Does FDI spur innovation, productivity and knowledge sourcing by incumbent firms? Evidence from manufacturing industry in Estonia

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Abstract

Does FDI affect innovation, knowledge sourcing activities and productivity growth of domestic firms? This study employs firm-level panel-data from Estonia's manufacturing sector to investigate different channels through which FDI affects domestic firms. Using instrumental variables approach, I find no evidence of an effect of FDI entry on local incumbents' short-term productivity growth. However, there are positive spillovers on process innovation. The results show positive correlation between the entry of FDI and the more direct measures of spillovers. This is consistent with the view that FDI inflow to a sector intensifies knowledge flows to domestic firms.

Keywords: foreign direct investment, productivity, innovation, learning

JEL codes: F21, F23, O31, O33

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1 Introduction

The existing empirical evidence base on the effects of foreign direct investments (FDI) on domestic firms is, at best, limited. There are many papers attempting to study the effects of entry of foreign owned firms on local incumbents, i.e. the spillovers of FDI. However, this type of study is difficult. The researcher needs to account for likely econometric problems of reverse causality, endogeneity of FDI, endogeneity of inputs in estimation of the production function, heterogeneity of effects, lack of good instruments or natural experiments for identification of causal relationships. Only very few papers can account for these issues. Reflecting these problems and the resulting likely biases in estimated effects, the findings in different papers and different countries can vary a lot. Insignificant, and sometimes also positive or even negative spillovers have been found.[2]

This study adds to the literature by studying the channels of the effects of entry of foreign owned firms on domestic firms in the host economy of FDI. It uses instrumental variable (IV) regression approach to identify the effects. Differently from the prevailing production function based approach of the empirical literature on spillovers, I provide evidence also concerning the association between FDI entry and subsequent domestic firms' innovation activities (incl. innovation-related co-operation activities); and indicators of importance of knowledge flows from suppliers, clients and competitors of the firm. In addition, I investigate the effects of FDI entry in Estonia on incumbents' total factor productivity (TFP) and labour productivity growth in order to find out whether the use of innovation data and productivity data lead us to similar conclusions

[2] See, for example, Blomström and Kokko (2002), Görg and Strobl (2001), Görg and Greenaway (2004), or Barba Navaretti and Venables (2004) for literature reviews about effects of FDI on incumbent firms.

about the existence of spillovers. My analysis checks for potential heterogeneity of these effects: whether they depend on local incumbents' distance to the technology frontier, as suggested by models from endogenous growth theory, e.g. in Aghion *et al.* (2009).[3]

Most of the earlier literature has investigated the correlation between FDI presence in a host economy and productivity of domestic-owned firms, not the causal effects. Among the exceptions that endeavour to address the effects, by IV regression approach, are studies by Aghion *et al.* (2009) and Haskel *et al*. (2007). Also, for example Barrios *et al*. (2009), Crespo *et al*. (2009) or Halpern and Muraközy (2007) are among these that employ the GMM estimator to try to account for the endogeneity of FDI.

Most papers are also firmly rooted in the estimation of the production function of firms or plants. All that FDI entry is expected to do is to shift TFP. The current inconclusive evidence about spillovers, however, suggests that we should look more in detail into the different channels of these effects: the demonstration-imitation effect of foreign know-how; effects from increased competition, supplier training and labour mobility related effects, and effects on innovation incentives.

A notable example of analysis of a particular channel of FDI spillovers is by Görg and Strobl (2005) about the effects through worker mobility. So far, only few studies have investigated the FDI spillovers on innovation activities of domestic firms. These include Bertschek (1995), Blind and Jungmittag (2006), Girma *et al.* (2006) and

[3] Based on Aghion et al. (2009) and Acemoglu et al. (2006) we would expect that an increase in entry of technologically advanced firms (e.g. MNEs) has positive effects on incumbents' performance, innovation incentives and innovation activities if the incumbents are sufficiently close to the technology frontier. There are positive effects on innovation of these high-productivity firms as they can escape adverse effects of technologically superior competitors by innovating. However, we would also expect, based on the same models, that if incumbents are far from the technology frontier of the sector then the entry of FDI will reduce innovation incentives of these firms, as they have little hope of surviving the tougher competition. Thereby, it will have negative effect on their productivity growth.

Brambilla *et al.* (2009). Bertschek (1995) and Blind and Jungmittag (2006) use German data and find that the market share of foreign-owned firms is positively associated with innovation propensity of domestic firms in the same industry. Girma *et al.* (2006) study the FDI spillovers to innovativeness of Chinese state-owned enterprises—on average, they find a negative association with the FDI presence in a sector and state-owned firms' innovation activities. However, Brambilla *et al.* (2009) finds positive relationship between FDI presence at sector level in China and introduction of new products by the domestic-owned firms. To the best of my knowledge there are no other empirical papers studying FDI spillovers on domestic firms' innovation-related co-operation activities and only one econometric study of the association of FDI presence in a sector with direct measures of intensity of knowledge flows from domestic firm's competitors, suppliers and clients (by Crespi *et al*. 2008).

Some previous studies have investigated productivity spillovers of FDI in Estonia. These include papers by Sinani and Meyer (2004), Damijan and Knell (2005), Vahter and Masso (2007) and Vahter (2005). All of these look at the correlation between FDI share in a sector and the productivity of local firms and do not identify the causal effects. They do not look into the various channels though which the productivity spillovers work. Also, they tend to use biased proxies of FDI spillovers.[4] The advantages of this study are using a dataset for productivity analysis that includes the

[4] With the exception of Sinani and Meyer (2004), no significant correlations between FDI share in a sector and TFP of domestic firms has been found in these papers. Sinani and Meyer (2004) and Damijan and Knell (2005) use small samples of Estonian firms, that are significantly biased towards large firms and foreign owned firms. They do not correct their estimated effects for this sample selection bias and calculate the FDI share in each sector (the FDI spillover variable) also based on the biased sample. Sinani and Meyer (2004) paper suffers from serious attrition problem as the number of firms in their sample falls over the studied period falls from 490 to 290.

whole population of manufacturing firms in Estonia and a panel dataset of innovation-related variables from two Community Innovation Surveys (CIS).

The paper employs detailed firm level yearly data from Estonia, covering all manufacturing firms during 1995-2004. Estonia is a good case study for the effects of FDI, as it is a transition economy that has attracted a lot of FDI per capita. In terms of per capita stock of FDI, it has ranked ahead of most other locations among the Central and Eastern European (CEE) transition countries (UNCTAD 2009). Estonian data include indicators of innovation and knowledge sourcing from other enterprises. This means that, unlike other related studies (except only Crespi *et al*. 2008), I can test whether entry of FDI results indeed in spillovers to domestic firms—whether entry of FDI is positively associated with an increase in direct measures of knowledge flows to incumbents.

By using instrumental variables I can go beyond the standard analysis of correlations. To identify the impact of FDI entry on performance of incumbents, one needs an instrument that predicts changes in the FDI entry, but is unrelated to changes in incumbent productivity in Estonia (after controlling for other relevant factors). I employ the FDI entry rates in 3-digit level NACE sectors of other CEE countries as instruments for FDI entry rates in the corresponding industries in Estonia. These instrumental variables predict the FDI entry in Estonia. At the same time they are not likely to directly affect the performance characteristics of incumbent firms in Estonia. Previously, Haskel *et al*. (2007) have used similar instruments. They instrument FDI share in each sector in UK with FDI share in the same industry in the US.

The estimated main regressions of interest relate the change in TFP (estimated with the Levinsohn and Petrin (2003) method to account for endogeneity of inputs in the

production function), different measures of innovativeness, or knowledge sourcing of incumbent firms in a sector to lagged change in the share of foreign owned firms in a sector or a region and other firm and industry level controls.

