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DOES FDI SPUR INNOVATION, PRODUCTIVITY AND KNOWLEDGE SOURCING BY INCUMBENT FIRMS? EVIDENCE FROM MANUFACTURING INDUSTRY IN ESTONIA

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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, productivity growth, and knowledge sourcing activities of domestic firms? This study employs detailed firm-level panel-data from Estonia's manufacturing sector to investigate different channels through which FDI can affect domestic firms. Instrumental variables approach is used to identify the effects. There is no evidence of an effect of FDI entry on local incumbents' TFP and labour productivity growth in the short term.. However, there are positive spillovers on process innovation. These effects do not depend on the local firms' distance to the productivity frontier. The results show significant positive correlation between the entry of FDI in a sector and the more direct measures of spillovers in subsequent periods. This is consistent with the view that FDI inflow to a sector intensifies knowledge flows to domestic firms.

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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. Using instrumental variable (IV) regression approach to identify the effects, this paper investigates the association of FDI entry in Estonia with incumbents' total factor productivity (TFP) and labour productivity growth; innovation activities; and indicators of importance of knowledge flows from suppliers, clients and competitors of the incumbent firm. This study also checks for heterogeneity of these effects, whether they depend on local incumbents' distance to the technology frontier, as suggested by Aghion *et al.* (2009).

Most of the earlier literature investigates 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

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

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) 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 effects.

The effects of FDI entry on within-firm productivity growth of domestic firms can function through technology transfer and through an increase in toughness of competition. This paper employs detailed firm level data from Estonia, covering all manufacturing firms during 1995-2004. Estonia is a good case study for the effects of FDI, as it has been 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). Moreover, the 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), we 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 this paper 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). This paper employs 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-Petrin method to account for endogeneity of inputs in the production function), labour productivity (value added per employee) or 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. In some specifications these other controls include incumbents' distance to the local productivity frontier and an interaction term between distance to productivity frontier and FDI entry.

Based on Schumpeterian competition models outlined in Acemoglu *et al.* (2006) or Aghion *et al.* (2009) one could expect that an increase in entry of technologically advanced firms (e.g. multinational enterprises) has positive effects on incumbents' performance, innovation incentives and innovation activities if the incumbents are sufficiently close to the productivity frontier.[3] It could be also expected that if incumbents are far from the productivity frontier of the sector then entry of multinational enterprises (MNEs) will reduce innovation incentives of these firms and thereby have negative effect on their productivity growth.[4]

However, this paper gives no empirical support for these predictions. There is no significant effect of lagged entry of foreign owned firms on TFP or labour productivity growth of incumbent firms, regardless of their distance to the productivity frontier or geographical proximity to MNEs.

[3] According to Aghion *et al.* (2009) there may be positive effects on innovation of these high-productivity firms as they can escape adverse entry effects by innovating.

[4] Increasing frontier entry could reduce incumbents' innovation incentives if they are far from the technology frontier, as they have little hope of surviving the entry.

There are some positive correlations in the case of innovation activities. There is a positive association between the FDI entry rate in an industry and incumbents' probability of engaging in process innovation. There is no such significant correlation of FDI entry with product innovation or innovation-related co-operation.
One important question is whether these results can be seen as spillover effects? Analysis of probit and ordered probit models based on Estonian CIS[5] innovation surveys (CIS3 and CIS4) shows that the entry of FDI in 3-digit level sectors is indeed correlated with direct measures of spillovers. This gives support to the interpretation that FDI entry results in spillovers to domestic firms. So far only Crespi *et al*. (2008) have used similar data (from UK) to find out whether the indirect and direct measures of spillovers are correlated.

2. THEORETICAL BACKGROUND AND EMPIRICAL EVIDENCE

The spillovers of FDI on domestic owned firms' productivity and other performance characteristics can work through technology transfer and changes in competition. Detailed overviews of the theoretical background of these effects are provided, for example, in Barba Navaretti and Venables (2004) or Görg and Greenaway (2004).

The main prediction from theoretical literature is that the net impact on local firms in a host economy is ambiguous and may depend a lot on the characteristics of the host country and local firms (Barba Navaretti and Venables 2004). There can be negative effects of FDI entry due to changes in market shares of local firms, positive effects due to changes in incentives of incumbents to effort and to innovate, and positive effects due to technology transfer.

