Economic development and growth in transition countries

Rusinova, D.T.

Publication date
2010

Citation for published version (APA):
Rusinova, D. T. (2010). *Economic development and growth in transition countries*. Thela Thesis.

CHAPTER 3

TECHNOLOGY TRANSFERS THROUGH FDI AND IMPORTS AND LABOUR PRODUCTIVITY IN THE CENTRAL AND EASTERN EUROPEAN COUNTRIES

3.1 Introduction

The globalization process has led to increased attention to the impact of foreign factors on economic growth and productivity. R&D spillovers between countries have become an object of particular interest in this context. It has been shown that they are an important factor driving economic growth: Keller (1999) estimates that R&D spillovers explain around 40% of total factor productivity growth for developed countries. Clearly, for developing countries without substantial domestic R&D activities, the international spillovers are likely to play an even larger role. In turn, the main channels through which such spillovers are realized are international trade and FDI by multinational corporations. However, while there is empirical evidence on the role of imports, the findings on FDI are inconclusive.

It has been argued that transition countries constitute a suitable sample for studying the effect of international knowledge spillovers. Since these countries were initially far from the technology frontier, but well equipped for absorption of foreign technology, FDI and imports are likely to represent a technology transfer to a larger extent than to other developing countries (Campos and Kinoshita, 2002). The influence is likely to be particularly strong for the new EU member states that have enjoyed intensive trade and investment inflows from the "old" EU countries since the middle of the 1990s in view of their expected entry into the European Union.

In this chapter, we evaluate and compare the effect of FDI and imports on economy-wide labour productivity in eight Central and Eastern European new EU member states and Croatia. We pay explicit attention to distinguishing between short- and the long- run effects, since we conjecture that the relationships representing transmission of knowledge are more likely to be long-run ones.

The main result of our analysis is that FDI and imports affect productivity over different time horizons. The relationship between FDI and the productivity level seems to be a long-run one. The impact of FDI stemming from technological leaders is higher than that from the rest of the countries, and FDI targeted towards the manufacturing sector has a higher effect than FDI to the other sectors of the economy. As far as capital goods imports are concerned, they are significantly and positively related to domestic productivity both in the short and in the long run. The trade partners with the highest level of R&D stocks are also shown to induce a stronger increase in productivity through capital goods imports. The long-run nature of the estimated relationships suggests that these international linkages affect the host economy through total factor productivity, and are carriers of foreign knowledge and technology.

In order to obtain robust results and shed some light on the precise way trade and FDI affect productivity, we use several alternative theoretical specifications prevalent in the literature. They differ both with respect to modelling the link between FDI and productivity and to the way spillovers are quantified. These are a Solow-type model, an endogenous growth model and a Coe and Helpman-type model, considering explicitly the R&D stocks of the trade and FDI partners. Our major results appear to be quite consistent in all these modifications. However, a major limitation of our empirical analysis is the small number of observations, therefore the findings, particularly the ones concerning long-run relationships, have to be interpreted with caution.

The rest of the chapter is organized as follows. In section 3.2 we review the relevant empirical literature; in section 3.3 to 3.5 we present and discuss the models used for our estimation. Section 3.6 presents the data, and section 3.7 lists the empirical results. Finally, section 3.8 and 3.9 elaborate on the results and draw conclusions.

3.2 Literature review

FDI and international trade have been recognized in the literature as the two main channels for international R&D spillovers. They are found to be positively correlated with income and labour productivity (e.g. Savvides and Zachariadis, 2005)[1]. However, there is no agreement about which of these two factors has a stronger effect. Some works find that FDI has stronger effect as compared to imports (e.g. Hejazi and Safarian, 1999), while others argue that the influence of imports is stronger (Zhu and Jeon, 2007).

