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Impact of Firm Heterogeneity on Direct and Spillover Effects of FDI: Micro Evidence from Ten Transition Countries

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Impact of Firm Heterogeneity on Direct and Spillover Effects of FDI: Micro Evidence from Ten Transition Countries

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Abstract

This paper presents a comparative study of the importance of direct technology transfer and spillovers through FDI on a set of ten transition countries, using a common methodology and appropriate methods to account for selection and simultaneity correction. This paper considers by far the largest firm level dataset (more than 90,000 firms) used by any study on the spillover effects of FDI. The main novelty of the paper is the explicit control for various sources of firm heterogeneity when accounting for different effects of FDI on firm performance. Controlling for these variables leads to some interesting results which contrast with the previous empirical work in the field. We find that horizontal spillovers have become increasingly important over the last decade, and they may even become more important than vertical spillovers. Furthermore, this work shows that the heterogeneity of firms in terms of absorptive capacity, size, productivity and technology levels affect the results. These findings suggest that both direct effects from foreign ownership as well as the spillovers from foreign firms substantially depend on the absorptive capacity and productivity level of individual firms. Only more productive firms and firms with higher absorptive capacities are able to both compete with foreign affiliates in the same sector and benefit from the increased upstream demand for intermediates generated by foreign affiliates. In addition, these results show that foreign presence may also affect smaller firms to a larger extent than larger firms, but this impact may be in either direction.

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

JEL Classification: D24, F14

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1. Introduction

Foreign investors can transfer technology in two ways: directly to the affiliates under their ownership and control, and indirectly to other firms in the host economy through spillovers. There is ample empirical evidence of positive direct technology transfers from a multinational company (MNC) to its foreign affiliates in terms of higher productivity levels and growth. On the other hand, despite the theoretical justification of potential spillovers, the evidence of technology spillovers from a foreign affiliate to its host country horizontal competitors and/or vertically linked suppliers and customers is weak or even negative. According to the literature, there are a number of potential reasons for empirical failure to find significant spillovers. They include the effectiveness of MNCs in protecting their technology advantages and thus in preventing potential spillovers, the low absorption capacity of host country firms, a lack of differentiation between vertical and horizontal spillovers, and the fact that most of the studies have been carried out at the aggregate or sectoral level despite the fact that only some categories of domestic firms are able to absorb FDI spillovers. This puts forward the issue of firm heterogeneity. In addition to these, there are several other data and methodology related reasons for the failure to find evidence of spillovers.

Recently, many studies have been conducted on FDI spillovers in transition countries. Most of these analyses are based on firm level panel data and suggest only a few intra-industry spillovers from FDI, if any. Some of the more recent studies provide more optimistic results about FDI spillovers in some transition countries, at least in some sectors or categories of FDI. These studies provide useful insight into the effects of international R&D spillovers to transition economies at the firm level, but due to the heterogeneous methodology used, they remain merely case studies.

This paper has two primary objectives. The first objective is to provide a comparative study on the importance of direct technology transfer and spillovers through FDI using an exhaustive firm-level dataset on a group of comparable countries by using a common methodology and appropriate methods to account for selection and simultaneity problems. This is a way of achieving comparability of results and of providing credible insight into the importance of FDI as a channel of international technology transfer for firms in transition countries. The second objective of the paper is to account for the inherent heterogeneity of firms. Most of the empirical work so far dealing with the issue of spillover effects from FDI on firm performance has neglected the fact that local firms in competition with foreign affiliates in the same sector or in cooperation with upstream foreign affiliates are not homogeneous in terms of size, absorptive capacity, productivity or technology. Some recent studies, however, demonstrate that firm heterogeneity in terms of absorptive capacity might explain a significant portion of the differential impact of FDI on firm performance. This paper explicitly accounts for different aspects of firm heterogeneity, including size, absorptive capacity, productivity and the technology gap relative to foreign affiliates.

We differentiate between direct effects of FDI from the parent firm to foreign affiliates and horizontal and vertical spillovers from these affiliates to domestically owned local firms. To calculate horizontal and vertical spillovers and to differentiate between backward and forward vertical linkages, we use the methodology developed by Blalock (2001) and Damijan et al (2003a, 2003b). The importance of these different channels of technology transfer is then estimated in the framework of the growth-accounting approach using a unique firm-level database that consists of a panel of some

91,500 firms in 10 transition countries from 1995-2005. The countries include eight new EU member states (Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Poland, Romania and Slovenia), plus Croatia and Ukraine.¹ We use several correction methods to account for possible biases in the data. We deal with the simultaneity problem that typically arises in the growth-accounting approach in a panel data framework by using the Olley - Pakes method. In addition, we correct for potential selection bias that arises due to possibly endogenous foreign investment decisions using a generalized Heckman two-step procedure.

Over the course of the estimations, the dataset is divided by country, and then into smaller subsamples according to size, productivity, and technology gaps, controlling for firm absorptive capacity. This empirical exercise reveals several interesting findings. First, direct effects of foreign ownership on firm performance are rarely present in this exhaustive dataset of ten transition countries (only in three countries), but, if present, they are strictly positive. Second, horizontal spillovers are mostly negative if the absorptive capacity of firms is not controlled for. When accounting for firms' absorptive capacity, in most of the countries (six to seven out of ten), firms benefit from the increased competition of foreign affiliates in the same sectors. Third, positive horizontal spillovers are equally distributed across firm size classes, while negative horizontal spillovers seem to be more likely for smaller firms. Fourth, positive horizontal spillovers seem more likely to be present in medium or high productivity firms with higher absorptive capacities, while negative spillovers are more likely to affect low to medium productivity firms. Fifth, vertical spillovers are less frequent than horizontal spillovers from FDI. If they are present, however, then smaller and more productive firms are more likely to benefit from positive vertical spillovers, while larger and less productive firms are more likely to suffer from negative vertical spillovers.

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

2. Channels of technology transfer through FDI

There are many ways that a firm can acquire new technology aside from its own investments in R&D capital. Despite trade, FDI is potentially the most important international vehicle of technology transfer for firms. Foreign investors can transfer technology in two ways: directly to the affiliates under their ownership and control, and indirectly to other firms in the host economy through spillovers. There is ample empirical evidence on positive direct technology transfers from MNCs to their foreign affiliates in terms of higher productivity levels and growth. Empirical studies using firm-level panel data have included developed as well as developing countries (for example, Haddad and Harrison, 1993; Blomström and Wolff, 1994; Blomström and Sjöholm, 1999; Aitken and Harrison, 1999; Girma et al, 2001; Barry, Görg and Strobl, 2002; Alvarez et al, 2002; Blalock, 2001; Damijan et al, 2003b; Arnold and Smarzynska-Javorcik, 2005; Girma and Görg, 2006). FDI may also be the cheapest means of technology transfer, as the recipient firm normally does not have to finance

¹ The selection of countries has been determined by data availability and quality.

the acquisition of new technology. Additionally, it tends to result in the transfer of newer technology more quickly than licensing agreements and international trade (Mansfield and Romeo, 1980), and it has the most direct effect on firm efficiency. FDI has been particularly important as a source of foreign technology and productivity growth for firms in transition economies because of the urgent need to restructure quickly (Blanchard, 1997).

The extent and scope of technology transfers from MNCs to their foreign affiliates heavily depends on the position of foreign affiliates in the MNCs' international production network (see, for instance, White and Poynter 1984, Bartlet and Ghoshal 1989, Young, Birkinshaw and Hood 1998).² This points to the importance of including parameters of foreign affiliates' heterogeneity in the analysis of technology transfer from their parent companies.

The other method of technology transfer through FDI is spillovers from foreign affiliates to domestic firms. These transfers take place when the entry or presence of foreign affiliates, which typically have better technologies and organizational skills than domestic firms, increases the knowledge of domestic firms and foreign investors do not fully internalize the value of these benefits (Griliches 1979, 1992). FDI spillovers can occur between firms that are vertically integrated with the MNC (vertical, inter-industry spillovers) or in direct competition with it (horizontal, intra-industry spillovers). Kokko (1992) identifies at least four ways that technology might be diffused from foreign affiliates to other firms in the host economy: the demonstration-imitation effect, the competition effect, the foreign linkage effect and the training effect. Not all spillovers are positive, as FDI can generate negative externalities when foreign firms with superior technology force domestic firms to exit. These negative externalities are also often referred to as the competition effect, the crowding-out effect or the business-stealing effect. The substantial body of empirical literature on FDI spillovers, which has developed over the last 30 years, has produced mixed empirical results. The econometric analyses have found positive, neutral, and negative spillovers from foreign subsidiaries to domestic firms. The discussion on FDI spillovers mainly focuses on estimates of the magnitude of intra-industry FDI spillovers in terms of domestic productivity, which constitutes the largest and most influential portion of the literature (Keller and Yeaple, 2003: 3-5). There is also no strong consensus on the associated magnitudes of FDI spillovers (Blomström et al, 2000) or on their causality (Lim, 2001; Rodrik, 1999).

Overviews of the literature on FDI spillovers (see, for instance, Görg and Strobl, 2001; Görg and Greenaway, 2004; Hanson, 2001; Smarzynska-Javorcik, 2004; Keller and Yeaple, 2003; Keller, 2004) mostly identify three types of analyses: case studies, sectoral studies, and the current predominant form, studies based on firm level data. Traditionally, FDI spillovers were assessed by sectoral and case studies. They demonstrated mostly positive FDI spillovers. Lately, firm level, preferably panel data based studies dominate the field (Görg and Strobl, 2001; Görg and Greenaway, 2004; Keller and Yeaple, 2003; Keller, 2004; Knell and Rojec, 2007). The main reason that empirical analysis of FDI spillovers moved towards using firm level data was a

² One of the first and still frequently used classifications of this kind is the one by White and Poynter (1984), who differentiate among five types of foreign affiliates - marketing satellite, miniature replica, rationalized manufacturer, product specialist and strategic independent unit - with obviously very different extents and scopes of technology transfers.

heterogeneity problem (Keller, 2004). Firm-level panel data analysis uses regressions of productivity on FDI and a number of control variables. Most firm level studies cast doubt on the existence of FDI spillovers in developing countries (Haddad and Harrison, 1993; Aitken and Harrison, 1999; Harrison, 1996; Blomström and Sjöholm, 1999; Lim, 2001 etc.); if positive, they have been found to be limited to certain (types of) industries (Haddad and Harrison, 1993; Blomström and Sjöholm, 1999; Blomström et al, 1994). The picture is slightly more optimistic for industrialized countries (Girma, Greenaway and Wakelin, 2001; Haskel et al, 2001; Barry, Görg and Strobl, 2002; Alvarez et al, 2002, etc.).

Recently, the literature on FDI spillovers in transition countries has grown; the evidence from firm-level panel data analysis suggests only a few intra-industry spillovers from FDI. Konings (2001) shows that FDI may be important for transferring technology to an affiliate. He provides no evidence of positive horizontal spillovers to local firms in Bulgaria, Poland or Romania from 1993 to 1997, but instead finds significant evidence of negative spillovers in Poland. Djankov and Hoekman (2000) also provide evidence of negative spillovers and suggest that there may not even have been much technology transfer to foreign affiliates in the Czech Republic from 1992 to 1996. Kinoshita (2000) provides evidence of spillovers in the Czech Republic from 1995 to 1998, however the spillovers are limited to firms engaged in R&D or in the production of electrical equipment. Tytell and Yudaeva (2005) demonstrate positive FDI spillover effects on domestic firms in Poland, Romania, Russia and Ukraine, but only in the case of export-oriented FDI. Damijan et al (2003b, for 10 transition countries), Gorodnichenko et al (2007, for 17 emerging market economies), Schoors and van der Tool (2001), and Smarzynska-Javorcik (2004) all find some evidence of (backward) vertical spillovers from FDI, but much less evidence, if any, for horizontal spillovers. Nicolini and Resmini (2006) find evidence of horizontal, vertical-backward and vertical-forward spillovers on domestic firms generated by foreign firms in Bulgaria, Romania and Poland.