Spillovers are more likely to materialise in the case of incumbents that are located close to the foreign owned firms. But the

[5] CIS - Community Innovation Survey.

predictions from theoretical literature about the role of distance to technology frontier have been mixed. Findlay (1978) argues that the relative backwardness of the host economy may in fact mean more scope for spillover effects from FDI. The larger is the difference in development between the home and host country of FDI, the greater is the pressure and need to adopt new technology. The view of Glass and Saggi (1998) is different. They argue that technology gap between domestic firms and foreign owned ones is related to the absorptive capacity of firms—the ability to adopt new technologies. The larger is the technology gap of domestic firms the lower is the possibility of spillovers. Also, more recent Schumpeterian competition models support this conclusion (see e.g. Aghion and Griffith 2005 for a thorough review of such theoretical studies).

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.

Evidence about spillovers from FDI to domestic firms is, despite the large number of studies, still ambiguous. The focus of research has shifted since 1990s from industry and country level towards firm or plant level studies, and from cross-section to panel data.

There are a several good literature surveys available by now. These include papers by Blomström and Kokko (1996), Görg and Strobl (2001), Görg and Greenaway (2004), Lipsey (2002, 2006), and Barba Navaretti and Venables (2004). The main lesson from the firm-level studies of panel data is that the results are very mixed. Also, most of the papers study correlation between FDI share in a sector and productivity of domestic firms, not the causal effects. Studies that are based on firm or plant level panel data are less likely to find positive significant spillovers than earlier studies that rely on cross-section and industry-level data. In transition economies often insignificant or even negative horizontal spillovers are found (Damijan *et al*. 2003). Researchers tend to find positive spillovers somewhat more often in the case of developed countries (e.g. Haskel *et al*. 2007 for UK).

The framework of analysis is usually based on estimation of the production function. A few exceptions to this approach include survey based evidence, e.g. by Spatareanu and Javorcik (2005). A standard approach has been to estimate an augmented production function with proxies for FDI presence in a sector included among other inputs (e.g. Aitken and Harrison study of Venezuela, 1999).

As an alternative, often the TFP is estimated separately in the 1st stage. Then, in the 2nd stage the TFP is regressed on a number of control variables, including the FDI share in a sector. More recent papers are able to account for endogeneity of capital or labour inputs in the 1st stage, for example by using semiparametric estimation procedures of TFP by Olley and Pakes (1996) or Levinsohn and Petrin (2003). A good and probably the most well known example of such study is by Javorcik (2004).

Neither these 1-step or 2-step estimation approaches are usually able to account for the endogeneity of the spillover variable. FDI is likely to flow to sectors and firms that would have higher productivity and higher productivity growth than others even without FDI inflow. Therefore FDI spillover variable needs to be treated as an endogenous one in the estimation of its effects on TFP or other variables.

A solution is to use instrumental variables approach. For that the researcher needs to find instrumental variable(s) that help to predict the FDI spillover variable, but are otherwise not affecting the (productivity of) domestic firms in the host economy (after controlling for other relevant factors). This way one can induce exogenous variation in the FDI spillover variable, needed for estimating the effects.

Two main related papers that endeavour to estimate the effects of FDI on domestic firms using IV models with external instruments are by Aghion *et al*. (2009) and Haskel *et al*. (2007), both based on UK data. Both find positive effects of FDI presence and FDI entry in a sector.

Aghion *et al*. (2009) investigate in detail the heterogeneity of the effects of FDI. They find that entry of FDI has positive effects on innovation and growth of TFP or labour productivity only for these incumbent firms within the same sector that are not very far from the productivity frontier.

There is an increase in number of papers that try to use dynamic panel data methods like system-GMM approach to investigate the productivity spillovers of FDI. For example, by Barrios *et al*. (2009), Crespo *et al*. (2009), Suyanto *et al.* (2009), Halpern and Muraközy (2005) and Muraközy (2007). However, Roodman (2006, 2007) points out that GMM can easily produce results that are in fact not depleted of endogeneity. Also, the results may vary a lot depending on which lags and differences are used as internal instruments for the explanatory variables.