Theoretically, the effects of FDI and of trade are of a different nature: FDI inflow is associated with a knowledge transfer in a broader sense, since besides superior technology it also conveys know-how in organization, efficiency, better governance and business practices[2]. These latter improvements are the ones that have been most relevant for output recovery in Central and Eastern European countries during transition (e.g. Campos and Coricelli, 2002). In comparison, imported capital goods can convey new technology but contribute relatively modestly thwough further efficiency - improving factors. Hejazi and Safarian (1999) support the idea that FDI can have additional effects as compared to the trade flow, for instance in the non-tradables sectors, or due to broad opportunities for technology transfer between the headquarters and subsidiaries of a multinational enterprise. Before continuing with the discussion of our particular setup, it is worth reviewing briefly the two strands of the empirical literature dealing separately with FDI and imports.

Although economic theory has clear predictions about the positive impact of FDI on growth, the empirical findings are much less conclusive. In most cases a clear-cut independent effect of FDI on growth has not been identified. Rather, it is conditional on the level of income of the accepting economy (Blomstrom and Kokko 2003, Herzer et al. 2008), on the technological gap between the firms in the source and host countries (Lim 2001, De Mello 1999) and the human capital level as a proxy for the absorption

[1]The literature also considers further spillover channels not covered in this paper, e.g. exports and disembodied spillovers, the so-called "learning by watching" (Keller 2004).

[2]Certainly, one has to acknowledge that M&A activity is a part of FDI and it has little to do with knowledge transfers. However, one of the distinguishing charcteristics of transition countries is that this aspect is relatively less important for incoming FDI in transition countries from developped economies, as compared to FDI between developped economies (Campos and Kinoshita 2002).

capacity of the home economy (Borensztein 1998, Eller et al. 2006, Benhabib and Spiegel 2005). Some studies argue that in developing countries a robust link between FDI and growth exists neither in the short nor in the long run (Herzer et al. 2008). Recent studies of FDI on the firm level have suggested one possible reason for the inconclusive macro findings: that the positive effects of FDI are in fact very limited in scope. Only vertical spillovers - those between a foreign firm and its affiliated firms in the host country - are present; horizontal spillovers - between the foreign firm and the competing domestic firms - are zero or even negative (e.g. Damijan et al. 2003). This might prevent the transfer of superior technology to the entire economy, leaving only a limited number of firms to enjoy its benefits.

A particular strand of the empirical literature has found the FDI impact to depend on the sector FDI flows into. Sector-level studies relating growth to FDI report substantial heterogeneity (e.g. Alfaro 2001, Vu and Noy 2009, Bijsterbosch and Kolasa 2008). In most cases, these studies identify a positive effect of FDI on manufacturing, but not on services. Keller (2004) also notes that FDI spillovers appear to be much stronger in high-technology sectors than in low-technology sectors. However, there are also alternative views: Eller et al. (2006) identify a positive effect of FDI into financial service on income growth. One of the goals of this chapter is to see whether some sectoral differences are also present in CEE countries, and to test the hypothesis that FDI into manufacturing is the main driver of productivity improvements in the whole economy. Therefore, we devote specific attention to sector heterogeneity by considering separately FDI to manufacturing, and those to the rest of the economy.

Transition countries might be distinguishable from other developing countries in terms of the potential effect of foreign technology on the domestic economy. Namely, they have started the period well-prepared for technology adoption (well-endowed with human capital), but far from the technological frontier. Therefore, transition countries offer the "right context" for studying the influence of FDI on growth (Campos and Kinoshita 2002), since there spillovers represent to the largest extent a technology transfer. Indeed, studies covering transition countries as host countries tend to find positive results more often than general ones.

As far as the empirical literature on imports and productivity is concerned, there appears to be more evidence on their positive effect (Coe and Helpman 1995, Grunfeld 2002). There are two issues that might provide an explanation of why some results are conclusive and others not. Firstly, it seems that the degree of relative development of the source and host countries matters: Zhang and Zou (1995) find significant impact of imports on economic growth in a panel of 50 developing countries, just as Kim et al. (2007) find convincing evidence about Korea. At the same time, Funk (2001) fails to find a long-run relationship between total factor productivity and imports in OECD countries, which are at similar development levels. Second, it has been shown that imports of capital goods rather than total imports are the carriers of R&D spillovers embodied in trade flows (e.g. Lee1995, Xu and Wang 1999). Funk (2001) also notes that his negative results may be driven by the fact that total and not only capital goods imports were considered. Based on this evidence, we also choose capital goods imports as a measure of the trade-related R&D spillover channel.