The overall impression of the lack of evidence on FDI spillovers is predominantly due to the results of the firm-level panel data analysis. This is important because panels using firm-level data are the most appropriate estimation method of FDI spillovers. Görg and Greenaway (2001, 2004) list a number of reasons for the failure to find unambiguously positive spillover effects in econometric work. This is supported by the work of other authors:

- a/ In a number of cases, there may really be no (or even negative) spillovers. Foreign investors may be effective in ensuring that their technology advantages and other firm specific assets do not spill over, or they may even reduce the productivity of domestic firms through competition effects (Aitken and Harrison, 1999; Caves, 1996; Konings, 2001; Sgard, 2001; Görg and Strobl, 2001).
- b/ Spillovers may not occur horizontally (intra-industry) but through vertical relationships, which are missed in conventional spillover studies (Blalock, 2001; Schoors and van der Tool, 2001; Kugler, 2006; Smarzynska-Javorcik, 2004; Damijan et al, 2003a, 2003b; Halpern and Murakozy, 2007, etc.).
- c/ Positive spillovers may only affect a sub-set of firms and aggregate studies. Therefore, the true significance of such effects is underestimated, due to the firm heterogeneity problem. Studies that further disaggregate data into more homogenous groups of firms and plants find more encouraging results as far as FDI spillovers are concerned (Görg and Greenaway, 2004). Firm heterogeneity includes

many aspects, which act in different directions; (i) the geographical distance between foreign affiliates and domestic firms, (ii) the time/dynamic dimension of FDI spillovers, (iii) the heterogeneity of foreign affiliates, (iv) the heterogeneity of foreign investors and (v) the heterogeneity the absorption capacity of domestic firms. The introduction of firm heterogeneity in the analysis proves to be a very important development in empirical studies of FDI spillovers.³

- d/ There is often a lack of absorption capacity in host countries. Empirical evidence (Kokko, 1994; Borensztein et al, 1998; and Kinoshita, 2000) demonstrates that FDI can only contribute to overall domestic productivity growth when the technology gap between domestic and foreign firms is not too large and when a sufficient absorptive capacity is available in domestic firms.
- e/ In addition to these, there are several other data and methodology related reasons for the failure to find evidence of spillovers. Some reasons are poor data quality, limited samples and the short panels of firms studied. Another reason could lie in the hypothesis of a linear relationship between spillovers and local firms' productivity growth, resulting in the incorrect specification of the model.⁴ Yet another reason could be the use of inappropriate econometric techniques such as simple pooled OLS or static panel data techniques (Görg and Greenaway, 2001, 2004; Knell and Rojec, 2007).

By applying the firm-level panel data analysis, this paper specifically tackles some of the above problems of FDI spillover analysis; that is, we distinguish between vertical and horizontal spillovers and introduce the following sources of firm heterogeneity: the geographical distance between foreign subsidiaries and domestic firms, the time/dynamic dimension of technology transfer through FDI, and the heterogeneity of domestic firms as far as technological capacities, productivity and human capital are concerned. Here, we briefly overview the evidence in the existing literature for the effects of heterogeneity on spillover effects.

Vertical and horizontal FDI spillovers. It was recognized long ago that entry of a MNC may stimulate the development of upstream host country industries supplying parts or components (Markusen and Venables, 1999). However, empirical studies of FDI spillovers have only recently begun to take explicit account of the differentiation between vertical and horizontal spillovers. The overwhelming conclusion of these studies is that horizontal intra-industry spillovers are less likely to take place than vertical spillovers. With rare exceptions, such as Smarzynska and Spatareanu (2002) for Romania, these studies suggest mostly positive vertical spillovers for host countries. Blalock (2001) finds positive productivity spillovers from FDI in upstream industries in Indonesia; Schoors and van der Tool (2001) find positive vertical spillovers in Hungary; Kugler (2006) finds FDI knowledge spillovers between but not within industries of the Colombian manufacturing sector; Smarzynska-Javorcik (2004) finds positive backward FDI spillovers but no horizontal spillovers in Lithuania; Damijan et al (2003b) find that vertical spillovers are much more important than horizontal spillovers for 10 transition countries. For 17 emerging market economies, Gorodnichenko et al (2007) find that

³ For an overview of the literature on the importance of different sources of heterogeneity for FDI spillovers, see Knell and Rojec, 2007.

⁴ Castellani and Zanfei (2007) claim that modelling MNCs' presence as the share of total activities should control for the size of the industry; if this is not done, then estimates of externalities tend to be biased towards zero. Keller and Yeaple (2003) and Görg and Strobl (2001) also put high importance on the accurate measuring of foreign presence.

backward spillovers are consistently positive and that forward spillovers are positive only for old and service sector firms, while horizontal spillovers are insignificant but positive; and Halpern and Murakozy (2007) find positive vertical and negative horizontal FDI spillovers in Hungary.⁵ The message of the above research is clear: empirical studies on technology spillovers should differentiate between horizontal and vertical spillovers, while the analysis of vertical spillovers should further differentiate between backward and forward linkages induced by foreign affiliates.

Geographical distance between foreign subsidiaries and domestic firms is probably the oldest recognized firm heterogeneity determinant of knowledge spillovers; it has already been looked at in the analysis done by Griliches (1979, 1992). Domestic firms that are located near MNCs and their subsidiaries may be more likely to benefit than other firms (Görg and Greenaway, 2004). Geographical proximity is necessary to facilitate knowledge spillovers (Audretsch, 1998), because for transmitting knowledge face-to-face, communication and personal interaction are important, especially as far as tacit knowledge transfer is concerned (Jacobs, 1993). With the exception of Sjöholm (1999) and Aitken and Harrison (1999), who fail to find evidence for a regional component of FDI spillovers in Indonesia and Venezuela, empirical evidence confirms that technological spillovers are limited by distance. Branstetter (1996) claims that spillovers are primarily intra-national in scope, Girma and Wakelin (2002) find positive spillovers in domestic UK firms located in the same region as foreign subsidiaries, while Sgard (2001) finds spillovers in domestic Hungarian firms located in the most developed region, closer to EU borders. Halpern and Murakozy (2007) also find that distance matters for backward linkages in the Hungarian case.

The time/dynamic dimension of FDI spillovers has rarely been present in the analysis of FDI spillovers, but it offers another possibility to improve the accuracy of empirical research. Kosova (2006) tackles the problem by analyzing the effect of foreign firm presence on the growth and survival of domestic firms in the Czech Republic. She finds both a negative crowding out effect and a positive technology spillover effect. Crowding out appears to be a short-term or static phenomenon: initial foreign entry increases the exit rate of domestic firms. Subsequently, however, the growth of the foreign industry segment is accompanied by increases in both the growth rate and survival of domestic firms. This seems to confirm that foreign subsidiaries tend, with the passage of time, to intensify their vertical relations with local firms and to establish more stable linkages with the local environment (Cantwell, 1989).

The heterogeneity of domestic firms as a determinant of technology spillovers through FDI relates primarily to their productivity, technological capacity and human capital. These factors determine domestic firms' absorption capacity for spillovers (For an overview of relevant literature see Knell and Rojec, 2007). Absorption capacity for knowledge spillovers is most frequently directly 'measured' by a firm's *level of technological capacity*. Any technology gap signals something about absorptive capacity (Glass and Saggi, 1998). Given that MNCs tend to tap into local lines of technological development and/or to import more technology to productive locations where local competition is strongest, existing centers of excellence in the development of a certain technology will benefit most from possible technological spillovers. In these

⁵ Other sources dealing with vertical versus horizontal FDI spillovers include Kugler (2001, 2002), Blalock and Gertler (2003), Damijan et al (2003a), Driffield et al (2002), Harris and Robinson (2002), Girma et al (2003).

productive areas, the importing of technology by foreign subsidiaries and the absorption of foreign technology by local firms will interact to generate virtuous circles of technological development (Cantwell, 1987, 1989). The empirical literature – Perez (1998) for the UK and Italy, Halpern and Murakozy (2007) for Hungary, Ben Hamida and Gugler (2007) for Switzerland, Abraham et al (2006) for the Chinese manufacturing sector, Girma et al (2006) for Chinese state-owned enterprises – predominantly confirms that knowledge spillovers occur more frequently if the technology gap between domestic and foreign firms is not too large and thus a sufficient absorptive capacity is available in domestic firms. In contrast, Findlay (1978) claims that a larger technological gap offers more room for technological spillovers.

Differences in the technological capacity of domestic firms are frequently proxied by *differences in their productivity levels*.⁶ According to Keller and Yeaple (2003: 28), the U.S case shows that a relatively high productivity is required for a firm to acquire FDI related spillovers. In the case of Bulgaria, Romania and Poland, only more productive firms have been able to reap the technological externalities emanating from FDI (Nicolini and Resmini, 2006). Quite the opposite, Haskel et al (2001) estimate that on average, less productive (and smaller) UK plants receive stronger FDI spillovers than more productive (and larger) ones. Castellani and Zanfei (2003), in the case of France, Italy and Spain, find that high productivity gaps tend to favor positive effects of FDI.

Human capital capacity is probably the most frequently used measure of a firm's absorption capacity for FDI spillovers. Human capital capacity has been argued to increase the ability of domestic firms to benefit from positive spillovers (Borensztein et al, 1998; Meyer and Sinani, 2001). Thus, Ben Hamida and Gugler (2007) only find positive FDI spillovers in a sub-sample of domestic Swiss firms that substantially invest in upgrading their human capital. Spillovers, however, negatively affect the productivity of domestic firms which do not actively engage in investment and learning. Girma et al (2006) similarly claim that there is a positive effect of FDI on Chinese state-owned enterprises that invest in human capital. Gorodnichenko et al (2007), however, find that firms with a higher proportion of university-educated workers do not enjoy greater FDI spillovers than firms with less educated workers.

Yet another determinant of domestic firms' absorption capacity and knowledge spillovers via FDI identified in the literature is *company size* (Knell and Rojec, 2007). Company size seems to have a positive influence on domestic firms' absorption capacity. It is generally recognized that size has a positive influence on firms' innovation activity (Veugelers and Cassiman, 1999) and absorption capacity (Ornaghi, 2004).⁷

⁶ Thus, Ben Hamida and Gugler (2007) define technological gaps of domestic firms as the ratio of the average labor productivity of foreign-owned firms in the relevant four-digit industry to the domestic firm's own labor productivity.

⁷ One of the rare exceptions is Aitken and Harrison (1999), who find that productivity in small Venezuelan firms increased following the arrival of MNCs, while similar effects do not occur for large domestic firms.

3. Modeling direct and spillover effects of FDI

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

Recent studies on technology transfer and spillovers through FDI are typically carried out using firm-level panel data. The impact of external technology spillovers can be measured indirectly in a production function approach by considering the Solow residual of output growth as the rate of technological change after subtracting the growth rates of labor and capital. However, this residual may be more a measure of ignorance than a measure of technological accumulation, as Abramovitz (1956) pointed out. An alternative method is to include the technology variables directly in the production function, a method similar to the endogenous growth models developed since the late 1980s. This approach provides a way to study the various factors that affect productivity growth, including technological accumulation. This is done using the growth-accounting approach and decomposing total factor productivity (TFP) into factors internal and external to the firm, such as R&D activity, human capital and channels of technology transfer.

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

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

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

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

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

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

$$(3) \quad T_{it} = f^i(G_{it}, Z_{it}),$$

where

$$\begin{aligned} (F_{it}, H_{it}) &\in G_{it} \\ (ES_{kt}, HS_{kt}, VSb_{kt}) &\in Z_{kt}, \end{aligned}$$

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

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

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

Knowledge spillovers can occur either between firms in the industry (external spillovers) or between foreign owned firms. Knowledge spillovers stemming from foreign owned firms arise between firms that are vertically integrated with the foreign affiliate (inter-industry spillovers) or in direct competition with it (intra-industry spillovers). Kokko (1992) and Perez (1998) describe at least five ways that knowledge spillovers from foreign affiliates can increase technical change and technological learning. First, competition with the foreign affiliate can increase intra-industry spillovers by stimulating technical change and technological learning. Greater competitive pressure faced by local firms induces them to introduce new products to defend their market share and adopt new management methods to increase productivity. This sort of spillover, known as the competition effect, is the most important in industries with relatively low actual and potential competition and high barriers to entry. Second, cooperation between foreign affiliates, upstream suppliers and downstream customers increases knowledge spillovers (vertical spillovers). To improve the quality standards of their suppliers, foreign affiliates often provide resources to improve the technological capabilities of both vertically and horizontally linked firms. Third, human capital can spill over from foreign affiliates to other firms as skilled labor moves between companies. These spillovers are especially important for firms that lack the technological capabilities and managerial skills to compete in world markets. Fourth, the proximity of local firms to foreign affiliates can sometimes lead to demonstration or imitation spillovers. When foreign affiliates introduce new products, processes and organizational forms, they provide a demonstration of increased efficiency to other local firms. Local firms may also imitate foreign affiliates through reverse engineering, personal contact and industrial espionage. Finally, a concentration of related industrial activities may also encourage the formation of industrial clusters, which further encourage FDI and local spillovers.

Although there are clear differences among these types of knowledge spillovers, the empirical literature mainly captures those spillovers occurring among firms within the same industry. The reason for this is that competitive effects within an industry are much easier to measure than linkage effects across industries. Studies that estimate spillover effects using the production function approach, similar to the one specified in

equation (2) subject to (3), unintentionally pick up inter-industry effects contained in the variable Y . But with the exceptions of Blalock (2001), Schoors and van der Tool (2001), Smarzynska (2002, 2004), Damijan et al (2003b), Kugler (2006), Halpern and Murakozy (2007), and Gorodnichenko et al (2007), all of the panel data analyses on the effect of knowledge spillovers on productivity growth consider only intra-industry effects. In the present study, we draw on Blalock (2001) and Damijan et al (2003b) in order to capture these inter-industry effects by incorporating direct requirement coefficients derived from the input-output accounts from each country into the empirical model.