2 Empirical modelling of the effects of FDI entry

The estimated empirical model is related to the model from the Aghion *et al*. (2009) empirical study based on UK data. It enables to estimate the effects of FDI entry on productivity growth and innovation indicators of firms. Firstly, we can expect effects of entry of foreign owned firms on innovation of incumbents due to increased competition (e.g. Aghion *et al.* 2009), which can increase incentives to innovate in order to escape competition. Secondly, we can expect effects of FDI entry due to technology transfer, i.e. imitation of production processes used by foreign owned firms, but new to the incumbent firms. Thorough overviews of the literature on spillovers of FDI are given by Görg and Strobl (2001), Görg and Greenaway (2004), or Barba Navaretti and Venables (2004).

The dependent variable (ΔY_{ijt}) in Equation (1) is, depending on specification, either the change in TFP or different measures of innovativeness at the incumbent firm level. Subscript *i* indexes incumbent firms, *j* indexes industries, *t* indexes years.

The estimated main regressions relate these different dependent variables to lagged entry of foreign owned firms (E_{jt-1}), distance of incumbents to the local productivity frontier (D_{ijt-1}), interaction term between these two variables, and some other firm and

industry level controls (X_{ijt}), firm fixed effects (μ_i), year effects (τ_t) and an error term (ε_{ijt}):

$$\Delta Y_{ijt} = \alpha + \beta E_{jt-1} + \gamma D_{ijt-1} + \delta E_{jt-1} D_{ijt-1} + X'_{ijt-1}\varphi + \mu_i + \tau_t + \varepsilon_{ijt} . \quad (1)$$

The entry of foreign owned firms is measured as the change in the share of foreign owned firms by their number of employees in each 3-digit NACE sector. The distance to local productivity frontier is defined here as difference between the highest productivity decile (the 90th percentile) of each 3-digit industry and each incumbent firm's productivity level in the sector. Its interaction term with FDI entry enables us to look at how effects of entry depend on distance to the frontier. Other controls include lagged sector-level import penetration and Herfindahl index, and log of size of the firm.[5]

In order to account for the endogeneity of FDI entry I need to instrument this term and its interaction with the distance to the productivity frontier. I need instrumental variables(s) that predict changes in the FDI entry rate, but are (otherwise) unrelated to changes in the dependent variable ΔY_{ijt}. Suitable instrumental variables that I use here

[5] We would expect that firms that are more exposed to foreign or local competition have higher productivity growth and engage more in innovation. Therefore we expect the increase in import penetration rate (a very broad proxy for foreign competition) to be positively associated with productivity growth and innovativeness of firms. Also, we would expect that higher Herfindahl index (i.e. less competition) is negatively related to the productivity growth and innovativeness of local firms. Firm size is included as an additional control, as larger firms may be more innovative, increase in firm size may make it easier for the firm to find funds to invest in innovation activities—and consequently, this may also result in higher growth rate of its productivity. It is quite standard finding that firm size is positively associated with firm's innovation indicators (e.g. Griffith et al. 2006).

are the measures of FDI entry (at 3-digit sector level) in other Central and Eastern European (CEE) transition economies.[6]

The FDI entry rates in different 3-digit industries are likely to be correlated across different CEE countries as the determinants of FDI inflow for several of the CEE countries are relatively similar. However, it is not likely that the FDI entry rates inside, for example, Slovakia or Lithuania affect directly the productivity growth rate of incumbent firms in Estonia. Here I need to assume that there are few knowledge flows from multinational firms (MNEs) that are geographically far from the incumbent Estonian firms.

A related question to the effects of FDI entry on productivity and innovation is whether the entry results in knowledge spillovers to the incumbent firms? The standard approach is to use the FDI share or FDI entry rate in a sector as an indirect proxy for the FDI spillovers (e.g. Aitken and Harrison 1999, Javorcik 2004, and many others). Based on data from the EU innovation surveys (CIS3 and CIS4 surveys) we can test whether there is any significant correlation between these indirect measures of spillovers and the importance of 'knowledge flows from other firms' for the domestic firms.

The main question asked from each firm about its knowledge flows in the EU CIS innovation survey is: "*Indicate the sources of knowledge and information used in your technological innovation activities, and their importance.*" The answer choices are: "*importance of the source is* i) *high,* ii) *medium,* iii) *low,* iv) *not used*." Knowledge sources listed in the questionnaire are the following: *from within the enterprise, from*

[6] I use FDI entry data from Hungary, Czech Republic, Slovakia, Poland, Latvia, and Lithuania.

suppliers, from customers, from competitors, (a number of other sources have been listed as well, but are seldom indicated as important by Estonian firms).

Based on the answers of domestic-owned firms, a set of indicator variables has been created, a dummy variable for each knowledge source. These variables are equal to 1, if the corresponding 'source of knowledge' is of high importance for the firm, 0 otherwise. Also, for each of the four types of information sources an ordered variable is created, as the four possible answer choices have a natural ordering. This ordered variable takes value 0 for answer 'not used', 1 for 'low importance', 2 for 'medium importance' and 3 for 'high importance' of the particular source of knowledge.

To test the correlation between the indirect measures of FDI spillovers and direct measures of knowledge flows between firms I estimate the following regression:

$$I_{ijt}^{m} = \beta^{m} E_{jt-1} + Z'_{ijt-1}\varphi^{m} + \mu_i + \tau_t + \omega_{ijt} . \qquad (2)$$

The dependent variable in Equation (2), I_{ijt}^{m}, is either a dummy variable or an ordered variable (with values 0, 1, 2, 3) indicating the importance of the m_{th} knowledge source. These include importance of knowledge flows from: i) competitors, ii) suppliers, iii) clients, and iv) within the same corporation. Explanatory variables are similar to the Equation (1).

3 Data

Estonia is a small Central and Eastern European country that has attracted a lot of inward FDI per capita. In 2007, the ratio of Estonia's stock of inward FDI to its GDP

peaked at 81 per cent (UNCTAD 2009). This figure is much higher than in the world, in the EU, or among the CEE countries on average.

One of the main attractive features for FDI in Estonia has been its relatively close cultural and geographic proximity to Finland and Sweden. These two countries make up about 55 per cent of FDI in Estonia. Although, the rapid growth of wages has outrun the growth of productivity in Estonia and the cost level is higher than in nearby Latvia or Lithuania, the costs of production are still significantly lower than in Western Europe. The costs of production inputs and entry to local market have been the main motivating factors of FDI in Estonia.

My econometric analysis is based on firm-level data of the Estonian manufacturing industry (i.e. sectors with NACE two-digit code between 15 and 37). I employ several different sources of data. For productivity analysis, I use yearly balance sheet and income statement information of the whole population of Estonian firms from the Business Register of Estonia. The period covered is 1995–2004. The unit of observation is the firm. The original dataset includes up to 5,400 domestic owned manufacturing firms per year. It includes information indicating whether each firm has foreign ownership or not and it allows to assess the effects of FDI entry on total factor productivity of domestic owned firms. The descriptive statistics of this database are given in Annex 1 in Table A1 and A2.

For analysis of effects on innovation and knowledge sourcing I employ a sample of Estonia's firms covered by the CIS3 and CIS4 innovation surveys. CIS is a regular survey in EU countries. CIS3 covers period 1998-2000 and CIS4 2002-2004. In the two surveys there are, respectively, 1,185 and 1,264 Estonia's domestic-owned manufacturing firms. There is a large overlap between the surveys in terms of firms

covered. The Estonian surveys have been conducted by the Statistical Office of Estonia and the response rate is rather high. It is 74 per cent in CIS3 and 78 per cent in CIS4, whereas the EU average is 55 per cent (Terk *et al*. 2007). The main descriptive statistics of innovation surveys are given in Table A3 in Annex 1.