Previous works make a variety of assumptions about the way R&D transfers affect productivity and income growth. Correspondingly, they adopt a range of approaches to testing their hypothesis. Some authors use a form of augmented Solow model, where foreign capital (imported goods or FDI) is a substitute to domestic capital (e.g., Campos and Kinoshita 2002) and therefore affects growth and labour productivity through increasing the capital stock. Others utilize endogenous growth models (Borensztein 1998, Bijsterbosch and Kolasa 2009), where the foreign capital affects directly the total factor productivity term by improving the technological level.

Studies also differ in the way they quantify the technology spillovers. Some of them simply include measures of the imports or FDI inflows as explanatory variables, like in the two models above. There is however another strand in the literature which regards bilateral FDI or imports as carriers of the specific knowledge stock from the source country. Therefore, it seeks to identify the influence of this knowledge stock, usually proxied by the R&D stock, on other countries and constructs for this purpose elaborate spillover measures containing the R&D stocks of the source countries. This is the method developed by Coe and Helpman (1995). Studies using this approach often report imports and FDI to be significant and substantial means of technology diffusion.

In this chapter, we strive towards using a broader range of underlying models and measures in order to ensure robustness and better comparability with the existing literature.

3.3 Choice of the theoretical model

This section presents the alternative models used in the current chapter. In the beginning, we follow the way they are fomulated in the literature; in section 4 we also elaborate on their implementation over the short- and long-run horizons.

3.3.1 Solow-type model

The Solow-type augmented growth model is based on the framework of Mankiw, Romer and Weil (1992). They use as a basis the Solow model with a Cobb-Douglas production function including physical and human capital and assuming exogenous technology and population growth. Using approximation around the steady state, they derive the following equation for steady-state growth:

$$\ln \hat{y} = \theta \ln A(0) + gt + \alpha_1 \ln s_k + \alpha_2 \ln s_h + \alpha_3 \ln(n + g + \delta) - \theta \ln y_0 + \varepsilon$$

This equation is then also estimated empirically: per capita output growth of a country is regressed on the rates of investment in physical and human capital, the population growth and the initial income level (Temple, 1999). Following MRW´s seminal work, this equation has been extended to include many further institutional and policy variables, forming the framework of the so-called informal growth regressions (Temple, 1999). Recently, this basic framework has also been extended with external factors like FDI (Campos and Kinoshita 2002, among others).

We also employ the basic framework, adding the FDI and imports variables, with the difference that instead of per capita growth, our dependent variable is labour productivity, measured by output per worker. This transforms the basic equation in the following way:

$$\Delta P_{it} = \gamma + \beta^I I_{it} + H_{it} + \beta^{FDI} FDI_{it} + \beta^{IM} IM_{it} + \alpha P_{it-1} + \eta_i + \lambda_t + \nu_{it} \quad (3.1)$$

Here ΔP_{it} denotes the change of productivity in country i, P_{it-1} is lagged productivity, I_{it} is capital investment, and H_{it} is the human capital variable. FDI_{it} is one of the several measures of FDI which we use, and IM_{it} is a measure of the imported capital goods. Since we are working with panel data, η_i are the country-specific and λ_t are the time-specific fixed effects.

3.3.2 Endogenous growth model

The second model we estimate is the endogenous growth model by Borensztein et al. (1998), which has been recently broadly used (e.g. Campos and Kinoshita 2002, Kolasa and Bijsterbosch 2008). They use a general equilibrium model with a Cobb-Douglas production function including physical and human capital and agents maximizing a standard intertemporal utility function. Further, they assume that the capital stock is composed of a continuum of varieties of capital goods produced both by domestic firms and by foreign firms which have invested in the host economy. This is expressed formally as

$$N = n + n^*$$

where N is the total number of domestically produced capital varieties, of which n by domestic firms and n^* by foreign firms. The foreign firms' investment (FDI) is the main driver of technological progress since it introduces into the economy the technology necessary to produce the new capital varieties. Foreign direct investment increases the variety of capital goods (or their quality) and in this way drives technological change. However, the process of technology adoption is costly and its cost depends on two factors:

