflating the capital input, the implied value of the real capital stock may be strongly biased downwards. This could be particularly the case for buildings, as their historical prices would say very little about their present ability to produce value added expressed in current prices.

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

[23] For Slovenia, material costs were constructed as total turnover minus the proxy for value added. For Latvia and Lithuania, after experimenting with several available proxies we selected costs of goods sold, which could be at least partly correlated with the unobservable productivity shock, as firms with a positive productivity shock will produce and sell more, which usually involves higher costs of goods sold (as well as higher material costs).

A measure of the log of total factor productivity tfp_{it} is obtained as the difference between the log of value added and the log of capital and the 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[24] (the Herfindahl index of turnover *hhi* 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 the fixed-effects estimator.[25]

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

While the estimation of *tfp* is done on the 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:

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

The variable *foreign* is a dummy variable that equals 1 if the company *i* is a foreign company, and 0 otherwise. The higher is the value of output produced by foreign firms and the higher is 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 the 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 the firm's output sold to foreign companies by the share of the sector's output for intermediate consumption within the domestic economy sold to foreign companies in downstream sectors. The input-output tables reveal information about the amount supplied by the sector *j* to its sourcing sector *k*. In addition, we employ information about

[24] We also tried other control variables at firm level that should be correlated with total factor productivity, such as the share of intangible assets in fixed assets or the leverage of the firm. However, despite being significant (usually positive) in some countries, their inclusion did not alter the main results and did not lead to a higher R-squared.

[25] Most studies on spillovers use the fixed effects estimator, due to both 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 the random effects model. However, the Hausman test showed that in our case the hypothesis of no correlation between the regressors and the individual effects can be rejected, thus the fixed-effects model is appropriate.

the foreign presence in sector *k* (the variable *horizontal*). Thus, the 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).[26] 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*. Intra-industry supplies are not accounted for in this case either, 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).[27]

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

$$\begin{aligned} tfp_{ijt} = {} & \alpha_0 + \alpha_1 horizontal_{jt} + \alpha_2 horizontal_{jt}^2 + \alpha_3 backward_{jt} + \alpha_4 backward_{jt}^2 + \\ & \alpha_5 forward_{jt} + \alpha_6 forward_{jt}^2 + hhi_{jt} + \alpha_i + \alpha_t + \varepsilon_{ijt} \end{aligned} \tag{7}$$

[26] Ideally, one would need a series of I-O tables to capture the dynamics of inter-industry trade. Due to data limitations, we employ the last available I-O table for domestic intermediate consumption (Czech Republic 2003, Hungary 2000, Poland 2000, Slovenia 2001, Estonia 2000, Lithuania 2000) or – if only the use tables including imports are available – the use tables (Slovakia 2000, Bulgaria 2001, Romania 2003). For Latvia, 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. The I-O tables (supply and use tables) come from the national statistical offices and Eurostat and are at the 2-digit NACE level.

[27] For the descriptive statistics of the variables used in the regressions, see Tables A11–A12.

6. Estimation Results

As we have seen above, foreign firms outperform local firms in productivity levels, thus we expect to detect some productivity spillovers in our analysis. Moreover, there might also be some potential for spillovers due to possible complementarities between the technologies of domestic and foreign firms.

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

Table 3: Horizontal and Vertical Spillovers (linear effects)

	Czech Rep.	Hungary	Poland	Slovakia	Slovenia	Estonia	Lithuania	Latvia	Bulgaria	Romania
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***
Observations	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, *hhi* de notes the Herfindahl index of turnover.

Second, the 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 the 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 analysing these countries in the late 1990s.[28] Our findings indicate potential for the market stealing effect after 2000 and some crowding-out of domestic firms, but they might also reflect continued FDI inflow in these countries (i.e. purchases of more productive local firms by foreign companies). Furthermore, it is interesting to note that the horizontal spillovers turned significant in the Czech Republic, Poland, Lithuania, Bulgaria and Romania, i.e. the countries where the potential for horizontal spillover is higher (i.e. the countries with the largest number of foreign firms and highest share of foreign firms' turnover), the exceptions being Estonia and, to a lesser extent, Slovakia (which also have relatively large potential).

Third, we find that backward spillovers (if they are significant, as is the case in Slovenia, Estonia and Romania) tend to be rather positive, while forward spillovers (significant in Hungary and Slovenia) tend to be rather negative. This finding corresponds to the 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 supplier to foreign companies has a beneficial effect on a firm's productivity. On the other hand, a larger foreign presence in upstream sectors

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

negatively affects 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 also be in line with some anecdotal evidence from these countries in some supply networks such as the automotive or ICT industries (European Commission, 2003).

Concentration as measured by the 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.[29]

Table 4 presents the results with non-linear effects. The findings can be summarised 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 the opposite: it starts negative, eventually turning positive with an increasing level of foreign presence. For Romania, the result is in line with that for the late 1990s by Merlevede and Schoors (2005).

Table 4: Horizontal and Vertical Spillovers (non-linear effects)

	Czech Rep.	Hungary	Poland	Slovakia	Slovenia	Estonia	Lithuania	Latvia	Bulgaria	Romania
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***
Observations	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, *hhi* de notes the Herfindahl index of turnover.

Second, for the backward spillovers, we find opposite effects for the Czech Republic compared to Latvia and Romania. In the Czech Republic, the backward spillovers are again positive up to a certain threshold of foreign presence in the downstream sector (around 40%), after which the effect turns negative. In Latvia and Romania, on the contrary, the effect starts negative, turning positive after a certain threshold (in Latvia of around 30% and in Romania of around 50%). Third, in those countries where the forward spillovers are non-linear (the Czech Republic and Lithuania) the effect again differs. In the Czech Republic, the 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 is first negative and then turns positive when the foreign presence is higher. In

[29] The low R-squared (also in the following regressions) indicates that only a small part of the variation in productivity can be explained by spillovers. However, the range is in line with other papers testing for the existence of spillovers within the two-step method (i.e. having actually residuals from another regression as the dependent variable). An alternative approach including the foreign presence variable directly in the Cobb-Douglas function would yield a higher R-squared.

most countries, however, the forward effects are found to be just linear and negative rather than positive (with the exception of Romania).