One of the advantages of this study is that it can combine the information from innovation surveys with the firms' financial data from the Estonian Business Register's database. For example, in Western European countries, merging the CIS data with additional firm level databases is more difficult due to the more stringent administrative restrictions by the national Statistical Offices. Also, it has been possible to merge CIS3 and CIS4 data of Estonia's firms into a short two-period panel.

The sector level instrumental variables that are used to identify the effects of FDI on domestic owned firms are calculated based on the Amadeus dataset from the Bureau van Dijk, and datasets of Hungarian and Finnish manufacturing firms of the Hungarian and Finnish Statistical Offices.[7]

I measure capital as the book value of firm's capital stock and labour as average number of employees at the firm in a given year. Output, value added and intermediate inputs are deflated by respective deflators of the system of national accounts provided by the Statistical Office of Estonia. Detailed information about the deflators is available from the National Accounts of Estonia (2003).

An important problem in estimating the production function and TFP is the endogeneity bias resulting from the correlation between the unobservable productivity shock and the input choices of each firm. In order to account for this endogeneity bias, I have used the

[7] I owe thanks for help with calculation of these sector level variables to Claudia Hochgatterer from Vienna University of Economics, Balazs Muraközy from Hungarian Academy of Sciences, and Markku Pankasalo from Statistics Finland.

Levinsohn-Petrin (2003) approach to estimate the TFP. It is a semi-parametric procedure for estimating the production function that is by now fairly standard method in the literature. Therefore, a detailed description of these methods is omitted from here. In order to allow for heterogeneity of the production technology in different sectors, I allow the coefficient of each production input (capital and labour) to be different for each 2-digit NACE industry. The dependent variable in the estimated production functions is deflated value added.

As evident from Annex 1, the average share of FDI in employment in a 3-digit NACE sector grows from 16 per cent in 1995 to 32 per cent in 2004. The number of domestic owned firms in the panel varies between 2,761 in 1995 and 5,370 in 2003. Vahter and Masso (2007) find that multinational firms in Estonia have higher TFP, labour productivity, capital-intensity and wages than domestic firms. Previous studies have also shown that large firms, foreign owned firms, or firms that belong to a larger corporate group have more innovative activities than the rest (for evidence from Estonia, see Terk *et al*. 2007). During 1998-2000, on average 26 per cent of domestic firms in the manufacturing sector engaged in product innovation and 22 per cent in process innovation (see Annex 1). These figures are smaller than the ones for the whole CIS sample, that included also the foreign owned and services sector firms. A more detailed overview of the descriptive statistics, sample and questionnaire of the innovation surveys can be found from Terk *et al*. (2007).

4 Results

At first, this section presents the results concerning the effects of FDI entry on productivity growth. The first stage of the 2-stage least squares regression (2SLS)—with FDI entry rates in Hungary, Czech Republic, Latvia, Lithuania, Poland and Slovakia used as instruments for FDI entry rates in Estonia—is given in Table 1. It appears that the FDI entry rates in Hungary (Column 1 and 2) and in other CEE countries (Columns 3 and 4) are significantly and positively correlated, at 1 per cent significance level, with the FDI entry rates in the corresponding 3-digit industries in Estonia.

A standard problem in the IV approach can be weak identification (Murray 2006). It arises when the instruments are correlated with the endogenous regressor(s), but only weakly. Estimators can perform poorly in this case. A commonly used diagnostic of weak instruments is the F-statistic of significance of instruments in the 1st stage of the 2SLS (Angrist and Pischke 2009). Stock, Wright and Yogo (2002) suggest that this statistic should be at least as large as 10. Then we can usually (but not always) reject the H0 that the instruments are weak. Indeed, the F-statistics in Table 1 of the significance of instruments are above 10, and above the critical values calculated in Stock and Yogo (2005).

Table 1. First stage of the 2SLS approach: relationship between FDI entry in Estonia and FDI entry in other Central and Eastern European countries

Dep var:	FDI $entry_{jt}$	FDI $entry_{jt}$	FDI $entry_{jt}$	FDI $entry_{jt}$
FDI $entry_{jt}$ in Hungary (at 3-digit NACE sector level)	0.103***	0.12***	0.091**	0.089***
	(0.039)	(0.041)	(0.043)	(0.044)
FDI $entry_{jt}$ in Czech Republic			0.066***	0.076***
			(0.017)	(0.017)
FDI $entry_{jt}$ in Latvia			0.037***	0.042***
			(0.008)	(0.009)
FDI $entry_{jt}$ in Lithuania				0.0361***
				(0.009)
FDI $entry_{jt}$ in Poland			0.038**	0.0312
			(0.019)	(0.019)
FDI $entry_{jt}$ in Slovakia			0.07**	0.092***
			(0.027)	(0.027)
Year dummies	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Distance to frontier, import, and competition effects	Yes	No	Yes	Yes
Number of observations	10366	10366	10366	10366
F-test of instrumental variables	26.5 (p=0.00)	27.6 (p=0.00)	28.1 (p=0.00)	33.0 (p=0.00)
Weak identification test critical values (from Stock and Yogo 2005):				
Maximal 5 % allowed IV bias	16.38	16.38	18.37	18.37
Maximal 10 % allowed IV bias	8.96	8.96	10.83	10.83
Maximal 20 % allowed IV bias	6.66	6.66	6.77	6.77

Period: 1995-2004. FE- fixed effects. FDI entry indicators are calculated at 3-digit NACE sector level. Population of domestic-owned firms, Estonia's manufacturing industry.

Next, in Table 2 I show the 2nd stage of the 2SLS and describe the effect of FDI entry on TFP growth. Columns 1 and 2 show estimates from the standard FE model. Columns 3-5 endeavour to address the endogeneity of FDI and report the 2SLS results, with firm-level fixed effects included.[8] Similar regressions with labour productivity

[8] I have tested between the fixed effects and random effects specification. The value of the corresponding Hausman test statistic is 405.07 (p=0.000). This indicates that the FE model should be preferred. All regressions in Table 2 and 3 include year dummies and firm fixed effects. There are no sector or region dummies included, as these are already absorbed by the firm level fixed effects. Standard errors are given in parentheses and are heteroscedasticity robust.

growth as dependent variable have been estimated as well, the results were close to these based on TFP.

As evident from the FE model (Column 1 in Table 2), the average effect of FDI entry on productivity growth is not significantly different from zero. Accounting for endogeneity of FDI entry (see Columns 3 and 5 in Table 2) does not change this main conclusion. Column 3 in Table 2 shows the just-identified case, if only FDI entry rate in Hungary is used as an instrumental variable. Column 4 and 5 report the results if instrumental variables from 5 CEE countries are used.

In Table 2, the coefficient of FDI entry variable from the standard FE model is -0.062. In the IV model it has values -0.107 or -0.253, depending on the number of instruments used (see Columns 3 and 5), but is not statistically significant.[9]

Next, I check the prediction from Schumpeterian competition models (see e.g. Aghion *et al*. 2009) that the effect of FDI entry on incumbents' productivity growth may depend on the incumbents' distance to productivity frontier. For that I add an interaction term between FDI entry and distance to frontier to the set of explanatory variables. Based on the IV model (Column 4 in Table 2), there appears to be no significant correlation between FDI entry and productivity growth of incumbents regardless of their distance to the local productivity frontier.

[9] Despite the significant differences in estimated coefficients, the IV estimates are not more than one standard error from each other.