Another problem with most of the empirical literature is treating the link between FDI and productivity of domestic firms as a 'black box'. Usually, researchers do not attempt to address the channels through which these effects take place. In order to understand how the spillovers of FDI work, a detailed analysis about the channels of these effects is needed: like effects on innovation, work practices, and knowledge flows to domestic firms. So far, very few studies have studied the FDI spillovers on innovation activities of domestic firms. These include Bertschek (1995), Blind and Jungmittag (2006) and Girma *et al.* (2006). 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. However, they do not account for the likely endogeneity of the FDI spillover variable. 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.

Some previous studies have investigated FDI spillovers in Estonia. These include papers by Sinani and Meyer (2004), Damijan and Knell (2005), Vahter and Masso (2007). All of these look at the correlation between FDI share in a sector and the productivity of local firms. They are not able to investigate the causality and account for the endogeneity of FDI spillover variable, or look into the various channels though which the productivity spillovers work. 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 appear to 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. Many of the problems of earlier studies on FDI spillovers in Estonia are avoided in this one by using in productivity analysis a dataset that includes all manufacturing firms.

A parallel recent paper to this one, by Masso *et al.* (2010) looks at the correlation of inward and outward FDI with innovation activities of the investor or recipient firms in Estonia. As one result based on cross section data of CIS surveys, they show also some positive correlations between a broad FDI share in each 2-digit level sector and innovation outputs of firms.

3. EMPIRICAL MODELLING OF THE EFFECTS OF FDI ENTRY

The estimated empirical model follows closely the regression model from the empirical study of UK data in Aghion *et al*. (2009). The dependent variable (ΔY_{ijt}) in Equation (1) is, depending on specification, either the change in TFP, labour productivity (value added per employee) 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.

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).

In order to account for the endogeneity of FDI entry[6] the researcher needs to instrument this term and its interaction with the distance to the productivity frontier. One needs instrumental variables(s) that predict changes in the FDI entry rate, but are (otherwise) unrelated to changes in the dependent variable ΔY_{ijt}. There are few variables that satisfy these conditions.

However, suitable instrumental variables that can be used here are the measures of FDI entry (at 3-digit sector level) in other Central and Eastern European (CEE) transition economies.[7] 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 we need to assume that there are few knowledge flows from multinational firms that are geographically far from the incumbent Estonian firms. That is, we assume that

[6] Due to data availability, foreign owned firms are defined as the firms with at least 50 per cent foreign ownership and define the FDI entry rate also based on these firms only.

[7] This paper uses FDI entry data from Hungary, Czech Republic, Slovakia, Poland, Latvia, Lithuania as instrumental variables.

entry of FDI in countries like Slovakia or Lithuania does not result in spillover effects in Estonia.

In order to account for potential endogeneity of the *'distance to the productivity frontier'* (D_{ijt-1}) variable we try instrumenting it with the 3-digit industry level capital-labour ratio and 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). Similar variables[8] from the USA are used in the Aghion *et al*. (2009) study as instruments for the UK incumbent firms' distance to the technology frontier. The instruments 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 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

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[8] We use the ratio of intangible assets per employee as an instrument instead of the skill intensity measure used in Aghion *et al*. (2009) because the skill-intensity data of Sweden and Finland is not available at 3-digit NACE sector level. Intangible assets per employee is likely to be correlated with the R&D intensity of the firm, which is an important determinant of productivity of firms, and therefore, potentially, an important determinant of the 'distance to the productivity frontier' variable.

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 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 4 types of information sources an ordered variable is created, as the 4 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.

Similar question to the one above is also asked about the presence of innovation-related co-operation with firm’s competitors, suppliers, and clients. Again, a set of indicator variables has been created, for each type of innovation co-operation: ‘co-operation with competitors’, ‘co-operation with suppliers’, ‘co-operation with clients’. These dummy variables are equal to 1, if the corresponding type of co-operation is of high or medium importance for the firm, 0 otherwise.

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

$$I_{ijt}^{m} = \beta^{m} E_{jt-1} + Z'_{ijt-1}\varphi^{m} + \mu_{i} + \tau_{t} + \omega_{ijt} . \qquad (2)$$

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. In another specification, I_{ijt}^{m} is a dummy variable indicating the importance of innovation related co-operation with either the competitors, suppliers, or clients of the firm.

Explanatory variables are similar to the Equation (1). Again, the main regressor of interest is the FDI entry variable. The estimation of Equation (2) is performed based on the panel of the CIS3 (years 1998-2000) and the CIS4 innovation survey (years 2002-2004).