Interestingly, in this specification the effect of concentration is positive for the Czech Republic (i.e. lower competition is beneficial to 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), 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 breakdowns by absorptive capability, export orientation and firm size. We always estimate equation (3) with linear effects only, in order to make interpretation easier.

We define absorptive capability in terms of the 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 to 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_{ij} for a firm i is defined as the distance between firm i's average total factor productivity over the whole time period and the average "foreign productivity frontier", defined as the 90th percentile of the average productivity of foreign firms in the sector j over the whole time period.

We split the sample into three groups by absorptive capability. The group with low *AC* consists of firms with *AC* below the 25th percentile of the *AC* distribution across all domestic firms. The medium *AC* group contains firms with *AC* between the 25th and 75th percentiles, while the high *AC* group includes firms with *AC* above the 75th percentile.

Tables A5 and A6 present the results. Again, the results are rather mixed across countries. According to the theory, we expected some positive spillovers in the group of firms with a medium absorptive capacity, as these most probably have a productivity gap to fill and at the same time some basic level of technology that enables them to adapt to better technologies. However, only in three out of the ten countries do we find positive spillovers for firms with a medium absorptive capability (forward in the Czech Republic, horizontal in Poland and backward in Romania). Negative spillover effects were often found in groups with both low and 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. Those NACE 2-digit sectors with exports to the EU25 as a share of sectoral output below the 25th percentile of the export share are identified as low export orientation industries. Sectors with a medium export orientation have export shares between the 25th and 75th percentiles, while sectors with a high export orientation have export shares above the 75th percentile. Again, the average values of individual industries over 2000–2005 were used to ensure that individual firms stay in the same sub-sample over the time period in order to better control for firm fixed effects.

According to the theory, we expected firms in more export-oriented sectors to be more prone to positive spillovers. The results support this hypothesis for several countries (the Czech Republic, Hungary, Poland, Slovenia and Estonia), while in two countries (Slovakia and Romania) negative

spillovers are detected also for sectors with high exports. For the former group, the results suggest some positive scope for spillovers for those domestic firms which produce in export-oriented industries. For the latter group, the results seem 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. An alternative explanation of the negative spillovers for high-export industries could be that export-oriented domestic firms compete with foreign firms on the same foreign market.

Tables A9 and A10 present the results by 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). The breakdown into sub-samples was based on the average value of firms over time.[30] We expected medium-sized companies to be able to benefit most from spillovers. This hypothesis is supported only partly for Poland, Slovakia and Romania, while in other countries the pattern of spillovers across the firm sizes differs. [31]

To compare the magnitude of the coefficients across countries, we used the results of the linear spillovers from Table 3 and calculated the average impact on the productivity of domestic firms of an increase in the three foreign presence measures (horizontal, backward and forward) by one standard deviation.[32] Table 5 shows the results in terms of the percentage change in the average log of total factor productivity, including the decomposition of the total effect into the individual foreign presence variables.

Table 5: Effect of an Increase in Foreign Presence on Average Productivity of Domestic Firms (% of average ln tfp)

	Czech Rep.	Hungary	Poland	Slovakia	Slovenia	Estonia	Lithuania	Latvia	Bulgaria	Romania
total effect	-0.8	-6.1	-0.4	-0.4	-2.3	7.9	-0.1	-3.0	-7.1	12.4
horizontal	-0.7	-0.2	1.1	-0.2	0.2	0.3	-2.1	0.3	-2.4	-3.6
backward	-0.3	1.9	0.5	0.8	1.0	7.3	2.9	-3.6	-2.2	11.6
forward	0.2	-7.9	-2.0	-1.0	-3.5	0.3	-0.8	0.3	-2.4	4.4

Note: Shaded areas denote statistically significant effects at 10% level of significance.

Table 5 indicates that the total effect of increased foreign presence is negative in most countries, ranging from minus 7.1 to minus 0.1 per cent of the average tfp of domestic firms. The only exceptions are Estonia and Romania, where a simultaneous increase in all three foreign presence variables by one standard deviation has positive (and relatively large) overall effects on the productivity of domestic firms. The results are somewhat more positive when looking only at backward spillovers, where the positive effects are more prevalent.

[30] For Hungary, reliable data on number of employees were not available, thus we used the percentile distribution (below 25th percentile, between 25th and 75th percentiles and above 75th percentile) of domestic firms by their turnover to get three mutually exclusive sub-samples.

[31] Some of the estimated coefficients are rather large compared to the average values, for example the coefficient for backward for Hungary in the low exp group. This is mainly because of relatively low within-sample variation for some of the sub-samples. To increase the variation, we included variables for absorptive capability, export orientation and firm size directly into the estimated equation – see Section 7: Robustness checks.

[32] Comparison of the coefficients directly is not possible, as the estimations are performed on data in national currencies. For descriptive statistics of all the variables used in the regressions, see Tables A11–A12.

7. Robustness Checks

We performed three robustness checks: first, estimating a linear version of the equation in differences, second, excluding outliers (defined as the upper 5% and lower 5% of firms when ordered by tfp) and, third, reestimating the conditional spillovers, simultaneously adding variables for absorptive capability, export orientation and firm size.

The results of the first robustness check indicate that the results of the linear analysis do not prove to be very robust (see Table 6). Similar results to those of the estimation in levels are obtained for the Czech Republic, Hungary, Slovakia and Latvia, while for the other six countries the results differ.