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

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

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

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

In the next step, we account for potential vertical spillovers of foreign affiliates, i.e., for the impact of foreign affiliates on their upstream suppliers.⁸ Foreign affiliates often provide resources to improve the technological capabilities and quality standards of their upstream suppliers. We account for these backward linkages VSb_{kt} as the sum of the output of industries r purchased by firms in industry k weighted by the share of total foreign output HS_{kt} :

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

⁸ This paper only accounts for backward linkages, that is, for the impact of foreign affiliates on their upstream suppliers. Similarly, foreign affiliates can also provide technical assistance to their downstream customers. However, as foreign affiliates are mainly engaged in end-user consumer goods, these forward linkages have been found in empirical studies to be rather low or insignificant (Smarzynska-Javorcik (2004), Gorodnichenko et al (2007), Halpern and Murakozy (2007)). For this reason, we neglect this issue in the present study.

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

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

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

It is important to note that not all spillovers are positive. The parent firm can also have a negative impact on the direct transfer of technology to its affiliate and reduce knowledge spillovers to the local economy. For example, MNCs can provide their affiliates with too few, or the wrong kind, of technological capabilities, or even limit access to the technology of the parent company. This type of behavior may restrict the production of its affiliate to low-value activities and can also reduce the scope for technical change and technological learning both within the affiliate and as spillovers to the domestic economy. Even if the parent firm transfers new technology to its affiliate, it can reduce the potential for knowledge spillovers by limiting downstream producers to low value-added activities, or can eliminate them altogether by relying on foreign suppliers (including itself) for higher value-added intermediate products. Domestic firms that do not have the capability to adapt can also be crowded out of the market. Bardham (1998) also suggests that the parent company can restrict domestic production when it sets up affiliates with the main purpose of protecting existing property rights and taking out patents in the host country.

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

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

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

4. Data and econometric approach

4.1 Data

Data at the firm level provide the best way to test for FDI productivity spillovers. In order to analyze the importance of different channels of technology transfer via FDI in a comparative way, we gathered panel data for 10 transition economies: Bulgaria, the Czech Republic, Croatia, Estonia, Latvia, Lithuania, Poland, Romania, Slovenia and Ukraine. Balance sheet and financial statement data were collected for 1995-2005 for most of the countries, with the exception of Estonia (1997-2005), Latvia (1996-2005), Slovenia (1995-2003) and Ukraine (1998-2005). The source of these data is the Amadeus database (Bureau van Dijk), while for Slovenia, data were obtained from the local statistical office. We use the full Amadeus database but limit our database to manufacturing firms only, with no limitations on the size threshold. Thus, these data include firms from all size classes, including micro and small firms. The dataset consists of more than 90,000 firms with up to 11 annual observations, which would theoretically yield almost one million annual observations. However, the dataset is not balanced. Due to the requirements of the econometric methods used in this paper (Olley-Pakes corrections), we only include firms with 5 or more annual observations in the empirical estimations. These restrictions limit the size of our data to some 315,000 annual firm observations. Still, this is by far the largest firm level dataset used so far by any study on the spillover effects of FDI.⁹

[Insert Table 1]

Some basic characteristics of the data are reported in Table 1, which reveals that the best firm level data coverage is for Romania (48,500 firms), followed by Bulgaria (9,500 firms), the Czech Republic (8,500 firms), Poland (6,000 firms) and Ukraine (5,500 firms), while for Croatia, Estonia and Slovenia we have between 3,000 and 4,000 annual firm observations. On the other hand, we have relatively poor coverage for Lithuania (700 firms) and Latvia (1,500 firms).¹⁰ Note, however, that the most reliable dataset in this country sample is for Slovenia, which is obtained from the national statistical office and which covers virtually all manufacturing firms that were active in the period and that had at least one employee.

We also have data on the share of foreign investors in the total equity of domestic firms. According to other studies and our previous work, the foreign ownership variable is constructed as a dummy variable F_i equal to 1 when the share of foreign equity in the total capital of a domestic firm exceeds 10%, and 0 otherwise. Note that we are using the Amadeus database over a range of years, which allows us to detect any changes in

⁹ Our previous study (Damijan et al, 2003b), used data on some 8,000 firms in ten transition countries for 1994-1999. Note that Gorodnichenko et al (2007) use 2005 BEEPS data (Business Environment and Enterprise Performance Survey, a joint initiative of the European Bank for Reconstruction and Development (EBRD) and the World Bank Group) for 17 transition countries. The BEEPS 2005 data, however, has two important limitations. First, it accounts for only 200-600 surveyed firms per country, with the share of firms in services ranging from 50% to 65%, and between two-thirds and three-quarters of the firms are small (less than 50 employees). Second, it provides only one single observation (growth from 2002 to 2005 in sales and inputs) per firm.

¹⁰ Note that we had to omit from our sample countries like Hungary and Slovakia, which are extremely poorly represented in the Amadeus database.

ownership that occurred between two consecutive years. This allows the foreign ownership variable to change over time. Table 1 reveals that although the share of foreign firms in the total number of firms in the sample varies between 4% (Bulgaria) and 10% (Poland), their contribution to the value added of the sample firms varies between 7% (Bulgaria) and 29% (Poland). This shows that foreign owned firms are larger than domestic owned firms, indicating possible selection problems, which we will deal with in the next subsection.

Labor data enter our estimations as the number of employees, which is calculated from effective hours worked, while data on value added and capital are taken in local currencies. Capital data were deflated using GDP deflators, while data on sales were deflated using NACE 2-digit producer price indices for each country.¹¹

Data on input-output accounts come from local statistical offices. These data, conducted at the NACE 2-digit level, refer mainly to individual years between 2000 and 2003. Unfortunately, these input-output tables are not available at a more disaggregated level, and are not available for all years in our sample. This, of course, may substantially limit our potential to discover possible vertical spillovers, since these normally take place at a lower level of disaggregation. We are also forced to exclude dynamic changes in the structure of the studied economies. As a way of overcoming these limitations, we have applied the NACE 2-digit input-output coefficients to the NACE 3-digit sectors when calculating the vertical spillovers. We report results with both levels of spillover aggregation.

4.2. Correction for selection bias

The usual problem with empirical studies on the firm level effects of FDI is an inherent selection bias. This is due to the fact that foreign investment decisions are not randomly distributed, but instead are likely subject to firms' characteristics and their initial performances. Many studies report that foreign investors tend to acquire shares in the largest and most successful domestic firms (Hoekman and Djankov (2000), Evenett and Voicu (2001), Damijan et al (2003)). Hence, treating foreign and domestic firms as homogenous units of observation will likely produce biased results due to the possible endogeneity of foreign investment decisions. We deal with this problem using the two-step method proposed by Heckman (1979).¹²

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

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

¹¹ GDP deflators and PPI data for individual countries is taken from the Eurostat, with the exception of Croatia and Ukraine, for which the data sources are national statistical offices.

¹² The problem of sample selection bias has been extensively dealt with in the econometric literature (see also Amemiya, 1984, and Wooldridge, 2002, for excellent surveys of the literature and correction methods).

where i and j ($i=1,\dots,n$, $j=1,\dots,m$) indicate individual foreign and domestic firms, respectively. The error terms are assumed to be IID and normally distributed, thus $S(\cdot)$ is a cumulative distribution function of the standard normal distribution. \mathbf{X}_{i,j_0} is a matrix of firms' structural characteristics in the initial year, including firm size, capital intensity, labor productivity and industry characteristics such as the size of the industry and foreign penetration to the industry.¹³ We estimate the probit model using the data for the initial period (i.e., the first year a firm has entered our sample). As already noted above, the foreign ownership variable is also time variant since we are able to track changes in ownership throughout the whole period. In order to avoid autocorrelation, the first year's observations are then excluded from the estimations of our main empirical model (see model (11) below). The results of the Heckman probit estimations (see Table A1 in the Appendix) do in fact confirm the existence of selection bias for most of the countries in our database. The results, however, do not confirm the hypothesis that MNCs tend to acquire shares in the largest and most successful local firms, as pointed out by Evenett and Voicu (2001). Our results suggest that size and labor productivity are not decisive characteristics of target firms considered by foreign investors. MNCs only acquired larger local firms in two countries (Czech Republic and Estonia), while in five countries (Bulgaria, Latvia, Lithuania, Romania and Ukraine), smaller firms were selected by MNCs. For the remaining three countries (Croatia, Poland and Slovenia), the coefficient on size is negative but marginally insignificant. Similarly, high initial labor productivity only seems to be important in the selection process of MNCs in three out of ten countries (Estonia, Latvia and Romania), while in the other six countries, initial labor productivity was seemingly not important. Instead, MNCs were found to tend to acquire more capital intensive firms, which we have confirmed for 9 of the 10 transition countries. The hypothesis that foreign investors tend to cluster in larger industries with an established comparative advantage is rejected in 9 out of 10 countries. Finally, the evidence on the clustering of foreign investments in industries with already high foreign penetration in terms of foreign ownership is mixed. Significant positive coefficients were found in only four countries, while in four countries these coefficients are negative, and in the remaining two countries, the coefficients are insignificant.

These results are in line with the descriptive statistics on foreign presence in individual countries (Table 1), showing relatively low penetration both in terms of the number and the share in value added of foreign affiliates. This may, on the one hand, increase the scope for horizontal spillovers as foreign penetration in many industries is not too high. On the other hand, this may reduce the scope for backward spillovers as foreign firms may not be able to create a strong enough demand for intermediates of other vertically linked industries.

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

¹³ Foreign penetration of the industry is measured as the share of the total value added of the industry accounted for by foreign affiliates. The industry is defined at the NACE 2-digit level.

4.3 Econometric approach

To analyze the impact of different channels of technology transfer on a firm's TFP, we estimate a growth model (2) augmented by a firm's technology structure (3). As discussed by Griliches and Mairesse (1995) and followed by a vast literature, using the OLS approach to estimate the firm's productivity is inappropriate, as inputs k_i and l_i are probably determined simultaneously by the firm's past productivity. Present applications of estimating production functions have revealed significant problems of potential correlation between input levels and the unobserved firm-specific shocks. The idea is that firms that experience a large positive productivity shock may respond by using more inputs, which violates the OLS assumption of strict exogeneity of inputs and the error term. Another source of simultaneity between inputs and output in the production function approach is the selection issue. Olley and Pakes (1996) demonstrate that firm decisions are made, at least to some extent, on their perceptions of future productivity, which in turn are partially determined by the realizations of their current productivity. Considering only those firms that survived over the entire period, this would imply that a sample is being selected, in part, on the basis of the unobserved productivity realizations. This generates a selection bias in both the estimates of the production function parameters and in the subsequent analysis of productivity. Therefore, the authors present an alternative solution that serves to deal with both the simultaneity and self-selection issues at the same time.

While there are many econometric methods to deal with this simultaneity problem (see Appendix 1 for a discussion of the methods), this paper uses the Olley - Pakes (OP) method. The procedure to obtain unbiased estimates of total factor productivity (TFP) using the OP method relies on a three step approach. In the first step, the unobserved productivity shocks u_{it} in (A2) for each firm are estimated using the (firm-specific) investment equation and the dependence of investment on productivity shocks. These estimates can subsequently be used to control for the unobservable productivity shocks u_{it} in our estimations of (A1). We use a fourth order polynomial in capital and investment (with a full set of interaction terms) to approximate u_{it} . Using the estimates of productivity shocks, the primary production function is estimated to obtain unbiased estimates of the coefficient on labor as well as predicted values of the remaining (residual) part of the production function (A1). The second step of the estimation process involves the determination of the survival probability (the probability that a firm will survive in the local market), which depends on the firm's productivity remaining above the perceived cut-off level. In estimating the survival probability, we use a fourth order polynomial in (k_i, i_t) with industry and time dummies (which serve as a proxy for differences in market conditions and time-specific factors that impact survival probability). The third and final step of the estimation procedure utilizes the preceding two steps (whereby the first step estimation results are used to control for simultaneity, while the results of the second step serve to mitigate the selection bias) to estimate an expanded production function and obtain unbiased estimates of the coefficient of capital. The third step of the estimation algorithm is estimated using the nonlinear least squares method with bootstrapped regression coefficients (in line with Pavcnik, 2002). These three steps produce consistent and unbiased estimates of coefficients of capital ($\bar{\alpha}$) and labor ($\bar{\beta}$), which are then used to obtain unbiased estimates of total factor productivity (TFP) as a residual in the consistently estimated production function (1):

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

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

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

where tfp is the logarithmic growth rate of \overline{TFP} . F_{ikt} is a dummy for foreign ownership, w_{ikt} denotes the stock of human capital in the firm (proxied by the average wage bill), hs_{ikt} and vs_{ikt} stand for horizontal and vertical spillovers from FDI at the sectoral level, while es_{ikt} denotes the impact of sector economies of scale (proxied by the sector size). In line with recent research (Girma et al, 2006; Ben Hamida and Gugler, 2007), we include interaction terms of the spillover variables with the human capital variable (w_{ikt}) in order to control for the impact of firm absorption capacity on firm ability to reap the benefits of spillover effects from both the foreign and domestic firms in the sector. The variable λ_{ikt} is the inverse Mill's ratio from the Heckman correction for sample selection. Variables T and R denote the year and regional dummies, and ε_{ikt} is the remaining error term.