4. DATA

Estonia is a small Central and Eastern European country that has attracted a lot of inward FDI per capita. Until 2008 and the global economic crisis it had also very rapid economic growth. 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. Since 2000, an attractive feature has been its tax regime with allows postponement of taxation moment of the corporate income tax in the case of reinvested earnings.

By the end of 3rd quarter of 2008 the cumulative stock of FDI in Estonia amounted to 17 billion USD. Most of the FDI has gone to financial services sector (31 per cent of stock of FDI) and real estate and business services (29 per cent). Manufacturing industry accounts for 14 per cent of the FDI stock. The main target sectors of foreign investors inside manufacturing have been electronics, food processing and wood processing.

The 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). Several different sources of data have been employed. For productivity analysis, yearly balance sheet and income statement information of the whole population of Estonian firms from the Business Register of Estonia has been used. 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 (majority) ownership or not and it allows to assess the effects of FDI entry on total factor productivity of domestic (majority) 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 the author employs 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.[9]

This paper measures 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. The deflators are available for 16 sectors (that corresponds to the top level in ISIC Rev. 3.1). Capital is deflated using the gross capital formation price index (available only for the total economy). For more information about the deflators, see also the National Accounts of Estonia (2003). The region level FDI entry variable is calculated separately for each of the 15 counties in Estonia.

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, this paper has used the Levinsohn-Petrin (2003) approach to estimate the TFP. It is a semi-parametric estimation procedure for estimating the production function that extends the earlier Olley and Pakes (1996) approach. Both are by now fairly standard methods to estimate TFP at firm level. Therefore, a detailed description of these methods is omitted form here. In order to allow for heterogeneity of the production technology in different sectors, we allow the

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[9] The author owes 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.

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 Table A1 in Annex 1, the average share of FDI in a 3-digit sector is 18 per cent. This variable varies a lot across sectors and grows over time within sectors. The share of FDI in employment 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. As shown in Masso *et al*. (2004) there is a lot of entry and exit going on among firms in Estonia, and entry and exit account for about 50 per cent of the productivity growth in Estonia. Vahter and Masso (2007) find that the multinational firms in Estonia have higher TFP, labour productivity, and wages than the domestic firms. In addition, foreign owned firms are much more capital intensive than domestic firms (*Ibid.* 2007, p. 174).

Previous studies have 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 in 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 Table A3 in Annex 1). During 2002-2004, the corresponding figures were 21 and 19 per cent. These figures are smaller than the ones for the whole CIS sample, that included also the foreign owned and services sector firms. During 1998-2004 there was significant growth in knowledge flows to domestic firms and innovation-related co-operation with their suppliers and customers. A more detailed overview of the descriptive statistics, sample and questionnaire of the innovation surveys can be found from Terk *et al*. (2007). A more detailed description of the dataset of the Estonian Business Register can be found from Masso *et al*. (2004).

5. RESULTS

This section presents the results of estimating Equation (1) and (2). The main conclusion is that there are no significant effects of FDI entry on TFP or productivity growth of incumbents, regardless of the distance to productivity frontier or geographical proximity of domestic-owned and foreign-owned firms. However, there are significant positive effects on knowledge sourcing activities and positive correlation with process innovation of incumbent firms.

Effects on Productivity Growth

The key identification problem in this study is the endogeneity of FDI entry. 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. As pointed out by Bound, Jaeger and Baker (1995)—if the excluded instruments are only weakly correlated with the endogenous variables then the “cure can be worse than the disease”. With weak instruments, the IV estimates are biased and may be not consistent.

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

Dep var:	FE model FDI $entry_{jt}$	FE model FDI $entry_{jt}$	FE model FDI $entry_{jt}$	FE model FDI $entry_{jt}$
FDI $entry_{jt}$ in Hungary (at 3-digit NACE sector level)	0.103*** (0.039)	0.12*** (0.041)	0.091** (0.043)	0.089*** (0.044)
FDI $entry_{jt}$ in Czech Republic			0.066*** (0.017)	0.076*** (0.017)
FDI $entry_{jt}$ in Latvia			0.037*** (0.008)	0.042*** (0.009)
FDI $entry_{jt}$ in Lithuania				0.0361*** (0.009)
FDI $entry_{jt}$ in Poland			0.038** (0.019)	0.0312 (0.019)
FDI $entry_{jt}$ in Slovakia			0.07** (0.027)	0.092*** (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. Heteroscedasticity robust standard errors in parentheses.