$$F = F\left(\frac{n^*}{N}, \frac{N}{N^*}\right)$$

The cost decreases in the share of the intermediate products produced by foreign firms in the total number of products $\left(\frac{n^*}{N}\right)$, reflecting that foreign firms bring an advantage in the production of new intermediate goods (and the larger the share of foreign-produced goods, the larger this advantage is for the economy). Moreover, the cost decreases with increasing $\left(\frac{N}{N^*}\right)$, the number of capital varieties produced at home compared with the number of them produced in the leading countries, since in countries where this ratio is lower, the scope for imitation is larger and therefore the cost of adopting new technology is lower (Borensztein et al., 1998).

Borensztein et al. derive the following expression for steady-state growth:

$$g = \frac{1}{\sigma}\left(A^{\frac{1}{\alpha}} \phi F\left(\frac{n^*}{N}, \frac{N}{N^*}\right)^{-1} H - \rho\right)$$

Hence, growth is a function of the two ratios $\left(\frac{n^*}{N}\right)$ and $\left(\frac{N}{N^*}\right)$ as well as the level of human capital.

The testable hypothesis of Borensztein et al. (1998) relates total factor productivity to its lagged value, FDI, the level of human capital and an interaction term between the human capital and FDI. Our basic equation is very similar, with the difference that we use labour productivity instead of total factor productivity, and control for physical investment on the right-hand side.

$$\Delta P_{it} = \gamma + \eta_i + \lambda_t + \alpha P_{it-1} + \beta^I I_{it} + \beta^{FDI} FDI_{it} + \beta^{INT} FDI_{it} * H_{it} + \nu_{it} \qquad (3.2)$$

Here, H is the measure of human capital and $FDI * H$ is an interaction term between FDI and human capital, included in order to test whether human capital determines the magnitude of the effect of foreign technology absorption (see e.g. Benhabib and Spiegel, 2005). With this setup, the effect of a marginal unit of FDI becomes $\beta^{FDI} + \beta^{INT} * H_{it}$. Since both coefficients β^{FDI} and β^{INT} are expected to be positive, the cumulative effect of a marginal unit of FDI is expected to be higher the higher is the human capital in the country.

Apart from FDI, we also estimate a similar equation for imports.

$$\Delta P_{it} = \gamma + \eta_i + \lambda_t + \alpha P_{it-1} + \beta^I I_{it} + \beta^{FDI} IM_{it} + \beta^H H_{it} + \beta^{INT} IM_{it} * H_{it} + \nu_{it} \qquad (3.3)$$

The principal difference between Borenzstein's and the Solow-type model is that the latter assumes that the foreign capital (FDI or imports) is a substitute for national capital and therefore has a similar effect on productivity. Under this assumption FDI has no long-run effect on growth, and its effect on output and productivity levels is likely to be small (Campos and Kinoshita, 2002). In contrast, in the endogenous model foreign capital affects technology, and hence directly total factor productivity. Its effect on growth and productivity is therefore likely to be a long-term one. Since the testable equations corresponding to the Solow-type and the endogenous model are very similar, they may actually be selected by our estimation. If the Solow model gets more empirical support, we are more likely to estimate a short-term relationship; and if the endogenous growth model is better supported by the data, the long-term component would be present.

The second criterion for distinguishing the models is the role of human capital: it is logical that the better an economy is endowed with human capital, the better it absorbs new technologies. Therefore, in the endogenous model, human capital variables or interaction terms between them and foreign capital variables should be significant (Borensztein 1989, Campos and Kinoshita 2002).

3.3.3 Bilaterally-weighted model (Coe and Helpman type model)

Finally, we also estimate a model of the type designed by Coe and Helpman (1995) and further developed in Hejazi and Safarian (1999). They consider the technology adoption from a somewhat different perspective and take explicit account of the effect of the size of domestic and foreign R&D stocks. Similarly to Borensztein et al. (1998), they assume that R&D (domestic as well as foreign) can increase the variety of intermediate goods available to domestic production firms, or their quality. In order to construct an estimate of the foreign R&D stocks, the authors take the calculated R&D stock of the country's trade partners, and weight them with the share of these countries' imports in total imports. An alternative way of viewing this indicator is as an imports index, weighted by the R&D intensity of the trade partners: countries with larger R&D stocks receive a larger weight in the cumulative import flow to the host country[3].