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

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

Size classes are defined in the usual way according to the number of employees.¹⁴ Regressions across the quintiles of firm productivity are applied, as Bekes et al (2007) provide convincing evidence from a sample of Hungarian firms that larger and more productive firms (defined by the deciles of size and productivity) are more able to reap spillovers from multinational firms than smaller firms. In line with recent research (Girma et al, 2006), spillovers from FDI are most likely to occur when the technology gap between domestic and foreign owned firms is not too large. We therefore divide the data from each country into three sub samples according to the technology gap between domestic and foreign owned firms. The measure of the technology gap is defined as the ratio of average productivity of domestic firms to the average productivity of foreign owned firms within each sector (NACE 2- or 3-digit). This continuous gap variable is then sliced into three gap dummies. Gap1, Gap2 and Gap3 refer to domestic firms with a productivity level below 80%, between 80 and 120% and more than 120% of the average productivity of foreign owned firms within each sector, respectively. Gap1 thus denotes that domestic firms are lagging behind the multinational firms in the sector in terms of technology, while Gap3 indicates that domestic firms have a technology advantage over foreign owned firms in the sector. In contrast, Gap2 indicates that domestic and foreign firms are at roughly similar technology levels. Of course, these measures of technology gap refer to the overall absorptive capacity of the sectors, implying that in sectors with a lower technology gap, there is a greater potential for positive spillovers from FDI. The actual “utilization” of this potential, however, depends on an individual firm’s productivity level (indicated by firm classification into specific quintiles of productivity) and individual absorption capacity (indicated by its human capital stock).

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

5. Results

This section first presents estimation results on direct effects as well as on horizontal and vertical spillovers from FDI obtained from the sample of foreign affiliates and local firms. In addition to explicit control for individual firms’ productivity levels and absorption capacity, we also provide several robustness checks, including a matching technique when accounting for direct effects, and different aggregation of sectors when accounting for horizontal and vertical spillovers from FDI. Note that we estimate the fully specified empirical model (11), while due to the table dimensions, the results are presented separately for direct effects, horizontal effects and vertical effects from FDI.¹⁵

¹⁴ Micro firms (< 10 empl.), small firms (10 ≤ empl. < 50), medium firms (50 ≤ empl. < 250), and large firms (250 ≤ empl.).

¹⁵ Regression results are suppressed due to space limitations. Refer to Table A2 in the Appendix for regression statistics.

5.1 Direct effects from FDI

5.1.1 Basic results

In line with the previous study (Damijan et al, 2003b), we attribute direct effects of FDI to the impact of foreign ownership on firm TFP growth, as foreign ownership is believed to enhance firm performance through direct technology transfers. Table 2 reports the coefficients for F_{ikt} from the regression model (11). Note that both the time and region dummies are included in all specifications. As shown in the first three columns, the results do not change significantly when time and region dummies are included. One exception is Romania, where the overall coefficient of the direct effect from foreign ownership becomes marginally insignificant after the region dummies are included in the regression model. The results show that on average, foreign owned firms grew faster in terms of TFP from 1995-2005 in only three out of the ten countries under examination (Czech Republic, Latvia and Slovenia). For other countries, the growth rate of affiliates was also higher than that of domestic firms, but not significantly.¹⁶ The average productivity growth premia of foreign affiliates in this period ranges between 2.4% (Poland) and 9% (Czech Republic). Note that these results are obtained by including the time and region dummies. As demonstrated in Table 2, the results are in general robust to the inclusion of dummies, with exceptions for Romania (the coefficient for direct effects changed from significant to insignificant when region dummies were included) and Latvia (the coefficient for direct effects changed from insignificant to significant when region dummies were included).

[Insert Table 2]

While most studies stop at this point, we analyze these direct effects further by taking various sources of firm heterogeneity into account. By doing this, we can see that the productivity growth differential of foreign affiliates relative to domestic firms in the above three countries is driven by small (Czech Republic) and medium sized foreign affiliates (Latvia and Slovenia), as well as by affiliates of medium (Q3 quintile in the Czech Republic and Latvia) or high productivity (Q4 and Q5 quintiles in Slovenia).

In addition, by allowing for firm heterogeneity, we can also observe significantly higher productivity growth for certain categories of foreign affiliates in five of the remaining seven countries. In Bulgaria, we only find significantly higher growth of affiliates among the micro sized firms and the least productive firms (Q1). In Lithuania, significant effects are noted for medium sized firms and firms in the fourth quintile of productivity. In Poland, it is only the least productive firms (Q1), while in Romania it is the largest and the most productive firms (Q5) that show higher affiliate growth. Finally, in Ukraine this difference is only noted for micro firms. In terms of absorptive capacity, we find significantly higher TFP growth of foreign affiliates with the highest positive technology gap relative to domestic firms (in the Czech Republic and Romania) and affiliates at a roughly similar technology level to domestic firms (in Slovenia and Ukraine).

¹⁶ Note that the direct effect of FDI is not negative in any country examined.

5.1.2 Robustness check using the matching approach

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

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

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

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

Conditional on satisfying the balancing property of the propensity score, the fitted values obtained from estimating the above equation (the probit estimation) are used to pair foreign owned firms with domestically owned firms, and those matched pairs are subsequently used to estimate the average treatment effect of foreign ownership on subsequent firm productivity growth. The balancing property ensures that once the observations have been stratified into blocks according to the propensity score, the right hand side variables of (12) do not differ significantly between the groups of treated and non-treated observations within a block. The more closely the firms are matched with respect to regressors in (12), the more likely it is that the observed differences in productivity trajectories between foreign owned and domestically owned firms result purely from the fact that some firms have switched status from domestic to foreign ownership. We match foreign owned firms with their domestic owned counterparts using nearest neighbor matching (with random draws), which pairs the treated with the closest non-treated observations with respect to the propensity score. Given that the sample size is very small in some instances, all the reported standard errors were generated by bootstrapping with 100 repetitions.

[Insert Table 3]

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

(non-treated) firms over one to five years after the firms have switched their status from domestic to foreign ownership.¹⁷

The results are consistent with the findings in the previous section. When comparing the cohorts of fairly similar foreign and domestic owned firms over time, we find that foreign owned firms persistently outperform domestic firms in terms of TFP growth only in the Czech Republic and Slovenia. In both countries, firms are shown to make permanent productivity improvements after the ownership change, from the first to the last period under examination. In Estonia, Latvia and Poland, these productivity gains are only observed in the first year after the change in ownership, and seem to dissipate afterwards (in Latvia and Poland the TFP premia arise again in the fourth and fifth year, respectively). In Croatia and Romania, benefits of foreign ownership become significant in the second, third and fourth year after the switch in ownership, respectively, but dissipate afterwards. On the other hand, in Bulgaria, productivity improvements from foreign ownership become visible in the fourth year after the ownership change and seem to become permanent. In contrast, when controlling for exact heterogeneity among firms, a switch to foreign ownership seems to have a negative impact on firm cumulative TFP performance in Ukraine. These effects, however, are quite divergent over the period, indicating the possibility of significant turbulence in the economic environment in this country.¹⁸

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

5.2 Horizontal spillovers from FDI

As shown in the survey of the empirical literature on spillovers, most of the early firm-level panel data empirical studies of spillovers from FDI have so far found non-existent or even negative horizontal spillovers. More recent studies using either better firm level data or more accurate empirical approaches, however, find less evidence of non-existent or negative horizontal spillovers. The extensive research done so far seems to imply that the initial negative horizontal spillovers (i.e., crowding out effects) seem to dissipate with the local firms' catching up in terms of productivity. At the same time, negative horizontal spillovers seem to be compensated for by positive vertical spillovers (Damijan et al, 2003b; Gorodnichenko et al, 2007; Halpern and Murakozy, 2007).

This section provides results on horizontal spillovers based on two different sector aggregation levels.¹⁹ We first present results for NACE 2-digit sectors, and as a robustness check, we also show results for NACE 3-digit sectors. Table 4, showing

¹⁷ Note that we keep the samples of treated and non-treated firms for each country constant, allowing us to track the comparative changes in TFP for the same cohorts of firms.

¹⁸ Due to small sample sizes after the exact matching of foreign and domestic owned firms, we do not provide additional results for subsamples of firms with regard to the size and productivity dimensions.

¹⁹ Note that these results (11) include year and region dummies.

results for NACE 2-digit sectors²⁰, demonstrates that in general, i.e., for all firms and without any control for either absorptive capacity or size, productivity level or technological gap, none of the ten countries under examination show positive and significant horizontal spillovers from foreign affiliates. Moreover, in four out of ten countries (Estonia, Romania, Slovenia and Ukraine), significant negative horizontal spillovers are found. These results, however, are reverted when controlling for the absorptive capacity of firms – we find positive horizontal spillovers in six out of ten countries once we control for individual firms' wage levels as proxies for the levels of human capital.²¹ After controlling for absorptive capacity, negative horizontal spillovers are found in one country (Bulgaria) only. These results are quite robust to the level of sectoral aggregation, as at the NACE 3-digit level, positive overall horizontal spillovers are confirmed in seven countries after controlling for absorptive capacity.²² On the other hand, after controlling for absorptive capacity, negative horizontal spillovers are not found in any of the countries.

[Insert Table 4]

Controlling for absorptive capacity, the size heterogeneity of firms does not provide a very clear picture as far as the significance of horizontal spillovers is concerned. There are only three countries (Croatia, Romania and Slovenia) where horizontal spillovers seem to accrue in a non-discriminatory way regardless of firm size. In all three countries, positive horizontal spillover effects tend to increase with firm size. The results in other countries vary considerably.

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

These results are quite robust to sectoral aggregation, as most of the results obtained by NACE 2-digit sectors are also replicated, both in terms of size as well as the significance of coefficients, when estimating the model with the NACE 3-digit sectors.²³

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

²⁰ Note that due to space limitations, we only present here only the coefficients from model (11) related to horizontal spillovers.

²¹ These countries are the Czech Republic, Croatia, Estonia, Romania, Slovenia and Ukraine.

²² These are the Czech Republic, Croatia, Estonia, Romania, Slovenia, Ukraine and Poland.

²³ See Table A3 in the Appendix.

significantly high absorptive capacity can accommodate the competition and enjoy positive learning effects from the competitive pressures.

5.3 Vertical spillovers from FDI

This section estimates the impact of vertical spillovers of foreign affiliates on domestic firms. Previous studies, which dealt with both the horizontal as well as vertical spillovers, so far revealed a larger relative importance of the latter (see Section 2). As discussed in the methodology section, we focus on backward linkages only, i.e., on the impact of foreign affiliates on their upstream suppliers. Our preliminary results, as well as other empirical studies, demonstrate that forward linkages are rather low or insignificant in transition countries (Smarzynska-Javorcik (2004), Gorodnichenko et al (2007), Halpern and Murakozy (2007)). The primary reason for this is that foreign affiliates are mainly engaged in end-user consumer goods. While focusing on backward linkages, however, we take full account of firm heterogeneity in terms of size, absorptive capacity and technological gap. These results are presented with the spillovers aggregated to both the NACE 2-digit and NACE 3-digit sectors.²⁴

[Insert Table 5]

Unlike the horizontal spillovers, vertical spillovers seem to have more heterogeneous effects. Abstracting from the heterogeneity of firms, there are only two countries (Slovenia and Ukraine) that show positive vertical spillovers from FDI at the NACE 2-digit sector level, while there are four countries (Bulgaria, the Czech Republic, Poland and Romania) that demonstrate significant negative vertical spillover effects (see Table 5). These results change slightly when allowing for the absorptive capacity of firms. For example, in Bulgaria, the Czech Republic and Poland, firms with higher human capital are shown to be able to reap positive spillovers from their upstream links with foreign firms. Using NACE 3-digit sectors,²⁵ these negative backward spillovers are further reduced to only two countries (Lithuania and Romania), and to a single country (Lithuania) after controlling for firms' absorptive capacity.²⁶ On the other hand, with this more precise sectoral aggregation of spillovers, we find positive backward spillovers from foreign affiliates in four transition countries. In Croatia and Ukraine, these backward spillovers are generally accruable to all domestic firms, while in the Czech Republic and Romania, these are limited to firms with sufficient absorptive capacity. Interestingly, we find evidence of positive backward spillovers between foreign affiliates in only two countries (Poland and Slovenia), while in Romania, foreign affiliates seem to be affected negatively by other upstream foreign firms. These results are consistent for both levels of sector aggregation.

Allowing for further heterogeneity of firms in terms of size, productivity and technology gap, we can examine more closely the firm characteristics that may drive the above results. In general, there are hardly any patterns which hold across countries. Positive vertical spillovers appear in all size classes of firms, but most frequently in small and medium sized firms, at all productivity levels and at all technology gaps. Interestingly, in the Czech Republic, positive backward spillovers are limited to the

²⁴ Note that we report the results (11) including year and region dummies.