Table 2. Effects of FDI entry on TFP growth: FE and the second stage of the IV (2SLS) approach

Domestic firms only:	(1)	(2)	(3)	(4)	(5)
Method:	FE	FE	2-SLS, IV	2-SLS IV	2-SLS IV
Dep. var:	$\Delta lnTFP_{ijt}$	$\Delta lnTFP_{ijt}$	$\Delta lnTFP_{ijt}$	$\Delta lnTFP_{ijt}$	$\Delta lnTFP_{ijt}$
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

Table 3. Effects of FDI entry on labour productivity growth: FE and the 2nd stage of the IV (2SLS) approach

Domestic firms only:	(1)	(2)	(3)	(4)	(5)
Method:	FE	FE	2-SLS, IV	2-SLS, IV	2-SLS, IV
FDI entry$_{jt-1}$(E)	-0.077	0.12	-0.579	-0.681	-0.387
	(0.051)	(0.091)	(0.521)	(0.437)	(0.311)
Firm's distance to the productivity frontier$_{ijt-1}$ (D)	0.743***	0.746***	0.752***	0.764***	0.768***
	(0.021)	(0.021)	(0.021)	(0.024)	(0.024)
FDI entry$_{jt-1}$*Distance$_{ijt-1}$ (E*D)		-0.171**		0.278	
		(0.073)		(0.311)	
Size$_{ijt-1}$	0.141***	0.141***	0.138***	0.11***	0.11***
	(0.028)	(0.028)	(0.029)	(0.031)	(0.031)
Herfindahl-index$_{jt-1}$	-0.207***	-0.204***	-0.193***	-0.257***	-0.257***
	(0.054)	(0.054)	(0.057)	(0.062)	(0.062)
Import$_{jt-1}$	-0.107	-0.114*	-0.101	-0.134*	-0.131*
	(0.068)	(0.067)	(0.071)	(0.076)	(0.076)
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.	9080	9080	9080	9080	9080
R^2	0.37	0.37	0.38	0.38	0.38
Hansen χ^2 test of overidentifying restrictions			-	1.66 (p=0.434)	0.314 (p=0.575)

Note: robust standard errors in parentheses. Methods: FE, 2SLS-IV. Period 1995-2004. FDI entry and the productivity frontier are calculated at 3-digit NACE sector level. Population of domestic-owned firms in Estonia's manufacturing industry.

Next, Tables 2 and 3 show the 2nd stage of the 2SLS and describe the effect of FDI entry on TFP and labour productivity 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.[10]

As evident from the FE model (Column 1 in Table 2 and 3), 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 and 3) does not change this main conclusion. Also, exclusion of the size of the firm as an explanatory variable did not change the findings. Column 3 in Table 2 and 3 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 is -0.107 or -0.253, depending on the number of instruments used (see Columns 3 and 5). However, these estimates are not statistically significant.[11]

The standard errors of the IV model in Table 2 and 3 are much larger than in the OLS case. The econometrics literature has shown that the IV estimator has higher variance than the OLS. Therefore, if the explanatory variables were fully exogenous, then

[10] 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.

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

the OLS would be preferred because of its efficiency. This is not the case here.[12]

So far the regression models have assumed that FDI entry affects all domestic-owned firms similarly. This is a very strong assumption. Next, we check the prediction from 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 we add an interaction term between FDI entry and distance to frontier to the set of explanatory variables.

Based on the augmented FE model (Column 2 in Table 2 and 3), there appears to be a negative correlation between FDI entry and productivity growth of incumbents that are far from the local productivity frontier. However, this result is not confirmed once we try to account for the endogeneity of FDI entry (in Column 4).

The finding of no short-term effects on productivity growth, regardless of the 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). Theoretical literature underscores the expected role of absorptive capacity and distance to technology frontier in these effects (e.g. based on Glass and Saggi 1998). However, the finding of no horizontal 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. For example, Damijan *et al.* (2003), Lipsey (2006), or Görg and Greenaway (2004) provide overviews of findings in transition economies.

[12] The endogeneity of the FDI entry variable has been tested here with the Durbin-Wu-Hausman test. This test rejects the H0 that OLS is consistent (value of test statistic is 176.4 (p=0.00). Therefore 2SLS is the preferred approach over OLS.