The original equation of the model is the following:

$$\ln P_{it} = \alpha + \beta^{D} \ln S_{it}^{D} + \beta^{IM} S_{it}^{IM} + \eta_i + \nu_{it} \tag{3.4}$$

where the S_{it}^{D} is the domestic R&D stock of the host country and S_{it}^{IM} is the import-weighted R&D index:

$$S_{it}^{IM} = \sum_{h} m_{hit} S_{ht}^{d}$$

S_{ht}^{d} is the domestic R&D stock of foreign country h in period t,
m_{hit} is the capital imports inflow from country h to country i in period t.

However, we use several modifications of the model, most of them in order to ensure consistency and comparability across all models. First, we do not consider all trade and investment partners of the CEE countries, but similarly to Hejazi and Safarian (1999) choose a group of 6 technological leaders, assuming that imports from technologically more advanced countries are likely to have a stronger effect on productivity. The six countries are chosen by the size of the accumulated R&D stocks as estimated by Coe and Helpman, and whether the countries are significant trade partners of the countries from our sample. Second, as in the previous models, we strive towards a comparison of the effect of imports and FDI, therefore we construct an FDI-weighted measure of the R&D stocks analogous to the imports-weighted one (see equation 3.5 below).

Third, for consistency we employ labour productivity and not TFP as a dependent variable; therefore, as in sections 3.1 and 3.2, we control for investment in physical capital on the right-hand side. Fourth, we stick to our choice of capital goods imports instead of total imports, and therefore the bilateral weights are calculated using capital goods imports only. Finally, since the domestic R&D of the CEE countries is very limited, and comprehensive data on it is lacking, we omit this variable from our analysis.

With the modifications, the equation to be estimated is the following:

$$\ln P_{it} = \alpha + \beta^{FDI} \ln S_{it}^{FDI} + \beta^{IM} S_{it}^{IM} + \eta_i + \nu_{it} \tag{3.5}$$

where

$$S_{it}^{FDI} = \sum_{h} f_{hit} S_{ht}^{d}$$

and S_{it}^{FDI} are the FDI-weighted R&D stocks of the 6 technological leaders. Similarly to the imports weights, f_{hit} is the FDI stock from country h to country i in period t.

Based on Table 3 in Coe and Helpman, the countries with the largest R&D stocks are USA, Germany, France, UK, Netherlands, Sweden, Canada and Japan, and that there

[3] Keller (1998) criticized the approach of Coe and Helpman. He argued that the choice of weights to foreign R&D stocks is irrelevant to identifying research spillovers, and hence Coe and Helpman's approach does not prove that imports are indeed a spillover channel. However, Funk (2001) shows that the weights choice does actually matter.

is a large gap between their R&D stocks and those of the countries next in the ranking. We however do not consider Canada and Japan since their shares of imports/FDI in the CEE states were found to be rather small. In order to calculate the contemporary R&D stocks of the technological leaders, we follow the perpetual inventory method used by Coe and Helpman (1995): on the basis of the yearly R&D expenditure figures, it provides an estimate of the starting values of the R&D stocks, and then also constructs their current values assuming 5% depreciation.

Although it would be insightful to estimate this model on sectoral in addition to the national level, or at least to consider separately the manufacturing sector, we are unable to do it. The lack of FDI data disaggregated simultaneously by sector and by country does not allow us to repeat the construction of the bilaterally-weighted measures only for a certain sector.