²⁵ See Table A4 in Appendix.

²⁶ Note, however, that due to data unavailability, we are unable to control for absorptive capacity for Lithuanian firms.

least productive (Q1) and the least technologically advanced firms (Gap1). In Croatia, positive spillovers are consistently present for micro and small firms and for firms with the highest productivity levels (Q4 or Q5), as well as with medium or higher technology levels (Gap 2 and Gap3). In Poland, positive backward spillovers are accruable to medium sized firms and firms with lower to medium productivity levels (Q1 through Q4) and lower technology levels (Gap1). In Romania, mainly small domestic firms with higher absorptive capacity benefit from upstream foreign affiliates. On the other hand, low productivity (Q2) and low technology (Gap1) firms as well as high productivity Romanian firms (Q5) benefit from backward spillovers. In Slovenia, vertical spillovers are not consistent for domestic firms across different aggregation levels of spillovers, but they are quite consistent for foreign affiliates. Medium (Q2) or high productivity (Q4 and Q5) foreign affiliates benefit the most from other upstream foreign affiliates. Finally, in Ukraine either micro or large firms gain from upstream foreign affiliates, while larger positive spillovers seems to be accruable to firms with the lowest technology levels and medium productivity levels.

5.4 Summary of results

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

[Insert Table 6]

These findings suggest that spillovers from foreign firms substantially depend on the absorptive capacity and productivity level of individual firms. Only more productive firms and firms with higher absorptive capacity are able to both compete with foreign affiliates in the same sector and benefit from the increased downstream demand for intermediates created by foreign affiliates. Foreign presence may also affect smaller firms to a larger extent than larger firms, but this impact may be in either direction.

6. Conclusions

This paper provides a comparative study of the importance of direct technology transfer and spillovers through FDI on a set of ten transition countries, using a common methodology and taking into account various sources of firm heterogeneity. In this way, we achieve comparability of the results and provide a credible insight into the importance of different channels of technology transfer via FDI for firms in transition countries. Firm level panel data were gathered for ten transition economies for 1995-2005. This exhaustive dataset comprises some 90,000 manufacturing firms with up to 11 annual observations, yielding some 315,000 annual firm observations. This study differentiates between the direct effects of FDI from the parent firm to local affiliates as well as between horizontal and vertical spillovers from foreign affiliates to domestically owned local firms. The importance of these different channels of technology transfer via FDI for firm performance is estimated in the framework of a growth-accounting approach. We use several correction methods to account for possible biases in the data. The possible selection problem of domestic firms into foreign ownership has been accounted for using the Heckman procedure, while the simultaneity problem that typically arises in the growth-accounting approach in the panel data framework is dealt with using the Olley-Pakes method.

The main novelty of this paper is the explicit control for firm heterogeneity when accounting for different effects of FDI on firm performance. This results in some contrasting results to the previous empirical work in the field. We find that horizontal spillovers have become increasingly important over the last decade and might become even more important than vertical spillovers. Furthermore, these results show that the heterogeneity of firms, in terms of absorptive capacity, size, productivity and technology level, significantly affects the results. These findings suggest that both direct effects from foreign ownership as well as the spillovers from foreign firms do substantially depend on the absorptive capacity and productivity level of individual firms. Only more productive firms and firms with higher absorptive capacity are able both to compete with foreign affiliates in the same sector and benefit from the increased downstream demand for intermediates generated by foreign affiliates. In addition, these results show that foreign presence may also affect smaller firms to a greater extent than larger firms, but this impact may be in either direction.

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

References

- Abraham, F., J. Konings and V. Sloommaekers. 2006. FDI Spillovers, Firm Heterogeneity and Degree of Ownership from Chinese manufacturing. *Mimeo*, Catholic University Leuven.
- Aitken, B.J. and A.E. Harrison. 1999. Do Domestic Firms Benefit from Direct Foreign Investments? Evidence from Venezuela. *American Economic Review*, 89: 605-618.
- Alvarez, I., J.P. Damijan, and M. Knell. 2002. "Do Spanish Firms Get Technology through FDI and Trade?" *Mimeo*, University of Madrid.
- Arnold, J.M. and B. Smarzynska-Javorcik. 2005. Gifted Kids or Pushy Parents? Foreign Acquisitions and Plant Productivity in Indonesia. *World Bank Policy Research Working Paper*, No. 3597.
- Audretsch, D.B. 1998. Agglomeration and the Location of Innovative Activity. *Oxford Review of Economic Policy*, 14: 18-29.
- Barry, F., H. Görg, and E. Strobl. 2002. Productivity Spillovers and Labour-Market Crowding Out: Interactions between Foreign and Domestic Firms in Irish Manufacturing. *Mimeo*. University College Dublin.
- Bartlet, C. A. and S. Ghoshal. 1989. *Managing Across Borders: The Transnational Solution*. Boston: HBS Press.
- Bekes, G., J. Kleinert, F. Toubal. 2007. Spillovers from Multinationals to Heterogeneous Domestic Firms: Evidence from Hungary. *4th Empirical Investigations in International Economics Annual Conference*, Ljubljana, 14-16 June 2007.
- Ben Hamida, L. and P. Gugler. 2007. FDI and Spillovers in Switzerland: Interaction Effects between Spillover Mechanisms and Domestic Technological Capabilities. *33rd EIBA Annual Conference*, Catania, 13-15 December 2007.
- Bernstein, J. and P. Mohnen. 1998. International R&D Spillovers between U.S. and Japanese R&D Intensive Sectors. *Journal of International Economics*, 44: 315-338.
- Birkinshaw, J. and N. Hood (eds.). 1998. *Multinational Corporate Evolution and Subsidiary Development*. London: Macmillan.
- Blalock, G. 2001. "Technology from Foreign Direct Investment: Strategic Transfer through Supply Chains." *Mimeo*, University of California, Berkeley.
- Blalock, G. and P. Gertler. 2003. Technology from Foreign Direct Investment and Welfare Gains through the Supply Chain. Cornell University, Ithaca, NY. *Mimeo*.
- Blanchard, O. 1997. *The Economics of Post-Communist Transition*. Oxford University Press.
- Blomström, M., S. Globerman and A. Kokko. 2000. The Determinants of Host Country Spillovers from Foreign Direct Investment. *CEPR Discussion Paper No. 2350*.
- Blomström, M., A. Kokko and M. Zejan. 1994. Host Country Competition and Technology Transfer by Multinationals. *Weltwirtschaftliches Archiv*, Band 130: 521-533.
- Blomström, M. and F. Sjöholm. 1999. Technology Transfer and Spillovers: Does Local Participation with Multinationals Matter? *European Economic Review*, 43: 915-923.
- Blomström, M. and E. Wolff. 1994. "Multinational Corporations and Productivity Convergence in Mexico," In: W. Baumol, R. Nelson, and E. Wolff (eds.), *Convergence of Productivity: Cross-National Studies and Historical Evidence*. Oxford: Oxford University Press.
- Borensztein, E., J. De Gregorio, and J.W. Lee. 1998. "How Does Foreign Direct Investment Affect Economic Growth?" *Journal of International Economics*, 45: 115-135.
- Branstetter, L. 1996. Are Knowledge Spillovers International or International in Scope? Microeconomic Evidence from the U.S and Japan. 1996. *NBER Working Paper No. 5800*.
- Branstetter, L. 2001. Is Foreign Direct Investment a Channel of Knowledge Spillovers? Evidence from Japan's FDI in the United States. *NBER Working Paper No. 8015*.
- Cantwell, J. 1987. The Reorganisation of European Industries after Integration: Selected Evidences on the Role of Multinational Enterprise Activities. *Journal of Common market Studies*, 26: 127-151.
- Cantwell, J. 1989. *Technological Innovation and Multinational Corporations*. Oxford: Basil Blackwell.
- Castellani, D. and A. Zanfei. 2003. Technology Gaps, Absorptive Capacity and the Impact of Inward Investments on Productivity of European Firms. *Economics of Innovation and New Technology*, 12: 555-576.
- Castellani, D. and A. Zanfei. 2007. Multinational companies and productivity spillovers: is there a specification error? *Applied Economics Letters*, 14, 1047-1051.
- Caves, R. 1996. *Multinational Enterprise and Economic Analysis (second edition)*. Cambridge: Cambridge University Press.
- Clerides, S., S. Lach, and J. Tybout. 1998. "Is Learning-by-Exporting Important? Micro-Dynamic Evidence from Colombia, Mexico and Morocco." *Quarterly Journal of Economics*, 113: 903-947.
- Coe, D. and E. Helpman. 1995. International R&D Spillovers. *European Economic Review*, 39: 859-887.

- Coe, D., E. Helpman, and A. Hoffmaister. 1997. North-South R&D Spillovers. *Economic Journal*, 107: 134-149.
- Damijan, J.P., M. Knell, B. Majcen and M. Rojec. 2003a. The Role of FDI, R&D Accumulation and Trade in Transferring Technology to Transition Countries: Evidence from Firm Panel Data for Eight Transition Countries. *Economic Systems*, 27: 189-204.
- Damijan, J.P., M. Knell, B. Majcen and M. Rojec. 2003b. Technology Transfer through FDI in Top-10 Transition Countries: How Important are Direct Effects, Horizontal and Vertical Spillovers. *William Davidson Working Paper No. 549 (February)*. Ann Arbor: The University of Michigan Business School.
- Djankov, S. and B. Hoekman. 2000. "Avenues of Technology Transfers: Foreign Investment and Productivity Change in the Czech Republic." CEPR Discussion Paper 1883.
- Driffield, N., M. Munday and A. Roberts. 2002. Foreign Direct Investment, Transaction Linkages, and the Performance of the Domestic Sector. *International Journal of the Economics of Business*, 9: 335-351.
- Eaton, J. and S. Kortum. 1996. Trade in Ideas: Patenting and Productivity in the OECD. *Journal of International Economics*, 40: 251-271.
- Eaton, J. and S. Kortum. 1999. International Patenting and Technology Diffusion: Theory and Measurement. *International Economic Review*, 40: 537-570.
- Feenstra, R., J. Markusen, and W. Zeile. 1992. "Accounting for Growth with New Inputs: Theory and Evidence." *American Economic Review*, 82: 415-421.
- Findlay, R. 1978. Relative Backwardness, Direct Foreign Investment, and the Transfer of Technology: A Simple Dynamic Model. *Quarterly Journal of Economics*, 92: 1-15.
- Girma, S., Y. Gong and H. Görg. 2006. Can you Teach Old Dragons New Tricks? FDI and Innovation Activity in Chinese State-Owned Enterprises. *Mimeo*, University of Nottingham, Nottingham.
- Girma, S. and H. Görg. 2006. Multinationals' Productivity Advantage: Scale or Technology? *Research Paper 2006/22*. University of Nottingham, Nottingham.
- Girma, S., H. Görg and M. Pisu. 2003. The Role of Exports and Foreign Linkages for FDI Productivity Spillovers. University of Nottingham, Nottingham. *Mimeo*.
- Girma, S., D. Greenaway, and K. Wakelin. 2001. "Who Benefits from Foreign Direct Investment in the UK?" *Scottish Journal of Political Economy*, 48: 119-133.
- Girma, S. and K. Wakelin. 2002. Are There Regional Spillovers from FDI in the UK?. In D. Greenaway, R. Upward and K. Wakelin (eds.), *Trade, Investment, Migration and Labour Markets*. Basingstoke: Macmillan.
- Glass, A. and K. Saggi. 1998. International Technology Transfer and the Technology Gap. *Journal of Development Economics*, 55: 369-398.
- Görg, H. and D. Greenaway. 2001. Foreign Direct Investment and Intra-Industry Spillovers: A Review of the Literature. *GEP Research Paper 2001/37*. University of Nottingham, Nottingham.
- Görg, H. and D. Greenaway. 2004. Much Ado About Nothing: Do Domestic Firms Really Benefit from Foreign Direct Investment. *World Bank Research Observer*, 19: 171-197.
- Görg, H. and E. Strobl. 2001. Multinational Companies and Productivity Spillovers: A Meta Analysis. *The Economic Journal*, 111: 723-739.
- Gorodnichenko, Y., J. Svejnar and K. Terrell. 2007. When Does FDI Have Positive Spillovers? Evidence from 17 Emerging Market Economies. *IZA Discussion Paper No. 3079*. Institute for the Study of Labour (IZA), Bonn.
- Griliches, Z. 1979. Issues in Assessing the Contribution of R&D to Productivity Growth, *Bell Journal of Economics*, 10: 92-116.
- Griliches, Z. 1992. The Search for R&D spillovers. *Scandinavian Journal of Economics*, 94: 29-47.
- Grossman, G. and E. Helpman. 1991. *Innovation and Growth in the Global Economy*. Cambridge, MA: MIT Press.
- Haddad, M. and A. Harrison. 1993. "Are There Positive Spillovers from Direct Foreign Investments? Evidence from Panel Data for Morocco." *Journal of Development Economics*, 42: 51-74.
- Halpern, L. and B. Murakozy. 2007. Does Distance Matter in Spillover? *The Economics of Transition*, 15 (4): 781-805.
- Hanson, G. 2001. Should Countries Promote Foreign Direct Investment. *G-24 Discussion Paper Series*. Geneva: United Nations.
- Hausman, A.J. 1978. "Specification Tests in Econometrics." *Econometrica*, 46: 1251-1271.
- Heckman, J.J. 1979. "Sample Selection Bias as a Specification Error." *Econometrica*, 47: 153-161.
- Hsiao, C. 1986. *Analysis of Panel Data*. Cambridge, MA: Cambridge University Press.
- Hoppe, M. 2005. Technology Transfer through Trade. *Nota di Lavoro 19.2005*. Fondazione Eni Enrico Mattei, Milano.