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 Estonia towards the local productivity frontier. However, the convergence to a local productivity frontier need not imply convergence to the world productivity frontier.[13]

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. This size effect is stronger on labour productivity growth than on TFP growth. In addition, the higher Herfindahl index (i.e. higher concentration and weaker competition) and import orientation of the sector are negatively associated with incumbent firms' productivity growth. The finding concerning the effects of local competition is similar to Nickell (1996), who uses UK data and finds positive correlation between competition and productivity growth of firms.

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). But, as evident from Table 4, there appears to be no significant correlation between the FDI entry within the local geographical region and TFP or labour productivity growth of incumbents of the same region in Estonia. This is similar to Aitken and Harrison (1999) findings based on data from Venezuela. They find no evidence of horizontal spillovers, regardless of the geographical proximity between firms.

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

Table 4. FDI entry in the same region and industry of the incumbent, correlation with incumbents' productivity

Domestic firms only:	(1)	(2)
Method:	FE	FE
Dep. var.:	$\Delta\ln TFP_{ijt}$	$\Delta\ln LABPROD_{ijt}$
Region level (15 regions) FDI entry in	0.04	0.094
each 3-digit sector $_{jrt-1}$	(0.068)	(0.074)
Distance to the productivity frontier$_{ijt-1}$	0.743***	0.745***
	(0.02)	(0.022)
FDI entry$_{jrt-1}$*Distance$_{ijt-1}$	-0.027	-0.066
	(0.052)	(0.056)
Size$_{ijt-1}$	0.07***	0.141***
	(0.021)	(0.029)
Herfindahl-index$_{jt-1}$	-0.041	-0.203***
	(0.067)	(0.058)
Import$_{jt-1}$	-0.202**	-0.114*
	(0.072)	(0.068)
Year dummies	Yes	Yes
Number of obs.	10380	9080
R^2	0.34	0.38

Note: domestic-owned firms in the manufacturing industry. FE - fixed effects model. LABPROD - labour productivity (value added per employee). Robust standard errors in parentheses. Period: 1995-2004. FDI entry is calculated at 3-digit NACE sector level and within each of the 15 counties.

Table 5. 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 dummies	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Survey wave dummy (CIS3 or CIS4)	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.

Table 6. 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 dummies	Yes	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes	Yes
Survey wave dummy (CIS3 or CIS4)	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.

Table 7. 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 dummies	Yes	Yes	Yes
Region dummies	Yes	Yes	Yes
Survey wave dummy (CIS3 or CIS4)	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.

As a robustness test we have tried some additional instrumental variables—in order to allow for potential endogeneity of the distance to the productivity frontier. Unfortunately, the instruments tried—the Finnish and Swedish 3-digit NACE level capital-labour ratio and immaterial assets per employee are only weakly correlated with distance to productivity frontier in Estonia. These turn out to be weak instruments, and explain only a very small part of variation of 'distance to productivity frontier'.

One way how FDI can affect local firms is by intensifying the entry-exit and selection process among them. This can have effects of aggregate productivity of sectors, even if there are no within-firm changes in performance. Based on the heterogeneous producer competition model in Syverson (2004a) or the new-new trade theory model in Melitz and Ottaviano (2008) one could expect a more compressed spread of productivity across firms in sectors and markets that are more competitive. For example, in sectors with high FDI entry rates. This paper does not go into detail here with study of these effects. But if we regress the 3-digit NACE industry level TFP dispersion (e.g. ratio of the 90th productivity percentile to the 10th) on lagged FDI entry rate, year dummies and industry fixed effects, then we find no significant effects. This need not mean that there are no selection effects of FDI. It is likely that these results depend a lot on the level of aggregation of sectors used. The more detailed investigation of selection effects of FDI entry on the productivity distribution of firms is one potential extension of this study.

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 in 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 FDIs 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; personal contacts through trade organizations, or even through local Rotary clubs, etc. It is difficult to measure these interactions. For that, survey data may be a useful alternative to the standard firm-level datasets.

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.