Table 6: Horizontal and Vertical Spillovers (estimations in differences, non-linear effects)

	Czech Rep.	Hungary	Poland	Slovakia	Slovenia	Estonia	Lithuania	Latvia	Bulgaria	Romania
Δ horizontal	-0.271*	0.164	-0.0711	-0.194	0.0533	0.288	0.178	0.39	0.282	0.353
Δ backward	-0.93	-4.424	2.029	0.099	-7.573***	3.443	-0.0556	-7.979**	2.989	-14.95***
Δ forward	1.498**	-13.28***	0.22	-0.124	6.208	4.744	1.21	1.138	-1.739*	4.415***
hhi	0.496*	0.764	0.0184	0.0673	0.313	-0.578	-0.282	0.652	-0.246	-1.374**
Observations	7304	2172	6971	1106	2946	2560	696	1539	1587	23654
Firms	3331	1424	2913	568	1190	839	412	517	414	6990
R-squared	0.01	0.07	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects. Dependent variable: Δln TFP, *hhi* de notes the Herfindahl index of turnover.

Estimations performed on the sub-sample that excludes outliers suggest that our linear results are not that sensitive to extreme values of tfp, i.e. they seem not to be driven by outliers (see Table 7). In several cases, the significance decreased, but the sign and the order of magnitude of the coefficients remained the same.

Table 7: Horizontal and Vertical Spillovers (checking for outliers, linear effects)

	Czech Rep.	Hungary	Poland	Slovakia	Slovenia	Estonia	Lithuania	Latvia	Bulgaria	Romania
horizontal	-0.142	-0.0698	0.512***	-0.0916	0.0562	0.326	-1.164***	0.0402	-0.422*	-0.603***
backward	-0.588	1.778	1.547	0.576	1.125**	5.971***	2.821	-10.68***	-1.195	1.509
forward	0.127	-4.474***	-1.57	-0.518	-23.07***	1.234	-0.632	1.149	-0.656	1.161**
hhi	-0.337*	-0.0525	-0.225	0.215*	-0.0998	-0.673	-2.089***	0.389	-0.409	-2.475***
Observations	10240	6215	9317	1599	4150	3287	1039	1976	1871	28813
Firms	3466	2323	2845	577	1159	810	400	519	386	6429
R-squared	0.00	0.12	0.05	0.01	0.10	0.03	0.10	0.19	0.02	0.04

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects. Estimated on the sub-sample containing firms with average tfp between 5th and 95th percentiles. Dependent variable: ln TFP, *hhi* de notes the Herfindahl index of turnover.

In the last robustness check, we estimated the linear effects equation simultaneously including variables for absorptive capability, export orientation and firm size directly into the equation. As these variables differ not only across individual firms, but also over time, we included in comparison to the sub-sample analysis the time-variant variables (i.e. not the firms' averages). In this case, absorptive capability was defined as the distance between firm *i*'s total factor productivity and the "foreign productivity frontier" in the previous year, export orientation was defined as the share of exports to the EU25 in the industry's output, and firm size was defined as

the number of employees in thousands (or, in the case of Hungary, as total turnover in billions of domestic currency).

Table 8: Horizontal and Vertical Spillovers (including conditional variables, linear effects)

	Czech Rep.	Hungary	Poland	Slovakia	Slovenia	Estonia	Lithuania	Latvia	Bulgaria	Romania
horizontal	-0.891***	1.757***	0.815***	0.204	0.272	0.588	-0.803	1.109	-1.239***	0.564**
backward	-3.259*	1.049	6.343***	0.528	0.29	8.088***	-1.978	-51.19***	-9.346***	-4.996***
forward	1.437**	-10.05***	-2.194	-1.976	0.202	9.470**	5.149	-6.704	-1.302	1.701**
hhi	-1.085*	-6.460**	-0.476	-0.63	0.711	0.387	0.0671	-0.787	-1.964***	-2.752***
absorptive capability	0.327***	-0.251***	0.0446***	-0.304	0.443	-0.316**	-0.361	0.219	0.0889	0.184***
export orientation	-0.168*	0.0517	0.0979*	0.0745	0.288	-0.0161	0.0307	0.320***	0.0854**	0.380***
firm size	-0.208***	0.0340***	-1.05***	-0.0712	-0.599***	0.402	-1.65*	1.03***	0.496***	-0.230***
Observations	6700	1864	6845	635	1122	2424	631	1258	1310	23654
Firms	3202	1240	2881	425	575	833	400	479	405	6990
R-squared	0.01	0.09	0.09	0.05	0.13	0.02	0.08	0.14	0.04	0.05

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects. Dependent variable: ln TFP, *hhi* de notes the Herfindahl index of turnover. For Hungary, firm size denotes the turnover in bn of domestic currency, while for the other countries the number of employees in thousands

Table 8 shows that when conditioning for additional factors related to productivity, the results change for a number of countries. The horizontal spillovers are now positive in three countries and negative in only two countries, while the backward spillovers are negative for four countries and positive for only two. This somewhat contradicts the aggregated findings in Table 3. As regards the conditional variables, the results are mixed, but it seems that, on average, higher absorptive capability, higher export orientation and lower firm size correspond to higher productivity.

8. Conclusions

In this paper, we discussed the inflow of foreign direct investment into the CEE countries and analysed the indirect effects of FDI on productivity – the 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 the total factor productivity of domestic firms and linked it to foreign presence in the same sector (horizontal spillovers) and in sectors linked via the production chain (vertical spillovers).

We found that the vertical effects tend to be higher and thus economically much more important than the 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 also have some adverse impact on the productivity of local firms, for example via the brain drain or market stealing effects.

Furthermore, we found strong non-linearities in the effect of foreign presence on local firms' productivity. In addition, we found that the spillovers depend on a number of industry and firm-level characteristics, including the relative technological level vis-à-vis foreign firms (absorptive capacity), export orientation and firm size.