- Harris, R. and C. Robinson. 2002. Spillovers from Foreign Ownership in the United Kingdom: Estimates for UK Manufacturing Using ARD. University of Durham, Durham. Mimeo.
- Harrison, A. 1996. Determinants and Effects of Direct Foreign Investment in Cote d'Ivoire, Morocco, and Venezuela. In M.J. Roberts and J.R. Tybout eds., *Industrial Evolution in Developing Countries*. Oxford: Oxford University Press.
- Haskel, J., S. Pereira and M. Slaughter. 2001. Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms? Paper presented at the *NBER Summer Institute*. August.
- Jacobs, J. 1993. *The Economy of Cities*. New York: Random House.
- Jaffe, A. and M. Trajtenberg. 1998. International Knowledge Flows: Evidence from Patent Citations. *NBER Working Paper No. 6507*.
- Keller, W. 1998. Are International R&D Spillovers Trade Related? Analyzing Spillovers among Randomly Matched Trade Partners, *European Economic Review*, 42: 1469-1481.
- Keller, W. 2000. Do Trade Patterns and Technology Flows Affect Productivity Growth? *World Bank Economic Review*, 14: 17-47.
- Keller, W. 2002. Trade and the Transmission of Technology. *Journal of Economic Growth*, 7: 5-24.
- Keller, W. 2004. International Technology Diffusion. University of Texas, National Bureau of Economic Research, Centre for Economic policy Research. Mimeo.
- Keller, W. and S.R. Yeapl. 2003. Multinational Enterprises, International Trade, and Productivity Growth: Firm Level Evidence from The United States. *NBER Working Paper No. 9504 (February)*. National Bureau of Economic Research, Cambridge, MA.
- Kinoshita, Y. 2000. "R&D and Technology Spillovers via FDI: Innovation and Absorptive Capacity." *Mimeo*, CERGE-EI.
- Knell, M. and M. Rojec. 2007. The economic of knowledge and knowledge accumulation: A literature survey. *Mimeo*. NIFU-STEP and University of Ljubljana, Oslo and Ljubljana.
- Kokko, A. 1992. "Foreign Direct Investment, Host Country Characteristics, and Spillovers." *The Economic Research Institute*, Stockholm.
- Kokko, A. 1994. Technology, Market Characteristics, and Spillovers, *Journal of Development Economics*, 43: 279-293.
- Konings, J. 2001. "The Effects of Foreign Direct Investment on Domestic Firms: Evidence from Firm Level Panel Data in Emerging Economies." CEPR Discussion Paper 2586.
- Kosova, R. 2006. Do Foreign Firms Crowd Out Domestic Firms: Evidence from the Czech Republic. (March) Available at SSRN: <http://ssrn.com/abstract=891776>
- Kugler, M. 2001. The Diffusion of Externalities from Foreign Direct Investment: The Sectoral Pattern of Technological Spillovers. University of Southampton, Southampton. Mimeo.
- Kugler, M. 2002. The Diffusion of Externalities from Foreign Direct Investment: Theory ahead of Measurement. *Working Paper*. University of Southampton, Southampton.
- Kugler, M. 2006. Spillovers from Foreign Direct Investment: Within or between Industries? *Journal of Development Economics*, 80: 444-477.
- Lim, E-G. 2001. Determinants of, and the Relation Between Foreign Direct Investment and Growth: A Summary of the Recent Literature. *IMF Working Paper WP/01/175*.
- Mansfield, E. and M. Romeo. 1980. "Technology Transfer to Overseas Subsidiaries by U.S. Based Firms." *Quarterly Journal of Economics*, 95: 737-750.
- Markusen, J.R. 1989. "Trade in Producer Services and in Other Specialized Intermediate Inputs." *American Economic Review*, 79: 85-95.
- Markusen, J. and A. Venables. 1999. Foreign Direct Investment as a Catalyst for Industrial Development. *European Economic Review*, 43: 335-356.
- Meyer, K. and E. Sinani. 2005. Spillovers from Foreign Direct Investment: A Meta-Analysis. *Working Paper*, Department of Economics, University of Reading.
- Nicolini, M. and L. Resmini. 2006. The Impact of MNEs on Domestic Firms in CEECs: A Micro-Econometric Approach. ISLA, Bocconi University, Milan. Mimeo.
- Olley, S.G. and A. Pakes. 1996. "The Dynamics of Productivity in the Telecommunications Equipment Industry." *Econometrica*, 64: 1263-1297.
- Ornaghi, C. 2004. From Innovation to Productivity. Ph. D. Dissertation. Universidad Carlos III de Madrid, Departamento de Economia, Madrid.
- Perez, T. 1998. *Multinational Enterprises and Technological Spillovers*. Amsterdam: Harwood Academic Publishers.
- Rodrik, D. 1999. The New Global Economy and Developing Countries: Making Openness Work. *Policy Essay No. 24*. Overseas Development Council, Washington, D.C.
- Schoors, K. and B. van der Tol. 2001. The Productivity Effect of Foreign Ownership on Domestic Firms in Hungary. University of Gent, Gent. Mimeo.

- Sgard, J. 2001. Direct Foreign Investments and Productivity Growth in Hungarian Firms, 1992-1999. *Document de travail No. 01.19*. Paris: CEPII - Centre d'etudes prospectives et d'informations internationales.
- Sjöholm, F. 1999. Productivity Growth in Indonesia: The Role of Regional Characteristics and Direct Foreign Investment. *Economic Development and Cultural Change*, 47: 559-584.
- Smarzynska-Javorcik, B.K. 2004. Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages. *American Economic Review*, 94, 605-62.
- Smarzynska, B. and M. Spatareanu. 2002. "FDI Spillovers Through Backward Linkages in Romania: Some Determinants." *Mimeo*, World Bank.
- Tytell, I. and K. Yudaeva. 2005. The Role of FDI in Eastern Europe and New Independent States: New Channels for the Spillover Effect. *Working Paper No. 60*. Center for Economic and Financial research (CEFIR), Moscow.
- UNCTAD. 2000. *World Investment Report 2000*. Geneva: United Nations.
- Veugelers, R. and B. Cassiman. 1999. Make and buy in innovation strategies: evidence from Belgian manufacturing firms. *Research Policy*, 28: 63-80.
- White, R. and T. Poynter. 1984. Strategies for foreign owned subsidiaries in Canada. *Business Quarterly*, (Summer): 59-69.

Tables to be included into text

Table 1: Basic characteristics of the dataset

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

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

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

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

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

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

Notes: Results from the full specification of the model (11). See Table A2 in Appendix for regression statistics. t-statistics in brackets. ***, ** and * indicate significance at 1, 5 and 10 per cent, respectively.

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

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

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

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

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

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

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

Notes: Results from the full specification of the model (11). See Table A2 in Appendix for regression statistics. t-statistics are omitted from the results due to space limitations. Shadowed results indicate that the coefficient is significant at 10 per cent at the least.

Full results are available from the authors at request.

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

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

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

Notes: Results from the full specification of the model (11). See Table A2 in Appendix for regression statistics. t-statistics are omitted from the results due to space limitations. Shadowed results indicate that the coefficient is significant at 10 per cent at the least.

Full results are available from the authors at request.

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

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

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

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

Appendix

**Table A1: Results of the Heckman selection model
[Probit estimations]**

	BG	CZ	EE	HR	LT	LV	PL	RO	SI	UA
emp	-6,4E-04	1,8E-03	7,3E-04	-8,0E-05	-6,2E-04	-7,2E-04	-8,3E-05	-8,4E-05	-4,4E-04	-4,3E-04
	<i>-2,16**</i>	<i>10,83***</i>	<i>2,02**</i>	<i>-0,35</i>	<i>-4,35***</i>	<i>-3,19***</i>	<i>-0,95</i>	<i>-2,07**</i>	<i>-1,58</i>	<i>-1,71*</i>
k /l	1,4E-07	-1,7E-05	7,9E-05	7,2E-06	3,3E-06	5,8E-05	2,0E-05	2,1E-06	6,1E-08	4,1E-06
	<i>4,74***</i>	<i>-12,23***</i>	<i>2,00**</i>	<i>1,65*</i>	<i>1,95**</i>	<i>5,05***</i>	<i>3,66***</i>	<i>3,75***</i>	<i>1,98**</i>	<i>1,86*</i>
va/l	-3,8E-07	1,2E-04	7,4E-03	-2,9E-04	-2,5E-05	5,8E-04	1,7E-04	6,5E-04	1,1E-05	-3,1E-04
	<i>-0,01</i>	<i>0,83</i>	<i>2,85***</i>	<i>-0,75</i>	<i>-6,83***</i>	<i>2,55**</i>	<i>0,99</i>	<i>8,11***</i>	<i>1,47</i>	<i>-1,51</i>
seclsize	-1,3E-06	1,9E-08	-3,4E-06	-9,7E-07	-1,4E-06	-2,5E-06	-1,1E-07	-6,1E-08	-9,5E-09	-4,2E-07
	<i>-7,73***</i>	<i>0,36</i>	<i>-11,82***</i>	<i>-9,55***</i>	<i>-14,45***</i>	<i>-21,39***</i>	<i>-12,25***</i>	<i>-37,04***</i>	<i>-13,66***</i>	<i>-8,10***</i>
hs	-3,902	-8,058	-0,539	2,436	0,737	1,496	0,928	-2,612	1,001	-4,076
	<i>-3,07***</i>	<i>-14,41***</i>	<i>-1,06</i>	<i>2,28**</i>	<i>1,23</i>	<i>3,79***</i>	<i>2,90***</i>	<i>-31,51***</i>	<i>2,34**</i>	<i>-4,19***</i>
N. obs	9509	33657	4350	3341	5902	4049	3690	49251	5355	4728
Prob chi ²	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Note: Results from the probit model (9).
t-statistics in italics. ***, ** and * indicate significance at 1, 5 and 10 per cent, respectively.

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

Table A2: Summary statistics for regression results
[Estimations based on model (11)]

				Firms by size classes				Firms by quintiles of productivity					Gap of domestic vs. foreign firms in productivity			
		No dummies	Year dum.	Year & Region dum.	Micro	Small	Medium	Large	Q1	Q2	Q3	Q4	Q5	Gap1	Gap2	Gap3
BG	No. obs.	24.809	24.809	24.809	6.135	8.646	7.185	2.686	3.697	5.327	5.465	5.182	5.138	7.180	3.742	10.647
	R-sq.	0.23	0.24	0.24	0.17	0.19	0.32	0.44	0.19	0.18	0.22	0.19	0.39	0.24	0.28	0.23
CZ	No. obs.	19.940	19.940	19.940	4.348	9.605	4.987		3.602	4.370	4.153	3.997	3.818	8.509	3.814	5.683
	R-sq.	0.03	0.05	0.05	0.03	0.06	0.10		0.06	0.05	0.07	0.05	0.05	0.04	0.06	0.07
HR	No. obs.	19.472	19.472	19.472	9.265	5.587	3.259	1.276	3.900	3.977	3.908	3.939	3.748	4.399	5.344	4.441
	R-sq.	0.04	0.04	0.05	0.04	0.06	0.06	0.09	0.05	0.06	0.06	0.05	0.06	0.05	0.05	0.05
EE	No. obs.	13.935	13.935	13.935	5.359	6.495	1.780	239	1.694	2.727	3.163	3.197	3.154	10.624	1.048	851
	R-sq.	0.06	0.06	0.06	0.06	0.07	0.08	0.39	0.04	0.06	0.07	0.07	0.12	0.08	0.05	0.07
LT	No. obs.	4.080	4.080	4.080	187	1.307	1.802	768	735	810	831	886	818	2.048	118	668
	R-sq.	0.09	0.10	0.10	0.28	0.10	0.09	0.06	0.11	0.13	0.08	0.07	0.21	0.11	0.31	0.11
LV	No. obs.	3.176	3.176	3.176	99	850	1.701	512	629	647	645	641	614	1.193	174	979
	R-sq.	0.06	0.08	0.08	0.33	0.13	0.07	0.15	0.13	0.13	0.10	0.08	0.24	0.11	0.24	0.11
PL	No. obs.	12.059	12.059	12.059	392	2.501	5.772	3.361	1.968	2.335	2.517	2.582	2.657	7.268	2.229	2.335
	R-sq.	0.53	0.56	0.56	0.23	0.34	0.59	0.72	0.26	0.33	0.49	0.53	0.74	0.55	0.53	0.64
RO	No. obs.	171.270	171.270	171.270	78.252	61.997	21.269	8.940	14.641	30.453	38.382	42.952	44.842	125.797	35.267	10.044
	R-sq.	0.34	0.43	0.43	0.38	0.48	0.49	0.54	0.19	0.34	0.42	0.48	0.50	0.43	0.45	0.44
SI	No. obs.	27.916	27.916	27.916	14.456	7.227	4.567	1.634	5.027	5.683	5.797	5.772	5.637	10.706	14.604	1.919
	R-sq.	0.04	0.04	0.04	0.04	0.04	0.09	0.07	0.03	0.04	0.04	0.06	0.10	0.05	0.04	0.07
UA	No. obs.	18.750	18.750	18.750	155	1.302	9.526	7.757	2.594	3.981	4.143	4.255	3.777	5.973	2.265	4.192
	R-sq.	0.10	0.12	0.12	0.34	0.19	0.12	0.11	0.06	0.07	0.07	0.09	0.29	0.11	0.16	0.12

Note: Results from the full specification of the model (11).