3.4 Long-run vs. short-run relationships

It is intuitive to expect that the effects of the knowledge transfers are different in the long and in the short run, or even might be observable only in the long run. Firstly, the effect of FDI on productivity is unlikely to materialize in the same period as when FDI is recorded; rather, it would take longer to translate into productivity improvements. The reason is that FDI are usually counted in the national accounts in the year in which the foreign investment is received, and there is a time lag before the foreign firm starts its operations in the host country and they lead to measurable productivity increases. Second, productivity growth is neither driven by the capital inflow within one particular year, nor does the influence of the knowledge transfer expire after a particular year. Rather, the whole accumulated stock of transferred foreign knowledge is likely to play a role for productivity improvements over an extended period. In order to capture the long- and short-run effects, we use an error correction framework including a short-run and a long-run component. The long-run component is a cointegrating relationship between variables in levels and the short-run component, capturing the adjustment towards long-run equilibrium - in differences. Correspondingly, the long-run component would seek to identify the determinants of the productivity level, whereas the error correction equation explains productivity growth.

There is one further compelling econometric reason for such a differentiation. The equations (3.1) - (3.3) are very likely to represent a mix of stationary and non-stationary variables. In particular, the stock variables are by definition non-stationary, as opposed to the flow variables. Provided that our time horizon is very short and our data does not span even one full business cycle, the presence of non-stationary variables is likely to have a strong effect and lead to spurious inference.

In the literature, there is insufficient attention devoted to the issue of stationarity of the participating variables and the appropriateness of the models for nonstationary variables. In many works, relationships between variables which are most likely non-stationary, are being estimated through OLS methods (cited in Funk 2001). However, some studies pay explicit attention to non-stationarity: Zhu and Jeon (2007), Herzer et al. (2008), Funk (2001) apply panel data techniques to estimate cointegrating relationships between the variables. Since fully-fledged cointegration analysis (e.g. using the Johansen cointegration test) is not possible in our case due to the short time dimension of the data, we prefer implementing the Engle - Granger two-step procedure to construct error correction models as explained above.

Consider, for example, the Solow-type model from equation 3.1. If we denote with hats the long-run coefficients in order to distinguish them from the short-run ones, the long-run component of the error-correction model is formulated as follows:

$$P_{it} = \hat{\gamma} + \hat{\beta}^{I} I_{it} + \hat{\beta}^{FDI} FDIS_{it} + \hat{\beta}^{IM} IMS_{it} + \hat{\beta}^{H} H_{it} + \hat{\eta}_i + \hat{\nu}_{it} \tag{3.6}$$

where FDIS are the FDI stocks and IMS are the import stocks in the host country[4]. Then, the corresponding error-correction equation is estimated according to equation 3.7 , using the residuals $\hat{\nu}_{it}$ from the long-run component as an ECT:

$$\begin{aligned} \Delta P_{it} &= \gamma + ECT_{it} + \alpha P_{it-1} + \beta^{I} I_{it} + \beta^{FDI} FDI_{it} + && (3.7)\\ &\quad + \beta^{IM} IM_{it} + \eta_i + \lambda_t + \nu_{it} && (3.8)\\ ECT_{it} &= \hat{\nu}_{it} && (3.9) \end{aligned}$$

3.5 Estimation and data

3.5.1 Econometric methodology

Apart from non-stationarity, our estimation is problematic because of possible simultaneity bias of some of our key variables, for instance FDI or capital goods imports. It is intuitive that a country with higher labour productivity can attract more FDI[5]. For this reason, in addition to the fixed-effects OLS specification, we also estimate the regressions using GMM methods for dynamic panel data. The use of GMM methods is additionally necessitated by the fact that some models have a lagged dependent variable present on the right-hand side, in which case we are dealing with a dynamic panel. GMM methods have been recently extensively used in the empirical macroeconomic literature (Roodman 2006, Bond et al. 2001), including applications featuring FDI or international trade (e.g. Bun and Windmeijer 2007, Levine and Carkovic 2007). However, the OLS estimates are also useful as a benchmark and basis for comparison. Moreover, they represent a convenient way of addressing unobserved cross-country heterogeneity. (Acharya and Keller 2007).

An important limitation of the current study is the small sample (a “small N, small T”) panel, since most of the methods developed for panel data are intended for individual or firm data (“small T, large N” samples). The small sample limits the number of variables we can include, and compels us to use special estimating options. These modeling considerations are discussed in detail in Appendix D. However, here we present briefly the models used and some caveats that have to be borne in mind when working with them.