Another potential explanation why it is difficult to find evidence of spillovers of FDI is the mismeasurement of real outputs and inputs in the standard firm level panel datasets (Griliches and Mairesse 1995, Diewert 2001). For example, Keane (2005) has called it the 'Price*Quantity problem'. The problem is that in standard firm level panel datasets we almost never (except e.g. in Roberts and Supina 1997, Syverson 2004a) observe the firm or plant level price indices for output or the physical output. Therefore the standard approach is to use the value of sales or value added instead as the dependent variable in estimating the production function or in calculating the labour productivity. The sales figure is typically deflated by the industry level price index. This price index, however, can be very different from the unobserved firm level price index. Therefore, the estimated effect of FDI on such sales-based measures of productivity is actually a combination of the effect of FDI on physical productivity and the effect on price(s) of output(s). Still, this is a general problem in the literature and it does not explain why there are often positive spillover effects of FDI found in developed countries and less significant effects in transition countries.

FDI entry and Innovation

It pays to look into the potential channels of productivity spillovers. If we turn our attention to the relationship between FDI entry and innovation, then indeed there are some significant correlations. There is positive significant correlation of lagged FDI entry with process innovation activities of incumbents (see Table 5). This result can be both due to the competition effects of FDI on innovation incentives and knowledge transfer to domestic firms.

According to Table 5, 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.

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 and Knowledge Sourcing

Next, we show based on the CIS innovation survey data that FDI entry is likely to be resulting in knowledge spillovers to the incumbent firms. We explore the association between FDI entry and knowledge flows to incumbent firms and estimate Equation (2) by probit and ordered probit model.

As we can see from the probit model in Table 6 there is significant and positive association of FDI entry with importance of knowledge sourcing by incumbent firms in the following years after FDI entry. The dependent variable in Table 6 is 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.

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 marginal effects from ordered probit model are reported separately for each of the 4 possible answer choices in Annex 2. There the dependent variable is equal to 0, if the 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 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 results from the 2-stage sample selection model are presented in Annex 3. The 1st stage of the 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, 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, yet these are broadly similar results to the standard IV model in Annex 2.

The marginal effects in Tables 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 positive association in the case of knowledge flows from suppliers and from within the corporation itself. Notably, the significance of the FDI 'effect' on knowledge flows from firm's clients disappears once the instrumental variables version of the ordered probit is used. The significance of the effects on knowledge sourcing from competitors disappears once the sample selection issue is taken into account.

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.[14]

My findings about the importance of knowledge flows are related to a study by Crespi *et al*. (2008) based on UK data. 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 7). FDI entry is not significantly correlated with indicators of incumbents' innovation-related co-operation arrangements with

[14] 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.

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. All these have been of short supply among the domestic-owned firms in transition economies.

6. CONCLUSIONS

The main contribution of this paper to the literature is study of the channels of spillover effects of FDI—through effects of FDI on innovation and direct measures of knowledge transfer. For that, we can combine a rich firm level dataset from the Business Register of Estonia with survey-based information about firms' innovation activities and knowledge flows. Also, this study tries to account for the endogeneity of FDI spillovers.

This paper confirms, based on the IV approach, that the FDI entry in the local industry or region has no short-term effect on local incumbents' TFP and labour productivity growth. However, there is a positive spillover on process innovation. The effects do not depend on firm's distance from local productivity frontier.

Higher entry rate of foreign owned firms is associated with an increase in incumbents' probability of engaging in 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 are no productivity enhancing spillovers, the short-term effect of FDI on productivity in the host economy is still likely to 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 incumbent firms, driving low productivity incumbents out of the market and reallocating market shares and resources towards more productive firms. 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.

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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
1996	3,396	0.1
1997	3,883	0.13
1998	4,419	0.19
1999	4,526	0.26
2000	4,768	0.28
2001	5,060	0.31
2002	5,251	0.32
2003	5,370	0.29
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	0.08	0.28	0.12	0.33

Variable name	Variable definition	CIS3		CIS4	
		Mean	Std. Dev.	Mean	Std. Dev.
	or software was of high importance				
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)
Distance to the $frontier_{ijt-1}$ (D)	0.069***	-0.008**	-0.032**	-0.02***
	(0.024)	(0.004)	(0.012)	(0.008)
Sector, region and period dummies	Yes	Yes	Yes	Yes
Number of obs.	915			

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. Size of the firm is included as a control.