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

**Table A3: Horizontal spillover effects from FDI with NACE-3 digit sectors
[OLS on first differences after Olley-Pakes]**

		All	Micro	Small	Medium	Large	Q1	Q2	Q3	Q4	Q5	Gap1	Gap2	Gap3
BG	hs	0,018	-0,038	0,037	0,022	-0,024	0,128	0,005	0,035	-0,086	0,016	-0,181	-0,566	-0,016
BG	hsw	0,025	0,163	-0,005	0,020	0,173	-0,617	0,174	0,072	0,226	0,029	0,072	0,068	0,024
BG	hsf	0,003	0,137	-0,076	-0,097	0,194	-0,831	-0,087	-0,067	0,015	0,104	-0,113	0,082	-0,143
BG	hsfw	-0,005	-0,093	0,051	0,034	-0,034	0,088	0,037	0,038	-0,016	-0,010	-0,035	-0,031	0,038
CZ	hs	-0,010	-0,044	-0,014	-0,004	0,000	-0,020	-0,028	0,024	-0,021	-0,016	-0,012	-0,020	0,005
CZ	hsw	0,009	0,043	0,013	0,012		0,034	0,033	-0,023	0,021	0,006	0,003	0,022	0,052
CZ	hsf	0,024	0,100	0,030	0,032	0,000	-0,133	0,031	-0,036	0,060	0,006	0,019	0,045	-0,032
CZ	hsfw	-0,020	-0,091	-0,009	-0,027		0,220	-0,055	0,064	-0,060	-0,013	-0,020	-0,029	0,036
EE	hs	-0,012	-0,027	-0,040	0,005	0,065	0,028	-0,036	-0,033	-0,055	-0,003	-0,041	-0,007	0,006
EE	hsw	0,023	0,011	0,073	0,024	0,067	-0,122	0,076	0,086	0,058	0,017	0,067	0,196	-0,064
EE	hsf	0,003	0,083	0,036	-0,033	-0,030	0,016	-0,239	0,388	0,106	-0,042	0,012	-0,106	0,059
EE	hsfw	0,013	-0,039	-0,046	0,045	-0,050	0,648	0,517	-0,684	-0,051	0,038	-0,019	0,036	-0,013
HR	hs	-0,019	-0,013	-0,042	-0,031	0,016	-0,028	-0,060	-0,038	-0,015	-0,025	-0,009	-0,048	-0,013
HR	hsw	0,032	0,017	0,067	0,045	0,032	0,100	0,116	0,082	0,029	0,027	0,013	0,086	0,030
HR	hsf	0,044	-0,105	0,214	0,049	0,047	-0,009	0,085	0,016	0,029	0,076	0,019	0,016	0,023
HR	hsfw	-0,044	0,328	-0,209	-0,062	-0,035	0,017	-0,150	-0,010	-0,021	-0,047	-0,017	-0,036	-0,015
LT	hs	0,051	0,127	0,086	0,024	0,007	0,101	0,159	-0,038	0,104	-0,020	0,080	0,000	0,031
LT	hsw													
LT	hsf	-0,051	-4,070	-0,086	-0,009	-0,028	-0,649	3,214	-0,756	-0,137	-0,014	-0,024	0,508	0,267
LT	hsfw													
LV	hs	0,024	1,498	-0,017	-0,056	0,383	-0,051	0,024	0,122	0,055	0,071	0,193	0,000	0,270
LV	hsw													
LV	hsf	-0,013	0,000	0,000	0,005	-0,064	-0,024	-0,263	-0,212	-0,033	-0,011	-0,032	0,000	-0,033
LV	hsfw													
PL	hs	0,000	-0,107	-0,028	0,026	-0,006	-0,024	0,051	-0,007	0,002	-0,012	0,010	-0,043	0,000
PL	hsw	0,004	0,037	0,024	-0,022	0,012	0,050	-0,072	0,001	0,010	0,004	-0,004	0,009	0,001
PL	hsf	0,026	0,190	0,071	-0,005	0,035	0,065	-0,185	-0,065	-0,025	0,036	0,025	-0,034	0,070
PL	hsfw	-0,015	-0,066	-0,034	0,033	-0,040	-0,164	0,336	0,113	0,081	-0,014	-0,004	0,061	-0,071
RO	hs	-0,068	-0,005	-0,133	-0,282	-0,212	-0,299	-0,435	-0,420	-0,352	-0,014	-0,048	-0,028	-0,150
RO	hsw	0,018	0,008	0,016	0,049	0,037	0,148	0,166	0,113	0,087	0,011	0,014	0,069	0,037
RO	hsf	0,117	0,051	0,068	0,138	0,354	-0,446	0,225	-0,078	0,128	0,130	0,096	0,472	0,359
RO	hsfw	0,005	0,052	0,005	-0,029	-0,021	0,061	-0,060	0,112	0,020	0,007	0,006	-0,050	-0,008
SI	hs	-0,021	-0,018	-0,056	-0,012	-0,003	-0,040	-0,045	0,002	-0,065	-0,040	-0,023	-0,031	0,008
SI	hsw	0,092	0,084	0,195	0,070	0,067	0,386	0,357	-0,032	0,326	0,093	0,158	0,127	-0,009
SI	hsf	0,059	0,064	0,149	0,008	0,021	0,073	0,197	-0,022	0,136	0,056	0,051	0,083	0,101
SI	hsfw	-0,022	-0,022	-0,046	-0,004	-0,015	0,049	-0,105	0,031	-0,056	-0,019	-0,025	-0,028	-0,018
UA	hs	-0,052	-0,139	-0,007	-0,017	-0,283	-0,303	-0,290	-0,230	-0,007	-0,031	-0,384	0,209	-0,245
UA	hsw	0,020	0,350	0,048	0,018	0,184	0,520	0,189	0,240	0,017	0,012	0,105	0,011	0,158
UA	hsf	-0,062	0,000	0,125	0,699	0,505	0,201	0,479	0,367	0,336	-0,123	0,108	-0,664	0,830
UA	hsfw	-0,003	0,000	-0,239	-0,191	-0,191	0,337	-0,342	-0,528	-0,183	0,007	-0,271	0,221	-0,264
pos.	D	1	0	0	0	0	1	2	0	1	0	0	0	1
	Dw	7	6	5	2	5	3	4	4	4	6	6	4	1
neg.	D	5	3	5	2	1	0	4	3	4	1	5	2	1
	Dw	0	0	0	1	0	0	1	0	0	0	0	0	1

Notes: Results from the full specification of the model (11). See Table A2 for regression statistics. t-statistics are omitted from the results due to space limitations. Shadowed results indicate that the coefficient is significant at 10 per cent at the least.

Full results are available from the authors at request.

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

Table A4: Vertical spillover effects from FDI with NACE-3 digit sectors
[OLS on first differences after Olley-Pakes]

		All	Micro	Small	Medium	Large	Q1	Q2	Q3	Q4	Q5	Gap1	Gap2	Gap3
BG	vs	-0,059	0,106	-0,083	0,003	0,010	-0,172	-0,046	-0,085	0,119	0,036	0,150	0,102	-0,047
BG	vsw	0,046	-0,527	0,197	0,137	-0,263	0,142	0,014	0,121	-0,466	-0,044	-0,123	-0,418	0,492
BG	vsf	-0,147	-0,677	0,095	0,379	-0,479	0,448	0,563	0,047	-0,046	-0,756	-0,488	-0,349	0,622
BG	vsfw	0,459	0,359	-0,161	-0,160	0,101	0,261	-0,284	-0,037	0,010	0,143	0,174	0,128	-0,223
CZ	vs	-0,018	0,030	-0,008	-0,018		-0,135	0,008	-0,068	0,007	-0,015	-0,013	-0,029	-0,078
CZ	vsw	0,038	-0,003	0,034	0,023		0,434	0,019	0,087	0,004	0,008	0,031	0,045	-0,019
CZ	vsf	-0,029	-0,160	-0,125	-0,034		0,329	-0,010	0,057	-0,157	0,028	-0,019	-0,129	0,094
CZ	vsfw	0,001	0,155	-0,021	0,027		-0,129	-0,040	-0,106	0,134	0,005	0,007	0,088	-0,150
EE	vs	0,017	0,035	0,065	-0,106	-0,211	-0,037	0,095	0,069	-0,004	-0,039	0,071	0,157	-0,236
EE	vsw	-0,003	0,000	-0,015	0,016	0,022	0,035	-0,015	-0,014	0,009	-0,001	-0,013	-0,039	0,042
EE	vsf	-0,036	-0,214	-0,144	0,278	0,132	0,252	0,464	-0,241	-0,159	0,141	-0,042	-0,066	-0,015
EE	vsfw	-0,001	0,010	0,017	-0,032	-0,022	-0,160	-0,148	0,349	0,000	-0,009	0,006	0,024	-0,015
HR	vs	0,041	0,012	0,075	0,066	-0,028	-0,005	0,028	0,001	0,024	0,113	-0,071	0,098	-0,035
HR	vsw	-0,005	0,007	-0,010	-0,007	-0,015	0,010	-0,001	0,004	0,001	-0,005	0,009	-0,012	0,012
HR	vsf	-0,088	0,405	-0,461	-0,157	-0,079	0,055	-0,175	-0,157	-0,191	-0,150	0,265	-0,157	-0,032
HR	vsfw	0,016	-0,090	0,047	0,026	0,043	-0,032	0,048	0,032	0,030	0,010	-0,010	0,030	0,026
LT	vs	-0,132	-0,517	-0,151	-0,090	-0,120	-0,142	-0,418	0,230	-0,304	-0,086	-0,157	0,000	-0,304
LT	vsw													
LT	vsf	0,205	10,82	0,452	-0,147	0,256	0,388	0,196	0,126	0,464	0,377	-0,190	0,840	-0,290
LT	vsfw		8											
LV	vs	-0,015	-0,209	-0,017	0,005	-0,264	-0,176	-0,039	-0,026	-0,028	0,033	-0,043	0,000	-0,012
LV	vsw													
LV	vsf	-0,010	0,000	0,303	-0,047	0,438	0,325	0,142	0,132	0,487	-0,046	0,019	0,000	-0,012
LV	vsfw													
PL	vs	-0,006	0,199	0,033	-0,071	0,016	-0,020	-0,148	-0,092	-0,061	0,027	-0,031	0,007	-0,024
PL	vsw	0,000	-0,065	-0,025	0,067	-0,014	0,039	0,223	0,119	0,032	-0,002	0,037	-0,013	0,002
PL	vsf	-0,048	-0,686	-0,110	0,040	-0,083	-0,188	0,400	0,201	0,078	-0,098	-0,015	0,038	-0,120
PL	vsfw	0,037	0,211	0,060	-0,074	0,094	0,340	-0,708	-0,271	-0,118	0,038	-0,008	-0,082	0,112
RO	vs	-0,159	-0,115	-0,256	-0,060	0,243	0,031	0,458	0,141	-0,096	-0,160	-0,309	-0,220	0,215
RO	vsw	0,239	0,190	0,557	-0,272	-0,214	0,315	-0,165	-0,546	-0,168	0,226	0,651	-0,111	-0,384
RO	vsf	-0,099	-0,545	-0,475	-0,491	-0,317	-0,143	-0,135	-0,042	-0,358	-0,127	0,076	-0,154	-0,420
RO	vsfw	-0,029	-0,024	0,090	0,147	-0,005	0,745	0,511	0,015	-0,040	-0,035	-0,064	0,402	-0,003
SI	vs	0,008	-0,005	0,032	0,012	-0,030	-0,135	-0,003	-0,011	0,040	0,032	0,005	0,002	-0,003
SI	vsw	-0,001	-0,004	-0,007	0,005	0,022	0,099	0,024	0,076	-0,019	-0,010	-0,032	0,000	0,051
SI	vsf	-0,011	-0,020	-0,017	-0,009	-0,003	0,042	-0,061	0,009	-0,035	-0,013	-0,012	-0,015	0,007
SI	vsfw	0,049	0,095	0,056	0,035	0,013	-0,450	0,332	-0,082	0,172	0,053	0,068	0,063	-0,038
UA	vs	0,014	-0,007	0,018	0,005	0,041	0,101	0,031	0,095	-0,016	0,009	0,151	0,100	0,036
UA	vsw	-0,003	-0,020	0,000	-0,003	-0,020	-0,111	-0,037	-0,081	0,015	-0,002	-0,041	0,004	-0,018
UA	vsf	0,004	0,000	-0,142	-0,252	-0,043	0,000	-0,857	-0,350	-0,212	0,014	-0,613	-0,441	-0,058
UA	vsfw	-0,002	0,000	0,117	0,005	0,015	-0,502	0,696	0,639	0,004	-0,004	0,130	-0,003	0,018
pos.	D	2	0	2	0	1	1	1	1	0	1	4	2	1
	Dw	2	1	1	1	0	1	1	2	0	1	4	0	1
neg.	D	2	0	0	1	0	1	2	2	1	0	1	0	2
	Dw	1	0	2	0	3	1	1	1	0	1	4	2	2

Notes: Results from the full specification of the model (11). See Table A2 for regression statistics. t-statistics are omitted from the results due to space limitations. Shadowed results indicate that the coefficient is significant at 10 per cent at the least.