The GMM methods exploit a number of moment conditions, which allow us to construct internal instruments for the potentially endogenous variables as well as for the lagged endogenous variables. The GMM methods are suitable for growth regressions since

[4]The calculation of the import stocks is described in the Data section.

[5]In fact, some studies (Keller 2004) report that the biases introduced by the imports and FDI variables being endogenous are not large. Therefore, we also use the fixed effect estimations for comparison purposes.

they relax many of the assumptions imposed on the data generating process by earlier methods: they allow for endogenous explanatory variables, variables which are measured with error, and presence of country fixed effects (Bond et al. 2001, Roodman 2007). We apply both the "difference GMM" and "system GMM" [6]. The former one uses moment conditions derived from the assumptions that the errors are serially uncorrelated and the initial conditions are predetermined, which allows the use of levels lagged $t-2$ and further as instruments for the equations in differences (Bond et al. 2001). However, the differenced GMM has been shown to be subject to a downward finite-sample bias, particularly when the number of periods T is small. Another weakness is that differenced series may be weak instruments for levels if the original series are highly persistent, as is often the case with series like output or productivity (Bun and Windmeijer 2007). Therefore, the recently more popular GMM method is the "system GMM", which has superior finite-sample properties (Judson and Owen 1999). It exploits one additional moment condition, which requires that the initial conditions satisfy a mean stationarity restriction for each cross-section. This permits lagged differences of the series to be used as instruments for the equations in levels. However, this method also has a drawback: the additional condition is a nontrivial one and it might easily be violated (it is discussed in more detail in Appendix D). Therefore, we prefer system GMM estimation whenever diagnostic tests do not show problems with the instruments, but resort to difference GMM whenever system GMM tests have poor values, hinting at possible violation of the additional condition.

Another issue considered is whether we should use a linear or log-linear form for our equations (there is no consensus on this point in the literature). We have opted for the former one, since estimating the models in log-linear form would be equivalent to imposing restrictions on the model, i.e. constant elasticity of productivity with respect to FDI. Moreover, our FDI inflow series contain negative values, therefore taking logarithms would not be possible, and considering other transformations would complicate the interpretation of the results.

3.6 Data

Our data encompasses 12 years (1995 – 2006), but for several countries the actual length of the time series is shorter due to missing observations. The countries considered are 11: the 10 new EU member states from Central and Eastern Europe plus Croatia, a country which, although not yet an EU member, has structural characteristics very similar to those of Bulgaria and Romania.

The data about FDI is taken from the WIIW database on the foreign investment in Central and Eastern Europe[7]. We use FDI stocks for the long-run relationships and flows for the short-run ones. In order to avoid scale effects and to have a consistent way of measuring the variables, we divide both FDI and imports by the total employment in order to express them as a quantity per worker. There is a caveat which has to be kept in mind when using FDI flows: they are very volatile series, which often exhibit negative

[6] For a detailed discussion on the use of GMM methods in macroeconomic empirical problems, see Bond et al. (2001), and for their practical implementation in STATA - Roodman (2006) and Roodman (2007).

[7] Detailed information about the sources and the definitions of data used is contained in the Data Appendix.

values, and these are very hard to interpret meaningfully in terms of technology adoption: negative FDI values in a certain year are not likely to be associated with reversal of the productivity improvements. In general, we have to bear in mind that FDI data is of rather poor quality, which is shown by the sometimes large discrepancies in data between the database we use and alternative data taken directly from the national central banks (which we can not use for alternative estimation due to limited availability).

Apart from data about total FDI, we also use different disaggregations of the data available in the WIIW database. Firstly, in order to differentiate between economic activities and to test the hypothesis that FDI into manufacturing is especially effective in increasing labour productivity, we consider FDI into manufacturing and services separately. Second, in order to investigate whether the source country matters for the effect magnitude, we also use bilateral FDI data.

Total and bilateral imports data stem from UN Comtrade database. For calculating the import stocks, we apply once again the perpetual inventory method of Coe and Helpman (1995), which was already used for calculating R&D stocks. The calculations are based on the yearly import data, assuming a depreciation rate of 5%.