As discussed earlier, the theory and anecdotal evidence often support both positive and negative effects of horizontal and vertical spillovers. Thus, when estimating spillovers, we did not make

any ex ante hypothesis about whether there should be positive (or negative) spillovers, but were mostly interested in whether there are spillovers at all and what their sign is. The next step in the analysis would be to find and empirically test for the determinants of the existence and sign of spillovers.

According to our results, the existence of horizontal and vertical spillovers using different breakdowns according to characteristics differs across the CEE countries, and no common pattern was detected. While some part of the differences might be due to different data quality and degree of coverage, some economic and institutional variables may still play a role in explaining these differences. Additionally, the definition of foreign company is very narrow in our study and further investigation by expanding the sample to include companies with less than 51% foreign ownership would shed additional light on the issue. Moreover, the results of the robustness checks suggest that the message from the analysis is robust in only a few countries.

An interesting question would be whether the presence of positive productivity spillovers is correlated with FDI expenditures that governments provide to attract FDI. Unfortunately, data on FDI expenditures are not easily available. However, this strand of research could provide some important insights into the relationship between the nature of FDI and the government schemes and could offer some policy relevant messages.

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 have experienced surprisingly positive economic developments since 2000. However, the effects of foreign firms on the host economies and the indirect effects on local firms are different across countries and also depend on other conditions and characteristics on the firm-, industry- and national level as well on the nature of the FDI. These are issues that have to be analysed more thoroughly.

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Appendix A

The Levinsohn and Petrin (2003) Estimator of Productivity

The Levinsohn and Petrin (2003) technique assumes a Cobb-Douglas production technology:[33]

$$v_t = \beta_0 + \beta_l l_t + \beta_k k_t + \omega_t + \eta_t \quad \text{(A1)}$$

where v_t is the log of value added, l_t is the log of freely variable labour input and k_t is the 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 on 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 the 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:

$$m_t = m_t(k_t, \omega_t) \quad \text{(A2)}$$

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:

$$\omega_t = \omega_t(k_t, m_t) \quad \text{(A3)}$$

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

$$\omega_t = E[\omega_t \mid \omega_{t-1}] + \xi_t \quad \text{(A4)}$$

where ξ_t is an innovation to productivity that is uncorrelated with k_t.

Thus, (1) can be rewritten as

$$v_t = \beta_l l_t + \phi_t(k_t, m_t) + \eta_t \quad \text{(A5)}$$

where

[33] This part draws heavily from Levinsohn et al. (2004).

$$\phi_t(k_t, m_t) = \beta_0 + \beta_k k_t + \omega_t(k_t, m_t) \tag{A6}$$

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 the parameters of equation (A1) using OLS as

$$v_t = \delta_0 + \beta_l l_t + \sum_{i=0}^{3} \sum_{j=0}^{3-i} \delta_{ij} k_t^i m_t^j + \eta_t \tag{A7}$$

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

$$\hat{\phi}_t = \hat{v}_t - \hat{\beta}_l l_t = \hat{\delta}_0 + \sum_{i=0}^{3} \sum_{j=0}^{3-i} \hat{\delta}_{ij} k_t^i m_t^j - \hat{\beta}_l l \tag{A8}$$

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

$$\hat{\omega}_t = \hat{\phi}_t - \beta_k^* k_t \tag{A9}$$

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

$$\hat{\omega}_t = \gamma_0 + \gamma_1 \omega_{t-1} + \gamma_2 \omega_{t-1}^2 + \gamma_3 \omega_{t-1}^3 + \varepsilon_t \tag{A10}$$

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 the minimisation of the squared sample residuals of the production function

$$\min_{\beta_k^*} \sum_t (v_t - \hat{\beta}_l l_t - \beta_k^* k_t - \hat{E}[\omega_t \mid \omega_{t-1}])^2 \tag{A11}$$

Standard errors are estimated via a bootstrap procedure, but may also be derived analytically.[34]

[34] The Levinsohn and Petrin (2003) methodology is available as an ado file for the Stata program, where a bootstrap technique is used to derive standard errors – see Levinsohn et al. (2004).

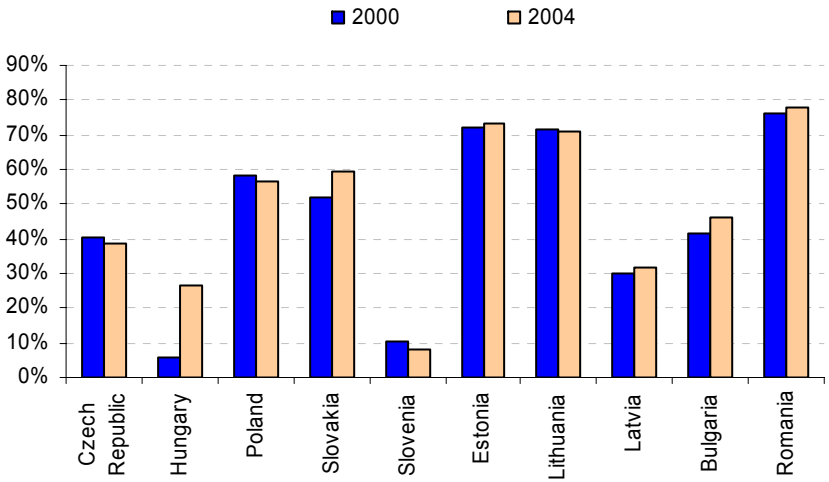
Table A1: Distribution of Manufacturing Turnover by NACE Sectors in 2004
(in % of total manufacturing turnover; Amadeus /Am/ versus WIIW /WI/)

	Czech Rep.		Hungary		Poland		Slovakia		Slovenia		Estonia		Lithuania		Latvia		Bulgaria		Romania	
	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI	Am	WI
Food products, beverages and tobacco	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
Textiles and textile products	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
Leather and leather products	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
Wood and wood products	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
Pulp, paper and paper products; publishing and printing	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
Coke, refined petroleum products and nuclear fuel	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
Chemicals, chemical products and man-made fibres	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
Rubber and plastic products	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
Other non-metallic mineral products	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
Basic metals and fabricated metal products	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
Machinery and equipment n.e.c.	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
Electrical and optical equipment	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
Transport equipment	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
Manufacturing n.e.c.	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	

Source: WIIW industrial database; Amadeus.