Table 2. Effects of FDI entry on TFP growth: fixed effects (FE) model and the second stage of the instrumental variables (2SLS) approach

Domestic firms only:	(1)	(2)	(3)	(4)	(5)
Method:	FE	FE	2-SLS, IV	2-SLS IV	2-SLS IV
Dep. var:	$\Delta\ln TFP_{ijt}$	$\Delta\ln TFP_{ijt}$	$\Delta\ln TFP_{ijt}$	$\Delta\ln TFP_{ijt}$	$\Delta\ln TFP_{ijt}$
FDI $entry_{jt-1}$(E)	-0.062	0.117	-0.107	-0.03	-0.253
	(0.057)	(0.093)	(0.875)	(0.414)	(0.346)
Firm's distance to the productivity $frontier_{ijt-1}$ (D)	0.738***	0.741***	0.743***	0.745***	0.772***
	(0.019)	(0.019)	(0.02)	(0.02)	(0.02)
FDI $entry_{jt-1}$*$Distance_{ijt-1}$ (E*D)		-0.164**		-0.218	
		(0.082)		(0.324)	
$Size_{ijt-1}$	0.068***	0.068***	0.072***	0.065***	0.065***
	(0.021)	(0.021)	(0.021)	(0.23)	(0.022)
Herfindahl-$index_{jt-1}$	-0.042	-0.036	-0.05	-0.059	-0.059
	(0.046)	(0.065)	(0.068)	(0.075)	(0.076)
$Import_{jt-1}$	-0.194***	-0.197***	-0.158*	-0.143*	-0.145*
	(0.072)	(0.072)	(0.079)	(0.079)	(0.079)
Year dummies	Yes	Yes	Yes	Yes	Yes
Instrumented terms	No	No	E	E, E*D	E
Firm effects	Yes	Yes	Yes	Yes	Yes
Type of instruments	-	-	FDI $entry_{jt-1}$ in Hungary	FDI $entry_{jt-1}$ in 5 CEE countries	FDI $entry_{jt-1}$ in 5 CEE countries
Number of obs.	10975	10975	10366	10366	10366
R^2	0.33	0.33	0.34	0.34	0.34
Hansen χ^2 test of overidentifying restrictions			-	1.249 (p=0.87)	*1.855 (p=0.76)*

Note: FE- fixed effects. Robust standard errors in parentheses. Methods: FE, 2SLS-IV. TFP is estimated with the Levinsohn-Petrin (2003) method in order to account for the endogeneity of inputs, allowing the coefficients of inputs to differ in each 2-digit sector. Period: 1995-2004. FDI entry and the productivity frontier are calculated at 3-digit NACE sector level. Population of domestic-owned firms, Estonia's manufacturing industry. The test statistic of Hansen J test, a test of overidentifying restrictions, has value 1.249 in Column 4 and 1.855 in Column 5. This means that we cannot reject the null hypothesis that the overidentifying restrictions are valid.

The finding of no short-term effects on productivity growth, and no role for distance of incumbents to the productivity frontier, does not confirm the theoretical predictions from the FDI spillover literature and from the endogenous growth model by Aghion *et al*. (2009). However, the general finding of no horizontal productivity spillovers is consistent with some earlier papers from CEE transition economies. Often, no significant correlation between FDI presence in a sector and productivity of domestic-owned firms is found in these papers (Damijan *et al*. 2003, Vahter and Masso 2007, etc).

The coefficients of other controls in Equation (1) deserve attention as well. Somewhat similarly to Bartelsman *et al*. (2008), we find also in Estonia that the domestic-owned firms that are below the local productivity frontier tend to grow faster than other domestic owned firms. This is an important result which deserves more detailed future study. It shows that there is productivity convergence taking place within sectors in Estonia towards the local productivity frontier. However, the convergence to a local productivity frontier need not imply convergence to the world productivity frontier.[10] [11]

Another firm level control, size of the firm (as measured by log of number of employees) is positively correlated with the growth rate of productivity.

[10] This has been recently demonstrated based on UK establishment level data in Bartelsman *et al*. (2008).

[11] As a robustness test I have tried to allow for potential endogeneity of the distance to the productivity frontier. The instrumental variable tried was the 3-digit industry level average intangible assets per employee in Sweden and Finland. Data of Sweden and Finland are chosen because they are the main donors of FDI in Estonia. About 55 per cent of FDI in Estonia comes from these two countries. Also, many industries in both of these countries are on the global technology frontier (Bartelsman *et al*. 2008). The instrument could be expected to be related to the productivity of Finnish and Swedish firms and their affiliates in Estonia. That way they could affect also the productivity frontier in each 3-digit sector in Estonia, and each domestic firm's distance to the productivity frontier. Also, these variables are not likely to have direct effect on productivity growth of Estonia's domestic-owned firm

Unfortunately, the instrument tried is only weakly correlated with distance to productivity frontier in Estonia. It turns out to be a weak instrument, and explains only a very small part of variation of 'distance to the productivity frontier'.

A standard prediction from theory is that FDI spillovers are stronger if the foreign owned firms are geographically close to the domestic enterprises (e.g. Jaffe *et al*. 1993). Therefore, Equation (1) was also estimated also based on region (county) level FDI entry variables. Still, there was no significant correlation between the FDI entry within the local geographical region and productivity growth of incumbents of the same region.

The fact that effects of FDI do not show up easily in productivity of incumbent firms in transition countries like Estonia, that have attracted a lot of FDI and (until 2008) have had very high output growth rates, is puzzling. It suggests that we should look more into the channels of these effects. The lack of significant association between productivity growth and lagged FDI entry need not mean that there are no spillover effects of FDI at all. The effects on productivity may simply need more time to occur. At first, the FDI may affect other variables like investments in R&D and assets, innovation, capital intensity, and survival of domestic owned firms.

Aghion *et al*. (2009) finds, using a similar empirical specification, that there are positive short term effects of FDI entry on productivity of incumbents in UK. But there appear to be no such effects in Estonia. This difference may have to do with the country-level difference in the absorptive capacity of incumbent firms. In UK the incumbent firms are not as different from the foreign owned firms than the incumbents in Estonia and other transition economies. Based on existing empirical literature we can conclude that gap between productivity and technology of foreign owned firms and domestic owned firms is much larger in transition economies than in Western European economies (see e.g. Bellak 2004, Damijan *et al*. 2003). Therefore, learning from foreign owned firms may be easier and take less time for domestic firms in Western Europe.

However, this does not explain why the (lack of) effects on productivity of incumbents in Estonia do not depend on firm's distance to the local technology frontier. Here the explanation could be that distance to the local productivity frontier may not be the best proxy for absorptive capacity of firms. What might matter more are the actual interactions of domestic firms with foreign owned firms: supplying goods and buying inputs from them[12]; personal contacts through trade organizations, etc. It is difficult to measure these interactions. For that, survey data may be a useful alternative to the standard firm-level datasets.

If we turn our attention to the relationship between FDI entry and innovation, then indeed there are some significant correlations. I find positive significant correlation of lagged FDI entry with process innovation activities of incumbents (see Table 3). This result can be both due to the competition effects of FDI on innovation incentives and knowledge transfer to domestic firms (i.e. imitation, not innovation, see Brambilla *et al.* 2009).

According to Table 3, an increase in FDI share in a sector by 10 percentage points increases the propensity of an incumbent firm in the same sector to engage in process innovation by 3-4 per cent. At the same time, there is no evidence of significant effects on product innovation.