Full results are available from the authors at request.

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

Appendix 2

Discussion of empirical methods to correct for endogeneity between inputs and output in production functions

Present applications to estimating production functions have revealed significant problems of potential correlation between input levels and the unobserved firm-specific shocks. The idea is that firms that experience a large positive productivity shock may respond by using more inputs, which violates the OLS assumption of strict exogeneity of inputs and the error term. Let us show this by rewriting our basic model (2) in order to capture possible endogeneity between inputs and performance. Consider a modified TFP growth-accounting model:ⁱ

$$(A1) \quad y_{it} = \gamma t_{it} + \alpha k_{it} + \beta l_{it} + \delta_{it} + (\eta_i + u_{it} + m_{it}), \quad \text{where } \alpha + \beta \neq 1$$

$$(A2) \quad u_{it} = \rho u_{i,t-1} + o_{it} \quad |\rho| < 1$$

$$o_{it}, m_{it} \sim \text{MA}(0),$$

where of the error components, η_i is an unobserved firm-specific effect, u_{it} is an autoregressive (productivity) shock and m_{it} represents serially uncorrelated measurement errors. Note that both labor (l_{it}) and capital (k_{it}) are potentially correlated with firm-specific effects (η_i) as well as with both productivity shocks (t_{it}) and measurement errors (m_{it}).

Given the AR(1) process in u_{it} according to model (A2), a firm's response to a positive productivity shock in the past ($u_{i,t-1} > 0$) by using more inputs in the period t clearly violates the OLS assumption on strict exogeneity between inputs and the error term ($E(\mathbf{z}_{it}' u_{it}) \neq 0$).ⁱⁱ This endogeneity usually shows up in OLS estimations in the form of persistent serial correlation and yields biased parameter estimates. Levinsohn and Petrin (2000) demonstrate that in the case where capital and labor are positively correlated, and both are also correlated with the productivity shock, the parameter for labor input will tend to be overestimated and the parameter for capital will tend to be underestimated. Given the usual quality of firm level datasets, this is the most likely case. Unfortunately, biased parameter estimates for capital and labor inevitably lead to biased estimates of productivity.

There is a need, hence, to find suitable methods to account for this correlation between inputs and the error term. Any such method, however, will inevitably prove to be inefficient as long as we have to deal with serious measurement problems in the stock of capital (see Griliches and Mairesse, 1995). The most simple methods are the application of fixed effects or first difference transformation in order to wipe out the firm-specific unobserved effects η_i . However, the drawback of both methods is to require that a component of the productivity shock is fixed over time, which gives little hope that we have dealt with the problem efficiently.

Another alternative is to apply the instrumental variables approach, but valid instruments are required that are correlated with firm-level input choices and orthogonal to the productivity shock. The problem is that, usually, there are simply no valid instruments.

Recently, three more sophisticated methods applied to estimating a production function in a dynamic panel data context were developed that claim to solve the problem of endogeneity between input levels and the unobserved firm-specific shocks in a satisfactory way. Olley and Pakes (OP, 1996) propose to use investment expenditure as a proxy for unobservable technological shocks. The advantage of this method is that we do not assume that unobserved productivity is fixed over time, and since there is no need for differencing, it leaves more variance in capital and labor. Another advantage of the OP method is that it also controls for the selection issue. There is, namely, a clear relationship between firm productivity, on one hand, and firm survival and input demand, on the other. Olley and Pakes find that as the least productive firms exit the market, the existing capital is redistributed to their more productive counterparts generating a strong negative bias on the capital coefficients in the production function. A common way of dealing with the selection issue is to consider only a balanced sample (by excluding the observations that are not present throughout the period of observation) but, as Olley and Pakes also show, firm decisions are made, at least to some extent on their perceptions of future productivity and those, in turn, are partially determined by the realizations of their current productivity. If one were to consider only those firms that survived over the entire period this would imply that a sample is being selected, in part, on the basis of the unobserved productivity realizations. This generates a selection bias in both the estimates of the production function parameters and in the subsequent analysis of productivity. Therefore they present an alternative solution that serves to deal with both the simultaneity and self-selection issues at the same time.

The estimation procedure that was first introduced by Olley and Pakes (1996) and since used extensively relies on a three step procedure to estimate the unbiased coefficients on labor and capital in the production function. The crucial first step of the estimation serves to estimate the unobserved productivity shocks u_{it} for each firm by employing the (firm-specific) investment equation and the dependence of investment on productivity shocks. These estimates can subsequently be used to control for the unobservable productivity shocks u_{it} in our estimations of (A1). In our empirical estimations presented in the next section we will use a forth order polynomial in capital and investment only (with a full set of interaction terms) to approximate u_{it} , since data on firm age was not available. Using the estimates of productivity shocks, the primary production function is estimated to obtain unbiased estimates of the coefficient on labor as well as predicted values of the remaining(residual) part of the production function (A1). The second step of the estimation process involves the determination of the survival probability (the probability that a firm will survive in the local market), which depends on the firm's productivity remaining above the perceived cut-off level. In estimating the survival probability we use a fourth order polynomial in (k_i, i_t) with industry and time dummies (which serve as a proxy for differences in market conditions and time-specific factors that impact the survival probability). The third and final step of the estimation procedure utilizes the preceding two steps (whereby the first step estimation results are used to control for simultaneity, while the results of the second step serve to mitigate the self-selection bias) to estimate an expanded production function and obtain unbiased estimates of the coefficient on capital. We estimate the third step of the estimation algorithm using nonlinear least squares with bootstrapped regression coefficients (in line with Pavcnik, 2002, 1000 repetitions were used in the bootstrap). Again, in contrast to the Olley - Pakes estimation, we have to forego the use of the firm age variable since it is not a part of the data set. Consistent and unbiased estimates of coefficients on capital ($\bar{\alpha}$) and labor ($\bar{\beta}$) can ultimately be used to obtain unbiased estimates of total factor productivity (TFP):

$$(A3) \quad \overline{tf}_i = y_i - \overline{\alpha}k_i - \overline{\beta}l_i$$

The estimates of TFP will be used in place of the value added measures in estimations of production function (1) subject to (2). The specification of the model will differ slightly from (1) since capital and labor will no longer need be included in the estimation.

The drawback of the OP approach, however, is in their assumption that there is only one single component of unobservable heterogeneity in the system, which is fully transmitted to the investment equation. In other words, OP assume that if capital input has already adjusted to the anticipated part of the productivity process ($\rho u_{i,t-1}$ in (A2)), the investment proxy will only account for the “news,” i.e. the unanticipated part of the technology shock (o_{it}). As a consequence, some correlation between the unobserved technological shock and capital, and therefore some bias, would remain in the estimated production function coefficients.

Instead, Levinsohn and Petrin (LP, 2000) propose to use materials (energy consumption or material costs) as a proxy for unobserved technological shocks. Material costs respond to the entire productivity shock u_{it} and not just to the unanticipated part of it. In addition, Basu and Fernald (1995) also suggest using material cost in the production function with value added as a dependent variable in order to control for unobserved demand shocks. Including material costs directly into the model as suggested by Basu and Fernald or applying the LP instrumentalization does not necessarily reduce the bias. While Levinsohn - Petrin method provide a viable alternative to the Olley - Pakes estimation algorithm by introducing material costs (in place of investments) in the first step of the estimation procedure, it is mostly difficult to employ it due to the lack of available data on the use of specific materials, such as energy consumption (instead, only data on aggregate expenditure on materials is available).

An alternative approach to control for the seemingly persistent simultaneity bias is to model the production function as a dynamic process since present firm growth is inevitably correlated with the past performance of the firm. Arellano and Bond (1991, 1998), Arellano and Bover (1995) and Blundell and Bond (1998, 1999) propose related econometric techniques to deal with the simultaneity bias in a dynamic panel data context. Consider a dynamic version of the growth model (A1):

$$(A4) \quad y_{it} = \rho y_{i,t-1} + \alpha k_{it} - \rho \alpha k_{i,t-1} + \beta l_{it} - \rho \beta l_{i,t-1} + (\delta_t - \rho \delta_{t-1}) + (\gamma_{it} - \rho \gamma_{i,t-1} + \eta_i(1 - \rho) + o_{it} + m_{it} - \rho m_{i,t-1}).$$

In model (A4), one can show that the OLS estimator will be seriously biased due to correlation of the lagged dependent variable with the individual-specific effects as well as with the independent variables. This is due to the fact that y_{it} is a function of η_i in model (A1), and then $y_{i,t-1}$ is also a function of η_i . As a consequence, $y_{i,t-1}$ is correlated with the error term, which renders the OLS estimator biased and inconsistent, even if u_{it} and m_{it} in model (A1) are not serially correlated. This holds also whether the individual effects are considered fixed or random (see Hsiao, 1986; Baltagi, 1995; Wooldridge, 2002). One way of controlling for this unobserved heterogeneity and simultaneity is to include exogenous variables into the first-order autoregressive process.

This, in turn, reduces the bias in the OLS estimator, but its magnitude still remains positive. Another way of controlling for the simultaneity is to apply the Anderson-Hsiao instrumental variable approach. We may first differentiate our model (A1) in order to eliminate η_i , which is the source of the bias in the OLS estimator. Then we may take the second lag of the level ($y_{i,t-2}$) and the first difference of this second lag ($\Delta y_{i,t-2}$) as possible instruments for $\Delta y_{i,t-1}$, since both are correlated with it ($\Delta y_{i,t-1} = y_{i,t-1} - y_{i,t-2}$) but uncorrelated with the error term Δu_{it} ($= u_{it} - u_{i,t-1}$). This approach, though consistent, is not efficient since it does not take into account all the available moment conditions (i.e. restrictions on the covariances between regressors and the error term).

An appropriate approach that allows for controlling for the unobserved simultaneity in model (A4) is the application of GMM (general method of moments) estimators. Most studies estimate production function in first differences in order to obtain estimates of differences in growth performance of privatized firms as well as to eliminate unobserved firm-specific effects. Since lagged-level instruments used in the difference-GMM approach are shown to be weak instruments for first-differenced equation (see Arellano and Bover, 1995; Blundell and Bond, 1998, 1999), one may apply the system-GMM approach, which in addition to lagged levels uses also lagged first differences as instruments for equations in levels. As the model is estimated in first differences, corresponding instruments for $\Delta x_{i,t-3}$ are $x_{i,t-1}$ and $\Delta x_{i,t-1}$ (where x stands generally for all included variables), and so on for higher time periods. This allows for a larger set of lagged levels and first-differences instruments and therefore to exploit fully all of the available moment conditions. Hence, the system-GMM approach, in principle, maximizes both the consistency as well as the efficiency of the applied estimator.

However, this is not necessarily true in every case. Levinsohn and Petrin (2000) point out that "...lagged values of inputs will not generally be valid instruments because chosen input levels may depend upon past values of the (potentially correlated) shock. Frequently, instrumental variables suffers from the same drawback as that of the within estimator; valid instruments are usually weak instruments - that's generally what makes the exclusion restriction believable - and weak instruments significantly weaken the signal, exacerbating other imperfections in the data."

Hence, we should notice again that the above methods can be efficient only when we are dealing with accurately measured datasets. When this precondition is violated, no existing econometric technique can help in controlling for the unobserved productivity shocks and simultaneity bias.

ⁱ We use the Blundell and Bond (1999) notations.

ⁱⁱ Where, again, \mathbf{Z}_{it} is a matrix of inputs k_{it} and l_{it} .