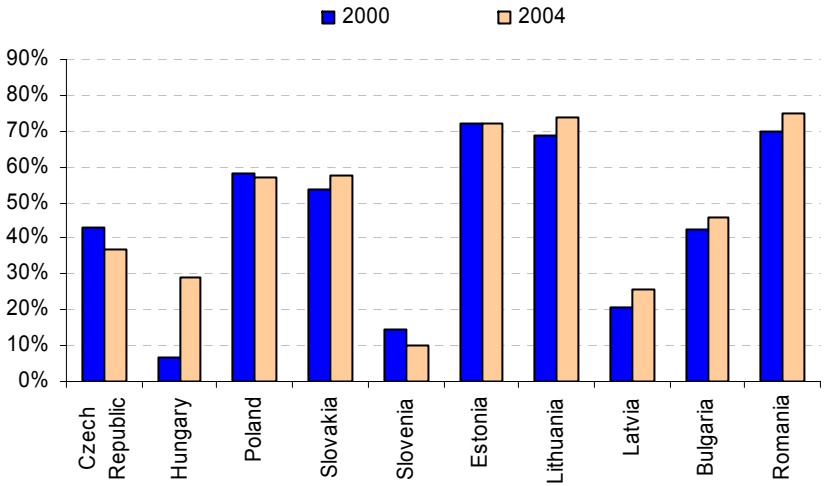
Figures A1 – A4

Share of foreign firms in total assets



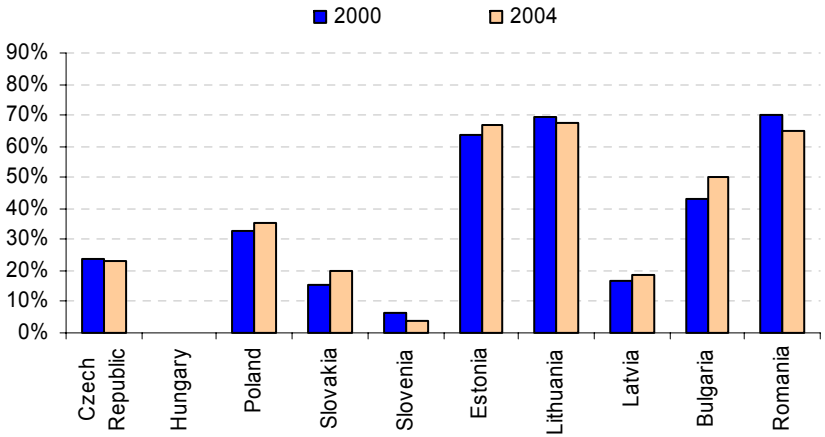
Source: Amadeus

Share of foreign firms in total turnover



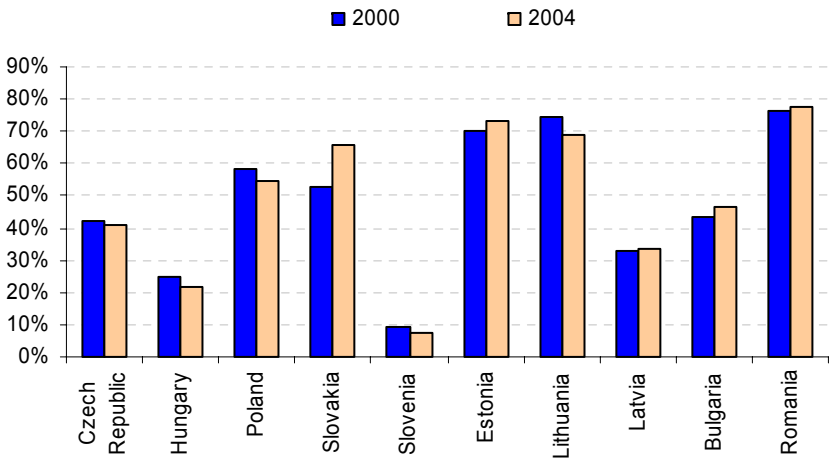
Source: Amadeus

Share of foreign firms in employees



Source: Amadeus

Share of foreign firms in stock of investment (fixed assets)



Source: Amadeus

Table A2: Descriptive Statistics by Ownership Status (as of 2004)

	Czech Republic	Hungary	Poland	Slovakia	Slovenia	Estonia	Lithuania	Latvia	Bulgaria	Romania
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%

Source: Amadeus.
Note: ROE = return on equity; for SI, ROE computed using P/L for period, otherwise P/L before tax is used; the difference in means is in all cases statistically significant.

Table A3: Total Turnover: Domestic versus Foreign Ownership Breakdown across Industries in 2004 (%)

	Czech Republic			Hungary			Poland			Slovakia			Slovenia		
	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
Food products, beverages and tobacco	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
Textiles and textile products	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
Leather and leather products	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
Wood and wood products	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
Pulp, paper and paper products; publishing and printing	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
Coke, refined petroleum products and nuclear fuel	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
Chemicals, chemical products and man-made fibres	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
Rubber and plastic products	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
Other non-metallic mineral products	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
Basic metals and fabricated metal products	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
Machinery and equipment n.e.c.	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
Electrical and optical equipment	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
Transport equipment	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
Manufacturing n.e.c.	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	62.9	37.1	100	70.8	29.2	100	43.2	56.8	100	42.3	57.7	100	89.8	10.2

Source: Amadeus.
Note: D = domestic firms, F = foreigh firms.