[12] Often input-output tables are used in examining the spillovers through vertical interactions with suppliers and buyers. Unfortunately, the input-output tables may not be always suitable for study of these buyer-supplier interactions in transition economies. In these countries often the input-output tables are available only at relative aggregate sector levels. Most of vertical interactions between firms take place at less aggregated levels (e.g. between sectors defined at 4-digit NACE level). Also, only few input-output tables are available for the whole period studied. Hence, one has to assume that input-output relationships do not change over time. This assumption is plausible in Western European countries, but is less plausible in transition countries, where the changes in buyer-supplier relations are more frequent.

Table 3. Correlation between FDI entry and innovation

Domestic firms only, panel of CIS3 and CIS4:	(1)	(2)	(3)	(4)
Method:	Bivariate probit	Bivariate probit	Bivariate probit	Bivariate probit
Dep. var.:	Pr(product innovation$_{ijt}$=1)	Pr(process innovation$_{ijt}$=1)	Pr(product innovation$_{ijt}$=1)	Pr(process innovation$_{ijt}$=1)
FDI entry$_{jt-1}$	0.169	0.318***	0.211	0.406**
	(0.107)	(0.108)	(0.172)	(0.163)
Distance to the productivity frontier$_{ijt-1}$	-0.05**	-0.06**	-0.048*	-0.056**
	(0.023)	(0.022)	(0.022)	(0.022)
FDI entry$_{jt-1}$*Distance$_{ijt-1}$			-0.038	-0.09
			(0.118)	(0.111)
Size of the firm$_{ijt-1}$	0.079***	0.094***	0.079***	0.094***
	(0.014)	(0.014)	(0.015)	(0.014)
Sector, region, and period dummies	Yes	Yes	Yes	Yes
Number of obs.	1000	1000	1000	1000
Log likelihood	-920.5	-920.5	-529.7	-529.7

Note: domestic-owned firms in the manufacturing industry. Estimation by bivariate probit, marginal effects reported (at sample means). All specifications include lagged import intensity of each 3-digit sector and Herfindahl index. Two innovation surveys (CIS3 and CIS4) are included, i.e. panel of two time periods (1998-2000 and 2002-2004) is used in this estimation. Dependent variable in the bivariate probit model is equal to 1 if the firm engages in i) product or ii) process innovation. Stata command *inteff* (developed by Ai and Norton 2003) is used in order to calculate the marginal effect of the interaction term.

A potential explanation to this difference can be that knowledge that helps a firm to improve its production process can spill over from foreign owned firms to incumbents more easily than product-specific knowledge. Information that helps to improve the production process can be used and combined with local knowledge even in firms that are very different from the foreign owned firms and produce substantially different products.

Notably, the 'effect' of FDI entry on incumbent's innovation activities does not depend on incumbent's distance to the technology frontier. This is different from the predictions and findings of Aghion *et al*. (2009) based on the UK data. This is also different from the view of Glass and Saggi (1998) that FDI spillovers depend on the

absorptive capacity of local firms, as measured by firm's distance to the productivity frontier.

FDI entry could be resulting in knowledge flows to the incumbent firms. As we can see from the probit model in Table 4 there is significant and positive association of FDI entry with importance of different types of knowledge flows for incumbent firms in the following years after FDI entry. The dependent variable is in this Table either equal to 1 or 0: it is equal to 1 if the corresponding source of knowledge (e.g. knowledge sourcing from suppliers) is of high importance for the firm, it is 0 otherwise.

Table 4. Correlation between FDI entry and direct indicators of knowledge flows to the domestic firms

Domestic firms only, panel of CIS3 and CIS4:	(1)	(2)	(3)	(4)
Method:	Probit	Probit	Probit	Probit
Dep.var.:	Knowledge sourcing from Competitors	Knowledge sourcing from Suppliers	Knowledge sourcing from Clients	Knowledge sourcing from within own corporation
$FDI\ entry_{jt-1}$	0.017	0.171***	0.07	0.227***
	(0.034)	(0.06)	(0.064)	(0.07)
$Distance\ to\ the\ frontier_{ijt-1}$	-0.009	-0.06***	-0.032**	-0.043**
	(0.009)	(0.013)	(0.014)	(0.016)
$Size_{ijt-1}$	0.015***	0.022**	0.016**	0.042***
	(0.006)	(0.009)	(0.009)	(0.01)
Sector, region, and period dummies	Yes	Yes	Yes	Yes
Number of obs.	907	907	907	907
Log likelihood	-145	-261.5	-258.5	-322.4

Note: domestic-owned firms in the manufacturing industry. Estimation by probit, marginal effects reported (at sample means). Two innovation surveys are included (CIS3 and CIS4), i.e. panel of two time periods (1998-2000 and 2002-2004) is used in this estimation. The dependent variable is equal to 1, if the corresponding type of knowledge sourcing is of high importance for the firm.

However, the CIS questionnaire provides significantly more detailed answer choices. There are 4 different ordered answer choices about the importance of each type of knowledge flows. Therefore, in order to use the variation in data in more detail, also an

ordered probit model is estimated. The corresponding marginal effects are reported separately for each of the 4 possible answer choices in Annex 2. There the dependent variable is equal to 0, if a particular type of knowledge sourcing (from suppliers, clients, or competitors) is 'not used', it is 1 if it is of 'low importance', 2 if it is of 'medium importance', 3 if it is of 'high importance' for the incumbent firm.

Due to the nature of the CIS data, there is a sample selection problem in estimating the effects of FDI on knowledge flows. The respondents to the questionnaire may say that they do not use the knowledge source in their existing innovation process (i.e. their answer choice is "0"), but they may also choose the same answer choice simply because they do not engage in innovation at all. The analysis would need to distinguish between firms that engage in innovation (and thus choose their knowledge sources in innovation process), and firms that do not engage in innovation at all. A way to account for this problem by using a selection model has been outlined for example by Piga and Vivarelli (2004). Not accounting for this issue may result in biased estimates of the FDI spillovers. The results of a selection model that adjusts the findings for the presence of sample selection bias are presented in Annex 3.

The 1st stage of the selection model estimates the probability that the firm engages in innovation activities. The second stage estimates ordered probit model, using data of only these firms that engage in innovation, and using the inverse of Mill's ratio from the 1st stage as an additional control to account for selection bias. As evident from results in Annex 3, the size and significance of the estimated effects is affected by use of the sample selection model and smaller sample of only innovative firms. The sample selection model yields smaller estimates of the effects of FDI, yet these are broadly similar results to the standard IV version of the ordered probit model in Annex 2.

The marginal effects in Annex 2 and 3 show that there is positive association of FDI entry with the intensity of knowledge sourcing in the following periods. We find statistically significant robust positive association in the case of knowledge flows from suppliers and from within the corporation itself.

Based on these results (Annex 2 and 3) we can calculate, for example, that an increase in FDI share in the employment of a sector by 50 percentage points results in about 13 - 24 percent subsequent increase in the likelihood that knowledge flows from incumbent's suppliers are 'highly important' for its innovation activities. Also, FDI entry in a sector lowers the probability that knowledge sourcing from suppliers and from within own corporation is 'not used' in the innovation process of the incumbent firm. The entry of FDI has been instrumented here with entry rates elsewhere in the CEE.[13]

My findings about the knowledge flows are related to a study by Crespi *et al*. (2008) based on UK. They find that FDI share in a sector is positively correlated with knowledge sourcing of UK local firms from their competitors, but they do not find significant association in the case of learning from other sources.

In addition to innovation and learning from other firms, the FDI entry might also affect innovation related formal co-operation between firms. Still, this is not the case in Estonia (see Table 5).

[13] The estimation is performed in Stata with the command *cmp*. It is developed by David Roodman (2009) and it enables to estimate also an IV version of the ordered probit model.