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)
Distance to the $frontier_{ijt-1}$ (D)	0.123***	-0.002	-0.053***	-0.067***
	(0.025)	(0.003)	(0.012)	(0.014)
Sector, region and period dummies	Yes	Yes	Yes	Yes
Number of obs.	915			

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. Size of the firm is included as a control.

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)
Distance to the frontier$_{ijt-1}$ (D)	0.103***	0.004	-0.039***	-0.059***
	(0.024)	(0.003)	(0.01)	(0.014)
Sector, region and period dummies	Yes	Yes	Yes	Yes
Number of obs.	915			

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. Size of the firm is included as a control.

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)
Distance to the frontier$_{ijt-1}$ (D)	0.101***	-0.001	-0.038***	-0.062***
	(0.024)	(0.001)	(0.01)	(0.015)
Sector, region and period dummies	Yes	Yes	Yes	Yes
Number of obs.	915			

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. Size of the firm is included as a control.

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 dummies	Yes
Region 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 the 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: Method: ordered probit	(1)	(2)	(3)	(4)
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)
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. Distance to the productivity frontier, sector, region and period dummies and inverse of Mill's ratio are included as control variables.

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

Domestic firms only, panel of CIS3 and CIS4: Method: 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)
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. Distance to the productivity frontier, sector, region and period dummies and inverse of Mill's ratio are included as control variables.

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

Domestic firms only, panel of CIS3 and CIS4: Method: 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)
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. Distance to the productivity frontier, sector, region and period dummies and inverse of Mill's ratio are included as control variables.

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

Domestic firms only, panel of CIS3 and CIS4: Method: 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)
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. Distance to the productivity frontier, sector, region and period dummies and inverse of Mill's ratio are included as control variables.

KOKKUVÕTE

Kas välisinvesteeringud mõjutavad kohalike sihtriigi ettevõtete innovatsioonitegevust, tootlikkust ja teadmiste siiret ettevõtete vahel?

Käesolev töö uurib välisinvesteeringute (OVI) kaudseid mõjusid (i.k. spillovers) Eesti kohalikul kapitalil põhnevate ettevõtete innovastiooni-indikaatoritele, tootlikkuse kasvule ja teadmiste hankimise viisidele ning nende intensiivsusele. Töö püüab täiendada varasemat kirjandust OVI mõjukanalite detailsema uurimisega kui sarnastes töödes tavapäraks. Samuti proovitakse arvestada OVI endogeensusega ning leida nihketa hinnangud OVI kaudsete mõjude osas.

Töös kasutatakse Eesti töötleva tööstuse ettevõtete andmeid Eesti Äriregistri andmebaasist (perioodist 1995-2002), mis on ühendatud Eesti CIS3 (1998-2000) ja CIS4 (2000-2002) innovatsiooniuuringute andmebaasidega. Mõjude identifitseerimiseks kasutatakse erinevaid instrumentmuutujatel põhnevaid regressioonimudeleid.

Töö kinnitab, et ka otseinvesteeringute endogeensusega analüüsil arvestades ei leita, et väliskapitaliga ettevõtete sisenemisel oleks lühiajalisi olulisi kaudseid mõjusid kohalike etttevõtete kogutootlikkuse ja tööjõu tootlikkuse kasvule. Samas leitakse statsitiliselt oluline OVI kaudne seos kohalike ettevõtete protsessiinnovatsiooni indikaatoritega. Nn järjestatud probit mudeli abil läbi viidud Eesti innovatsiooniuuringute andmete analüüsist ilmneb, et OVI sisenemine toob kaasa intensiivistunud teadmiste siirde sihtriigi ettevõtete vahel. Intensiivistub kohalike ettevõtete teadmiste hankimine nende tarnijatelt ning ka ettevõtte/kontserni sisestest allikatest.

Kokkuvõtvalt võib tööst järeldada, et OVI tulemuste analüüsil on oluline tähelepanu pöörata mitte ainult mõjule lühiajalistele tootlikkuse näitajatele, vaid ka pikaajalise tootlikkuse kasvu tegureile: sh innovatsioonile ja teadmiste siirde indikaatoritele.

Eesti CIS3 ja CIS4 innovatsiooniuuringute andmete analüüs annab oluliselt positiivsema pildi OVI kaudsetest mõjudest Eestis kui tavapärasem tootmisfunktsiooni hindamisel põhinev kaaaegse kirjanduse standardne lähenemine.