Table A4: Total Turnover: Domestic versus Foreign Ownership Breakdown across Industries in 2004 (%)

	Estonia			Latvia			Lithuania			Bulgaria			Romania		
	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
Food products, beverages and tobacco	18.5	34.9	65.1	32.8	81.0	19.0	28.2	28.6	71.4	16.8	59.9	40.1	20.8	34.0	66.0
Textiles and textile products	9.5	17.4	82.6	8.4	79.7	20.3	7.5	23.9	76.1	7.5	62.6	37.4	8.1	29.6	70.4
Leather and leather products	0.5	38.3	61.7	0.1	100.0	0.0	0.5	35.8	64.2	0.8	69.7	30.3	2.1	24.4	75.6
Wood and wood products	15.6	32.8	67.2	19.2	59.2	40.8	9.0	19.2	80.8	2.2	85.9	14.1	3.5	37.0	63.0
Pulp, paper and paper products; publishing and printing	5.7	42.0	58.0	5.3	83.1	16.9	6.0	29.6	70.4	9.7	60.6	39.4	3.5	29.4	70.6
Coke, refined petroleum products and nuclear fuel	1.0	67.4	32.6	0.0	n.a.	n.a.	0.4	0.0	100.0	0.0	0.0	100.0	6.7	2.7	97.3
Chemicals, chemical products and man-made fibres	5.6	7.2	92.8	2.4	85.3	14.7	4.2	19.1	80.9	6.2	68.1	31.9	5.9	18.6	81.4
Rubber and plastic products	4.4	30.8	69.2	4.1	78.8	21.2	7.8	41.7	58.3	3.5	32.6	67.4	4.3	29.4	70.6
Other non-metallic mineral products	5.1	40.8	59.2	5.7	25.5	74.5	4.3	27.9	72.1	4.4	31.0	69.0	4.6	22.3	77.7
Basic metals and fabricated metal products	9.3	25.7	74.3	7.9	87.7	12.3	6.2	26.1	73.9	35.8	48.7	51.3	17.8	17.5	82.5
Machinery and equipment n.e.c.	3.1	37.9	62.1	1.9	58.8	41.2	3.2	54.4	45.6	3.1	51.1	48.9	5.1	27.2	72.8
Electrical and optical equipment	10.1	12.5	87.5	5.0	84.4	15.6	14.0	12.0	88.0	7.7	54.2	45.8	6.2	27.7	72.3
Transport equipment	4.5	19.1	80.9	2.6	88.4	11.6	3.4	23.2	76.8	0.9	70.1	29.9	7.7	19.6	80.4
Manufacturing n.e.c.	7.2	28.0	72.0	4.5	87.5	12.5	5.3	35.4	64.6	1.4	31.4	68.6	3.8	36.9	63.1
Total	100	28.0	72.0	100	74.5	25.5	100	26.5	73.5	100	54.1	45.9	100	25.0	75.0

Source: Amadeus.
Note: D = domestic firms, F = foreigh firms.

Table A5: Spillovers by Absorptive Capability (dependent variable: ln TFP)

	Czech Republic			Hungary			Poland			Slovakia			Slovenia		
	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	-0.473	-0.19	-0.234	-0.209	-0.026	-0.798	-0.0848	0.400*	0.720**	0.0188	-0.194	-0.189	0.0728	0.636	0.885*
backward	1.314	-1.097	0.892	1.012	-0.87	-0.114	-0.303	-0.268	2.028	-3.278	0.167	0.805	-8.789*	1.602	0.454
forward	-2.218**	1.091**	0.485	5.328*	-6.016***	-2.339	-5.739	-1.393	-0.898	-3.555**	-2.202**	0.0942	17.05	-10.30*	-32.38***
hhi	-0.521	0.184	0.292	0.398	0.0871	-0.271***	-0.0572	-0.0342	-0.494	0.576*	0.111	0.281	-2.433***	0.367	-0.00342
Observations	2629	5736	3021	1440	2974	2450	2596	5319	2352	338	702	732	490	1134	3043
Firms	962	1926	962	566	1135	880	789	1581	789	126	253	262	158	318	811
R-squared	0.01	0.01	0.00	0.15	0.12	0.14	0.04	0.05	0.07	0.09	0.02	0.02	0.27	0.13	0.11

Note: ac = average absorptive capability defined as industry-specific distance to foreign productivity frontier, estimated via Levinsohn and Petrin (2003) technique
low ac = firms with ac below 25 percentile of ac distribution; medium ac = firms with ac between 25 and 75 percentile; high ac = firms 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 (dependent variable: ln TFP)

	Estonia			Lithuania			Latvia			Bulgaria			Romania		
	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	2.144	0.00242	-0.750*	1.97	-1.598***	-0.944***	0.651	0.0171	-0.265	0.268	-0.950***	-0.216	-1.292	-0.589**	-1.220***
backward	7.845	1.601	8.310**	1.02	3.494	1.326	-19.51	-11.92***	-6.868**	-0.43	-2.677	3.145	-3.443	3.402**	2.968
forward	13.84	-0.286	-4.111	5.34	-3.03	0.154	6.151	3.03	-4.537***	-2.354	-0.768	-0.436	-0.505	0.855	0.322
hhi	-0.252	-0.314	-0.87	-0.706	-1.847**	-0.726*	4.422	1.029	-0.124	0.811	-1.130**	-0.265	-0.39	-1.424**	-1.866***
Observations	772	1880	928	247	576	354	433	1099	654	454	1036	585	7653	16075	8103
Firms	224	450	224	111	222	111	140	283	152	104	210	114	1785	3573	1785
R-squared	0.05	0.07	0.05	0.14	0.1	0.22	0.19	0.18	0.25	0.05	0.03	0.03	0.05	0.03	0.05