Table 5. Correlation between FDI entry and indicators of innovation related co-operation with competitors, suppliers and clients

Domestic firms only, panel of CIS3 and CIS4:	(1)	(2)	(3)
Method:	Probit	Probit	Probit
Dep.var.:	Innovation related co-operation with Competitors	Innovation related co-operation with Suppliers	Innovation related co-operation with Clients
FDI entry$_{jt-1}$	0.073	0.012	0.086
	(0.05)	(0.046)	(0.078)
Distance to the frontier$_{ijt-1}$	-0.01	-0.02*	-0.017
	(0.1)	(0.011)	(0.012)
Size $_{ijt-1}$	0.009*	0.023***	0.021***
	(0.005)	(0.007)	(0.008)
Sector, region, and period dummies	Yes	Yes	Yes
Number of obs.	907	907	907
Log likelihood	-163.7	-207.2	-216.3

Note: domestic-owned firms in the manufacturing industry. Estimation by probit, marginal effects reported (at sample means). The dependent variable is equal to 1, if the corresponding type of innovation-related co-operation is of medium or high importance for the firm.

It appears that FDI entry is not significantly correlated with indicators of incumbents' innovation-related co-operation arrangements with other firms. This is not very surprising. Informal knowledge flows are likely to work faster in spreading the knowledge from foreign owned firms to local incumbents in CEE countries. To be considered for innovation related co-operation by MNEs, the incumbents need high levels of expertise and significant own innovation activities.

5 Conclusions

The main contribution of this paper is studying some of the channels of spillover effects of FDI—through effects of FDI on innovation and direct measures of knowledge

transfer. Also, this study tries to account, to an extent, for the endogeneity of FDI spillovers.

I find that the FDI entry in the local industry or region has no short-term effect on local incumbents' productivity growth. However, there is a positive spillover on process innovation. Also, FDI inflow to a sector intensifies knowledge sourcing activities from other firms and from within the incumbent itself. The empirical evidence presented here shows that FDI entry is associated with knowledge flows (spillovers) to incumbent firms. But these spillovers are not reflected in short-term in the productivity growth of incumbents. Effects on productivity may take longer to materialise than implicitly assumed in the standard empirical approach of the literature.

In future, survey evidence about spillovers (e.g. like Spatareanu and Javorcik 2005, Javorcik 2008) can shed more light into the longer-term effects. Also, even if there were no productivity enhancing spillovers, the effect of FDI on productivity in the host economy could still be positive. This is, partly, due to the compositional change in the structure of industries, where more productive foreign owned firms increase their share in employment and sales compared to the domestic firms. Also, FDI entry can toughen the selection process among incumbents, driving firms with low productivity out of the market and reallocating market shares and resources towards more productive firms (e.g. as implied by recent heterogeneous producer models of competition and trade: Syverson 2004, Melitz and Ottaviano 2008). This selection effect could increase the average productivity of local industries in the host economy, even if there are no positive spillovers on productivity growth within incumbent firms.

References

Acemoglu, D., Aghion, P. and Zilibotti, F. (2006), "Distance to Frontier, Selection, and Economic Growth." *Journal of the European Economic Association* 4(1): 37–74.

Aghion, P., Blundell, R., Griffith, R., Howitt, P. and Prantl, S. (2009), "The Effects of Entry on Incumbent Innovation and Productivity." *The Review of Economics and Statistics* 91(1): 20–32.

Ai, C. and Norton, E. C. (2003), "Interaction terms in logit and probit models." *Economics Letters* 80, 123-129.

Aitken, B. J., and Harrison, A. E. (1999), "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela." *American Economic Review* 89 (3): 605–618.

Angrist, J. and Pischke, J. (2009), Mostly Harmless Econometrics. An Empiricist's Companion. Princeton University Press, 373 p.

Barba Navaretti, G., and A. J. Venables with Barry, F.G., Ekholm, K., Falzoni, A. M., Haaland, J. I., Midelfart, K. H. and A. Turrini (2004), Multinational firms in the world economy. Princeton University Press.

Barrios, S., Görg, H. and Strobl, E. (2009), Spillovers through Backward Linkages from Multinationals: Measurement Matters! IZA Discussion Paper 4477, October 2009.

Bartelsman, E. J., Haskel, J. and Martin, R. (2008), Distance to Which Frontier? Evidence on Productivity Convergence from International Firm-Level Data .CEPR Discussion Paper No. DP7032.

Bellak, C. (2004), "How Domestic and Foreign Firms Differ and Why Does it Matter?" *Journal of Economic Surveys* 18(4): 483–514.

Bertschek, I. (1995), "Product and Process Innovation as a Response to Increasing Imports and Foreign Direct Investment." *Journal of Industrial Economics* 43, 341–357.

Blind, K. and Jungmittag, A. (2004), "Foreign direct investment, imports and innovations in the service industry." *Review of Industrial Organization* 25, 205–227.

Blomström, M. and Kokko, A. (2002), "Multinational Corporations and Spillovers." *Journal of Economic Surveys* 12 (2), 1–31.

Brambilla, I., Hale, G. and Long, C. (2009) "Foreign Direct Investment and the Incentives to Innovate and Imitate." *Scandinavian Journal of Economics* 111(4), 835–861.

Crespi, G., Criscuolo, C., Haskel, J. and Slaughter, M. J. (2008), "Productivity Growth, Knowledge Flows, and Spillovers." NBER Working Paper No. W13959.

Crespo, N., Fontoura, M. P., and Proença, I. (2009), "FDI spillovers at regional level: Evidence from Portugal." *Papers in Regional Science* 88(3), 591–607.

Damijan, J. P. and Knell, M. (2005), **"**How Important Is Trade and Foreign Ownership in Closing the Technology Gap? Evidence from Estonia and Slovenia." *Review of World Economics* 141(2), 271–295.

Damijan, J. P., Knell, M., Majcen, B. and Rojec, M. (2003), "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(2), 189–204.

Girma, S., Gong, Y. and Görg, H. (2006), Can You Teach Old Dragons New Tricks? FDI and Innovation Activity in Chinese State-Owned Enterprises, No 2267, IZA Discussion Papers.

Glass, A. and Saggi, K. (1998), "International Technology Transfer and the Technology Gap." *Journal of Development Economics* 55, 369–398.

Görg, H. and Greenaway, D. (2004), "Much Ado about Nothing? Do Domestic Firms Really Benefit from Foreign Direct Investment?" *World Bank Research Observer* 19(2), 171–197.

Görg, H. and Strobl, E. (2001), "Multinational Companies and Productivity Spillovers: A Meta-Analysis." *The Economic Journal* 111 (475): 723–739.

Görg, H. and Strobl, E. (2005), "Spillovers from Foreign Firms through Worker Mobility: An Empirical Investigation," *Scandinavian Journal of Economics* 107(4), 693–709

Griffith, R., E. Huergo, J. Mairesse, and B. Peters (2006), "Innovation and Productivity across Four European Countries." *Oxford Review of Economic Policy* 22, 483–498.

Halpern, L. and Muraközy, B. (2007), "Does distance matter in spillover?" *The Economics of Transition* 15, 781–805.

Haskel, J. E., S. C. Pereira, and Slaughter M. J. (2007), "Does Inward Foreign Direct Investment Boost the Productivity of Domestic Firms?" *The Review of Economics and Statistics* 89(3), 482–496.

Jaffe, A., Trajtenberg, M., and Henderson, R. (1993), "Geographic localization of knowledge spillovers as evidenced by patent citations." *Quarterly Journal of Economics* 108, 577–598.

Javorcik, B. (2008), "Can Survey Evidence Shed Light on Spillovers from Foreign Direct Investment?" *World Bank Research Observer* 23(2), 139–159.

Javorcik, B. (2004), “Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages.” *American Economic Review* 94 (3), 605–627.

Levinsohn, J. and Petrin, A. (2003), “Estimating Production Functions Using Inputs to Control for Unobservables.” *Review of Economic Studies* 70 (2), 317–341.

Melitz, M. and Ottaviano, G. (2008), "Market Size, Trade, and Productivity." *Review of Economic Studies* 75(1), 295–316.

Murray, M., (2006), "Avoiding Invalid Instruments and Coping with Weak Instruments." *Journal of Economic Perspectives* 20(4), 111–132.

Muraközy, B. (2007), "Do Vertical Spillovers from FDI Lead to Changes in Markups? Firm-level Evidence from Hungary." *Applied Economics Quarterly* 53(2), 197–218.

National accounts of Estonia: yearbook., 2003. Tallinn, Statistical Office of Estonia.

Piga, C. A. and Vivarelli, M. (2004), "Internal and External R&D: A Sample Selection Approach," *Oxford Bulletin of Economics and Statistics* 66(4), 457-482.

Roodman, D. (2009), "Estimating Fully Observed Recursive Mixed-Process Models with cmp," Working Papers 168, Center for Global Development.

Sinani, E. and Meyer, K. (2004), “Spillovers of technology transfer from FDI: the case of Estonia.” *Journal of Comparative Economics* 32 (3), 445–466.

Spatareanu, M. and Javorcik, B. (2005), Disentangling FDI Spillovers Effects: What Do Firm Perceptions Tell Us?” In **M. Blomström, E. Graham and T. Moran, eds.**, Does Foreign Direct Investment Promote Development?, Institute for International Economics, Washington.

Stock, J., Wright, J. and Yogo, M. (2002), "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments." *Journal of Business and Economic Statistics* 20(4), 518–529

Stock, J. H. and Yogo, M. (2005), Testing for Weak Instruments in Linear IV Regression. **In D.W.K. Andrews and J.H. Stock, eds.** Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg. Cambridge: Cambridge University Press, 2005, 80–108.

Suyanto, Salim, R. and Bloch, H. (2009), "Does Foreign Direct Investment Lead to Productivity Spillovers? Firm Level Evidence from Indonesia." *World Development* 37(12), 1861-1876.

Syverson, C., (2004), "Market Structure and Productivity: A Concrete Example." *Journal of Political Economy* 112(6), 1181–1222.

Terk, E., Viia, A., Lumiste, R. and Heinlo, A. (2007), "Innovation in Estonian Enterprises. Estonian results of the Fourth Community Innovation Survey (CIS4)", Tallinn. Enterprise Estonia.

Vahter, P. (2005). "An Econometric Study of Estonia and Slovenia: The Effect of FDI on Labour Productivity." In **Stephan, J. (ed.)** Technology Transfer via Foreign Direct Investment in Central and Eastern Europe – Theory, Method of Research and Empirical Evidence. Palgrave/Macmillan, pp. 96–125.

Vahter, P. and Masso, J. (2007), "Home versus Host Country Effects of FDI: Searching for New Evidence of Productivity Spillovers." *Applied Economics Quarterly* 53(2), 165–196.

World Investment Report 2009. (2009). New York and Geneva: United Nations, UNCTAD.

Annex 1: Descriptive statistics

Table A1. Descriptive statistics: domestic firms in Estonia's manufacturing industry

Variable	Mean	Std. Dev.
ΔLn(TFP)	0.049	0.652
ΔLn(Value added per employee)	0.08	0.664
Ln(TFP)	9.108	1.385
Ln(Value added per employee)	10.962	1.019
Ln(Capital)	11.794	2.274
Distance to TFP frontier (in log)	1.107	0.885
Distance to labour productivity frontier (in log)	1.149	0.881
Import orientation (3-digit)	0.409	0.303
Ln (Size)	2.288	1.377
Herfindahl index (3-digit)	0.124	0.152
FDI $entry_{jt-1}$ in Estonia(3-digit)	0.014	0.135
FDI $entry_{jt-1}$ in Hungary (3-digit)	0.002	0.075
FDI $entry_{jt-1}$ in Czech Republic (3-digit)	0.053	0.138
FDI $entry_{jt-1}$ in Latvia (3-digit)	0.021	0.208
FDI $entry_{jt-1}$ in Poland (3-digit)	0.025	0.123
FDI $entry_{jt-1}$ in Slovakia (3-digit)	0.005	0.092
FDI $share_{jt-1}$ in employment in Estonia (3-digit)	0.182	0.165
FDI $share_{jt-1}$ in employment in Hungary (3-digit)	0.296	0.163
FDI $share_{jt-1}$ in employment in Czech Republic (3-digit)	0.278	0.224
FDI $share_{jt-1}$ in employment in Latvia (3-digit)	0.179	0.233
FDI $share_{jt-1}$ in employment in Poland (3-digit)	0.216	0.164
FDI $share_{jt-1}$ in employment in Slovakia (3-digit)	0.04	0.126

Period: 1995-2004. Data sources: Business Register data of all manufacturing firms in Estonia; Amadeus database of Bureau van Dijk.

Table A2. Basic facts about manufacturing firms in the Business Register's dataset

Year	Number of domestic-owned firms	Share of foreign-owned firms in employment
1995	2,761	0.16
2000	4,768	0.28
2004	4,885	0.32

Note: FDI share is calculated based on firms with majority foreign ownership.

Table A3. CIS3 and CIS4 innovation surveys: summary statistics

Variable name	Variable definition	CIS3		CIS4	
		Mean	Std. Dev.	Mean	Std. Dev.
Innovation/knowledge variables					
Product innovation	Dummy, 1 if firm reports having introduced new or significantly improved product	0.26	0.44	0.21	0.41
Process innovation	Dummy, 1 if firm reports having introduced new or significantly improved production process	0.22	0.41	0.19	0.4
ln(Value added/employees)	Value added per employees	11.09	0.81	11.31	0.79
Knowledge flow variables					
Sources of innovation related knowledge within the firm or other firms within the group	Dummy, 1 if information from internal sources within the firm or group was of high importance	0.13	0.33	0.15	0.36
From Competitors	Dummy, 1 if information from competitors and other firms from the same industry was of high importance	0.03	0.18	0.05	0.2
From Customers	Dummy, 1 if information from clients or customers was of high importance	0.08	0.27	0.14	0.35
From Supplier	Dummy, 1 if information from suppliers of equipment, materials, components or software was of high importance	0.08	0.28	0.14	0.34
Innovation cooperation					
Other enterprises within the group	Dummy, 1 if firm had any cooperation arrangements on innovation activities with other enterprises within the corporation	0.04	0.19	0.04	0.2
Suppliers	Dummy, 1 if firm had any cooperation arrangements on innovation activities with suppliers of equipment, materials, components or software was of high importance	0.08	0.28	0.12	0.33
Customers	Dummy, 1 if firm had any cooperation arrangements on innovation activities with clients or customers	0.08	0.28	0.11	0.32
Competitors	Dummy, 1 if firm had any cooperation arrangements on innovation activities with competitors	0.05	0.21	0.07	0.25

Note: domestic-owned firms from manufacturing industry only. The number of domestic-owned manufacturing firms is 1,185 in CIS3 and 1,264 in CIS4 survey.

Annex 2: IV version of the ordered probit model

Table A4. Knowledge sourcing from competitors: marginal effects for different answer choices

Domestic firms only, panel of CIS3 and CIS4: Method: IV-ordered probit	(1)	(2)	(3)	(4)
Answer choice:	Not used	Low importance	Medium importance	High importance
FDI entry$_{jt-1}$ (E)	-0.92***	0.151***	0.566***	0.353**
	(0.395)	(0.045)	(0.182)	(0.167)
Sector, region, and period dummies	Yes	Yes	Yes	Yes
Number of obs.	915			
Log likelihood	-374			

Note: Estimation by ordered probit, marginal effects reported. Instrumented terms: E. Instrumental variables used: FDI entry$_{jt-1}$ in 5 CEE countries. Two survey waves included (CIS3 and CIS4), i.e. panel of two time periods (1998-2000 and 2002-2004) is used. The other controls included also firm's size and its distance to the local productivity frontier.