Note: ac = average absorptive capability defined as industry-specific distance to foreign productivity frontier, estimated via Levinsohn and Petrin (2003) technique
low ac = firms with ac below 25 percentile of ac distribution; medium ac = firms with ac between 25 and 75 percentile; high ac = firms 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 (dependent variable: ln TFP)

	Czech Republic			Hungary			Poland			Slovakia			Slovenia		
	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	-0.108	-0.551***	0.898***	1.744	-0.0432	1.271**	-4.621***	0.0107	0.727*	0.542	-0.212	-0.503	-14.29***	-0.19	-1.071
backward	2.623	-2.518**	2.121	512.5***	2.175	3.801	88.67	1.16	-3.531	4.548	0.503	0.488	-31.81***	0.572	9.419***
forward	-1.476*	-0.0432	1.762	-141.6***	-5.242***	8.120**	-43.07	-5.278**	0.654	-0.258	-0.765	-7.809**	-2.099	-32.38***	-8.105
hhi	1.118***	0.0172	0.604	4.397*	-0.0633	-0.440**	64.15***	-0.0987	-0.625	1.103	0.185	0.629**	1.218***	-1.440***	1.679**
Observations	3048	5833	2505	743	4418	1703	2761	5270	2236	412	1014	346	1004	2728	935
Firms	1007	2009	834	284	1667	630	842	1627	690	150	375	116	276	750	261
R-squared	0.01	0.01	0.01	0.30	0.12	0.12	0.05	0.07	0.04	0.05	0.01	0.05	0.26	0.24	0.05

Note: exp = export orientation defined as share of NACE 2-digit sectoral exports to EU25 to its total turnover (average over the whole time span)
low exp = sectors with exp below 25 percentile; medium exp = sectors with exp between 25 and 75 percentile; high exp = 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 (dependent variable: ln TFP)

	Estonia			Lithuania			Latvia			Bulgaria			Romania		
	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	-0.5	-0.462	0.00242	-0.222	0.336	-3.402	0	0.681*	-0.885	-0.0759	-0.687**	-0.645	-4.193	-1.193***	-5.638
backward	12.28	1.713	5.611**	-52.44***	3.456	6.837	0	-12.23***	-8.586	10.77	-2.293	-4.095	3565	9.103***	10.89
forward	-2.151	-1.083	-6.23	6.855	2.533	-0.776	0	0.352	5.799	0.603	-1.027	-2.903*	-33.21	4.319***	-11.19*
hhi	-0.711	-0.878	0.482	-3.711*	0.0457	0.409	0	0.152	0.341	-0.935	-0.384	-0.297	-8.658	-0.564	15.28***
Observations	942	1742	896	249	764	164	115	1687	384	427	1224	424	1434	24880	5517
Firms	236	444	218	85	299	60	34	436	105	86	258	84	325	5563	1255
R-squared	0.04	0.05	0.09	0.34	0.09	0.11	0.3	0.18	0.17	0.06	0.03	0.03	0.03	0.04	0.12

Note: exp = export orientation defined as share of NACE 2-digit sectoral exports to EU25 to its total turnover (average over the whole time span)
low exp = sectors with exp below 25 percentile; medium exp = sectors with exp between 25 and 75 percentile; high exp = 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 (dependent variable: ln TFP)

	Czech Republic			Hungary			Poland			Slovakia			Slovenia		
	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large
horizontal	-0.129	-0.189	-0.604***	0.00523	-0.0203	-0.143	0.42	0.234	0.952**	0.45	0.0908	-0.399	-0.759	0.206	0.408
backward	-0.248	-0.299	0.0141	-0.657	-3.703	9.675***	-4.709*	3.915*	1.733	-2.051*	0.926*	1.276*	1.493**	0.41	1.479
forward	-0.575	0.666	0.484	-3.367**	-4.177***	-5.272***	1.511	-2.402	-2.995	0.929	-0.76	-1.326	-20.70***	-21.81***	-30.53***
hhi	0.141	-0.235	0.550**	-0.025	-0.0868	-0.0438	-0.279	-0.3	0.521	0.34	0.229	0.204	-0.740**	-0.262	1.201***
Observations	3806	5599	1981	1520	3486	1858	2729	5584	1954	369	973	430	2149	1738	780
Firms	1521	1756	573	649	1296	636	924	1679	556	161	342	138	681	443	163
R-squared	0.01	0.00	0.02	0.11	0.16	0.09	0.05	0.05	0.07	0.12	0.04	0.06	0.13	0.13	0.08

Note: small firms = up to 50 employees; medium-sized firms = up to 250 employess; large firms = more than 250 employees
for Hungary, small firms defined as firms with average turnover in the first 25 percentile of distribution, medium-sized between 25 and 75 percentile and large above 75 percentile
significant at 10%; ** significant at 5%; *** significant at 1%. Estimated with firm and year fixed effects.