Table A5. Knowledge sourcing from suppliers: marginal effects for different answer choices

Domestic firms only, panel of CIS3 and CIS4: Method: IV-ordered probit	(1)	(2)	(3)	(4)
Answer choice:	Not used	Low importance	Medium importance	High importance
FDI entry$_{jt-1}$ (E)	-0.717**	0.015	0.309**	0.392**
	(0.306)	(0.017)	(0.13)	(0.175)
Sector and region dummies	Yes	Yes	Yes	Yes
Number of obs.	915			
Log likelihood	-336			

Note: Estimation by ordered probit, marginal effects reported. Instrumented terms: E. Instrumental variables used: FDI entry$_{jt-1}$ in 5 CEE countries. Two survey waves included (CIS3 and CIS4), i.e. panel of two time periods (1998-2000 and 2002-2004) is used. The other controls included also firm's size and its distance to the local productivity frontier.

Table A6. Knowledge sourcing from clients: marginal effects for different answer choices

Domestic firms only, panel of CIS3 and CIS4: Method: IV-ordered probit	(1)	(2)	(3)	(4)
Answer choice:	Not used	Low importance	Medium importance	High importance
FDI entry$_{jt-1}$ (E)	-0.344	-0.014	0.131	0.2
	(0.284)	(0.015)	(0.109)	(0.165)
Sector, region, and period dummies	Yes	Yes	Yes	Yes
Number of obs.	915			
Log likelihood	-291			

Note: Estimation by ordered probit, marginal effects reported. Instrumented terms: E. Instrumental variables used: FDI entry$_{jt-1}$ in 5 CEE countries. Two survey waves included (CIS3 and CIS4), i.e. panel of two time periods (1998-2000 and 2002-2004) is used. The other controls included also firm's size and its distance to the local productivity frontier.

Table A7. Knowledge sourcing from within the same corporation: marginal effects for different answer choices

Domestic firms only, panel of CIS3 and CIS4: Method: IV-ordered probit	(1)	(2)	(3)	(4)
Answer choice:	Not used	Low importance	Medium importance	High importance
FDI entry$_{jt-1}$ (E)	-0.606**	0.006	0.227**	0.373**
	(0.307)	(0.006)	(0.114)	(0.192)
Sector, region, and period dummies	Yes	Yes	Yes	Yes
Number of obs.	915			
Log likelihood	-304			

Note: Estimation by ordered probit, marginal effects reported. Instrumented terms: E. Instrumental variables used: FDI entry$_{jt-1}$ in 5 CEE countries. Two survey waves included (CIS3 and CIS4), i.e. panel of two time periods (1998-2000 and 2002-2004) is used. The other controls included also firm's size and its distance to the local productivity frontier.

Annex 3: Selection model: FDI and knowledge sourcing by incumbent firms

Table A8. First stage of the 2-stage selection model

Domestic firms only, panel of CIS3 and CIS4:	
Method:	Probit
Dep. var.:	Pr(Innovation=1)
FDI entry$_{jt-1}$	0.244**
	(0.122)
Distance to the productivity frontier$_{ijt-1}$	-0.078***
	(0.027)
Size of the firm$_{ijt-1}$	0.108***
	(0.018)
Sector, region and period dummies	Yes
Number of obs.	1000
Log likelihood	-553.2

Note: domestic-owned firms in the manufacturing industry. All domestic firms, not only the ones that engage in innovation. Estimation by probit, marginal effects reported (at sample means). Lagged import intensity and Herfindahl index of each 3-digit sector are included as controls. Two innovation surveys (CIS3 and CIS4) are included, i.e. panel of two time periods (1998-2000 and 2002-2004) is used in this estimation. Dependent variable in the probit model is equal to 1 if the firm engages in (product or process) innovation.

Table A9. Knowledge sourcing from competitors: marginal effects for different answer choices

Domestic firms only, panel of CIS3 and CIS4:	(1)	(2)	(3)	(4)
Method: IV-ordered probit				
Answer choice:	Not used	Low importance	Medium importance	High importance
FDI entry$_{jt-1}$ (E)	-0.122	0.013	0.078	0.058
	(0.146)	(0.017)	(0.093)	(0.07)
Sector, region, and period dummies	Yes	Yes	Yes	Yes
Number of obs.	357			
Log likelihood	-447			

Note: Only these domestic firms that engage in innovation. Estimation by ordered probit, marginal effects reported. Two survey waves included (CIS3 and CIS4), i.e. panel of two time periods (1998-2000 and 2002-2004) is used. Other controls included also firm's distance to the local productivity frontier, and the inverse of Mill's ratio from the 1st stage of the selection model.

Table A10. Knowledge sourcing from suppliers: marginal effects for different answer choices

Domestic firms only, panel of CIS3 and CIS4: Method: IV-ordered probit	(1)	(2)	(3)	(4)
Answer choice:	Not used	Low importance	Medium importance	High importance
FDI entry$_{jt-1}$ (E)	-0.222**	-0.051	0.05	0.225*
	(0.13)	(0.031)	(0.033)	(0.131)
Sector, region, and period dummies	Yes	Yes	Yes	Yes
Number of obs.	357			
Log likelihood	-447			

Note: Only these domestic firms that engage in innovation. Estimation by ordered probit, marginal effects reported. Two survey waves included (CIS3 and CIS4), i.e. panel of two time periods (1998-2000 and 2002-2004) is used. Other controls included also firm's distance to the local productivity frontier, and the inverse of Mill's ratio from the 1st stage of the selection model.

Table A11. Knowledge sourcing from clients: marginal effects for different answer choices

Domestic firms only, panel of CIS3 and CIS4: Method: IV-ordered probit	(1)	(2)	(3)	(4)
Answer choice:	Not used	Low importance	Medium importance	High importance
FDI entry$_{jt-1}$ (E)	-0.142	-0.035	0.036	0.142
	(0.128)	(0.033)	(0.034)	(0.128)
Sector, region, and period dummies	Yes	Yes	Yes	Yes
Number of obs.	357			
Log likelihood	-471			

Note: Only these domestic firms that engage in innovation. Estimation by ordered probit, marginal effects reported. Two survey waves included (CIS3 and CIS4), i.e. panel of two time periods (1998-2000 and 2002-2004) is used. Other controls included also firm's distance to the local productivity frontier, and the inverse of Mill's ratio from the 1st stage of the selection model.

Table A12. Knowledge sourcing from within the same corporation: marginal effects for different answer choices

Domestic firms only, panel of CIS3 and CIS4: Method: IV-ordered probit	(1)	(2)	(3)	(4)
Answer choice:	Not used	Low importance	Medium importance	High importance
FDI entry$_{jt-1}$ (E)	-0.229*	-0.053	0.002	0.28*
	(0.121)	(0.029)	(0.018)	(0.148)
Sector, region, and period dummies	Yes	Yes	Yes	Yes
Number of obs.	357			
Log likelihood	-438			

Note: Only these domestic firms that engage in innovation. Estimation by ordered probit, marginal effects reported. Two survey waves included (CIS3 and CIS4), i.e. panel of two time periods (1998-2000 and 2002-2004) is used. Other controls included also firm's distance to the local productivity frontier, and the inverse of Mill's ratio from the 1st stage of the selection model.