Table A10: Spillovers by firm size (dependent variable: ln TFP)

	Estonia			Lithuania			Latvia			Bulgaria			Romania		
	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large	small	medium-sized	large
horizontal	0.542	-1.186*	-5.935*	-0.282	-0.922**	-0.593	-0.508	0.247	0.878	-0.317	-0.495	-0.873*	-0.375	-1.800***	-2.611***
backward	4.350*	4.033	-26.1	-0.779	3.104	-14.75	-13.83***	-8.964**	-30.14***	3.073	0.754	-2.739	0.684	3.182	11.74**
forward	0.223	0.934	-19.97	-0.287	0.00366	-6.923	-0.0881	0.128	-3.412	-2.418***	0.121	0.866	-0.24	1.489*	0.466
hhi	-0.224	0.0386	-6.932	-3.139***	-0.152	-2.903	0.209	0.0636	2.454***	-2.150***	-0.184	0.776	-2.877***	1.649	0.82
Observations	2856	672	52	560	551	66	834	1076	276	739	901	435	23270	6944	1617
Firms	715	169	14	237	188	19	261	256	58	160	184	84	5291	1510	342
R-squared	0.04	0.1	0.19	0.07	0.13	0.48	0.27	0.15	0.2	0.08	0.04	0.06	0.04	0.03	0.03

Note: 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 A11: Descriptive Statistics of Variables Used in Regression

	Czech Republic				Hungary				Poland				Slovakia				Slovenia			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
ln real value added	11.094	1.484	1.792	17.926	11.592	1.665	2.064	23.137	9.053	1.346	1.609	14.713	11.292	1.399	5.170	17.691	12.425	1.399	5.977	17.977
ln real capital	9.910	2.099	0.000	17.634	11.619	1.845	0.022	19.634	8.284	1.863	-0.002	14.731	10.386	1.918	3.099	18.514	12.515	1.866	3.045	19.113
ln labor	4.374	1.316	1.099	10.109	10.754	1.645	-0.184	21.119	4.638	1.134	0.000	8.764	4.911	1.318	0.000	8.923	4.194	1.345	0.000	8.643
ln real materialcosts	10.668	1.869	0.000	18.551	12.566	1.636	0.000	24.746	8.744	1.861	-0.033	19.352	10.616	1.973	-0.106	18.838	13.127	1.502	6.180	19.036
ln tfp	6.982	1.396	-1.213	13.812	3.917	3.425	-4.607	16.638	5.023	0.978	-2.319	8.488	7.525	1.678	-0.229	13.195	8.521	1.407	2.792	12.919
horizontal	0.286	0.169	0.000	1.000	0.152	0.189	0.000	0.999	0.494	0.155	0.123	1.000	0.265	0.285	0.000	1.000	0.052	0.130	0.000	1.000
backward	0.119	0.089	0.000	0.304	0.058	0.053	0.000	0.238	0.127	0.089	0.001	0.325	0.114	0.095	0.001	0.480	0.033	0.076	0.000	0.337
forward	0.103	0.060	0.013	0.264	0.057	0.074	0.004	0.425	0.124	0.063	0.039	0.236	0.154	0.099	0.006	0.400	0.017	0.013	0.000	0.055
hhi	0.061	0.083	0.006	1.000	0.144	0.219	0.000	1.000	0.063	0.111	0.000	1.000	0.223	0.199	0.026	1.000	0.117	0.101	0.000	1.000
absorptive capability	0.831	0.124	-0.005	1.984	0.712	0.329	-4.464	4.001	0.758	0.345	-7.945	19.503	0.835	0.173	-0.031	2.057	0.922	0.077	0.669	1.230
export orientation	0.717	0.411	0.092	2.939	1.457	4.019	0.003	152.003	0.595	0.568	0.003	3.662	2.152	3.774	0.232	46.791	0.537	0.389	0.000	3.455
firm size (no of employees)	198	532	10	24561	…	…	…	…	196	310	10	6400	318	617	10	7500	172	369	10	5671

Table A12: Descriptive Statistics of Variables Used in Regression

	Estonia				Lithuania				Latvia				Bulgaria				Romania			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
ln real value added	8.294	1.408	-1.082	13.695	13.849	1.491	6.444	19.342	12.135	1.481	3.644	16.243	6.357	1.643	-2.284	12.337	5.396	1.768	-6.215	14.035
ln real capital	7.752	1.870	-0.347	14.338	13.908	1.783	1.990	20.168	12.458	1.675	5.444	17.145	5.800	2.044	-0.104	13.527	5.078	1.950	-6.908	14.438
ln labor	3.421	1.087	0.000	8.514	3.931	1.073	0.000	8.195	4.308	1.170	0.000	7.972	3.682	1.401	0.000	9.355	3.577	1.352	0.000	12.302
ln real materialcosts	8.637	1.731	-0.099	13.813	14.930	1.481	7.549	19.883	13.549	1.368	4.691	17.318	5.706	2.092	-0.147	13.408	5.722	1.948	-7.200	14.533
ln tfp	5.432	1.031	-2.733	8.647	6.782	2.152	-3.699	10.385	9.560	2.042	1.735	16.238	3.387	1.701	-3.275	7.803	2.032	1.105	-6.973	6.307
horizontal	0.697	0.117	0.000	1.000	0.700	0.141	0.000	1.000	0.236	0.188	0.000	1.000	0.461	0.172	0.000	1.000	0.657	0.085	0.404	0.982
backward	0.116	0.092	0.002	0.433	0.178	0.123	0.000	0.474	0.033	0.031	0.000	0.127	0.100	0.083	0.000	0.384	0.150	0.093	0.018	0.316
forward	0.116	0.096	0.000	0.303	0.150	0.098	0.000	0.434	0.034	0.035	0.006	0.314	0.169	0.090	0.013	0.520	0.308	0.186	0.024	0.622
hhi	0.067	0.086	0.020	1.000	0.148	0.159	0.000	1.000	0.110	0.126	0.000	1.000	0.095	0.086	0.025	1.000	0.018	0.035	0.000	0.483
absorptive capability	0.791	0.134	-0.466	1.288	0.866	0.116	0.327	1.203	0.834	0.144	0.091	1.620	0.769	0.301	-0.380	3.305	0.581	0.276	-3.049	2.537
export orientation	0.802	1.407	0.096	20.968	2.704	14.271	0.042	428.101	1.232	7.823	0.057	210.167	1.854	14.286	0.000	676.410	0.736	0.901	0.000	2.884
firm size (no of employees)	64	167	10	4985	97	206	10	3624	142	211	10	2900	116	320	10	11554	119	999	10	220127

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