Finally, for human capital, we use data from the Unicef TransMONEE database (2006), which is a comprehensive dataset with full coverage of transition countries for the years 1995-2005. More specifically, we use two alternative measures: higher education enrollment ratios and secondary education enrollment ratios, both as a percentage of the corresponding age group.

3.7 Results

First we apply unit root tests to our variables. We use the Fisher panel unit root test, which is suitable for unbalanced panels. The results are quite intuitive: for the stock and level variables (labour productivity, human capital, physical investment; R&D, FDI and import stocks) the test does not reject the presence of a unit root, whereas in the case of the flow variables (FDI flows, imports, and the change in productivity and investment) the null hypothesis was rejected, therefore the series were found to be stationary. For the weighted R&D measures, used for the Coe and Helpman-type model, the test also failed to reject the null hypothesis of a unit root.

In what follows, we describe in detail the estimation of each of our three main models separately. We start with the Solow-type model (in three versions: only with FDI, only with imports and combined), estimating the long-run and short-run components according to equations (3.6)-(3.7). The results are presented in Tables 3.1 - 3.3.

In the long run, there exist relationships both between labour productivity and total FDI stock and between productivity and the import stocks, which show stationary residuals. The FDI stock variable is lagged, hinting that in general, it takes at least a year for the technology transfers associated with FDI to be translated into a higher productivity. The coefficient of the human capital variable, although positive, was only significant in one specification.

Similar long-run relationships were established with the disaggregated FDI variables: between lagged manufacturing FDI stock and productivity, as well as (lagged) FDI stock from the 6 technological leaders and labour productivity. Interestingly, in both cases the

Table 3.1: Long-term relationships: Solow-type model

	3.1.	3.2.	3.3.	3.4.	3.5.	3.6.
Constant	7.012***	6.318***	5.952***	4.468***	5.356***	5.221***
	(0.919)	(0.771)	(0.905)	(0.746)	(1.071)	(0.812)
Investment	0.830***	0.785***	0.811***	0.644***	0.922***	0.615***
	(0.093)	(0.081)	(0.111)	(0.088)	(0.089)	(0.107)
Inward FDI stock (-1)	0.077**					
	(0.028)					
Inward FDI manufacturing stock (-1)		0.614***				0.458***
		(0.121)				(0.125)
FDI stock from G6 (-1)			0.221***			
			(0.079)			
Secondary education	0.018	0.022	0.034**	0.029**	0.024	
	'(0.019)	(0.017)	(0.015)	(0.013)	(0.02)	
Imports				6.679***		4.374**
				(1.188)		(1.904)
Imports from G6					13.438***	
					(5.554)	
Year dummies	yes	yes	yes	yes	yes	yes
Observations	92	92	93	118	118	92

Note: 1. Residuals are stationary.
2. One, two and three asterisks denote values significant correspondingly at the 10, 5 and 1 % levels.

coefficient of the narrow FDI measure was higher than the one of total FDI stock. This finding hints at differences across sectors: an additional unit of manufacturing FDI has a larger effect on productivity than a unit to the other sectors. Also, the long-run effect of FDI from technological leaders is larger than the one coming from the rest of the countries, probably because of the larger technology and efficiency gap between the source and host countries in this case. This finding is in line with works like De Mello (1999) and Lim (2001), who demonstrate that the magnitude of the effect from FDI increases in the size of the technology gap between the source country and the receiving country.

As opposed to FDI, contemporaneous import stocks performed better than the lagged ones. Again, as was in the case of FDI, we found that capital goods imports from the 6 technological leaders have a higher effect on productivity than those from all the world.

In the second step we estimated the error correction (EC) equations. In most of these EC equations (see Tables 3.2 and 3.3), the corresponding error correction terms were significant and with a negative sign, indicating that there is indeed a convergence process towards the long-run equilibrium. Otherwise, the equations performed poorly, particularly the ones involving FDI: they had a poor fit, reflected in a low R-squared, insignificant FDI variables and insignificance of the human capital measures in all regressions[8]. In the fixed effects estimation, none of the FDI variables was found to be significant; but a GMM regression suggested a significant positive short-run effect of FDI to manufacturing. In contrast to FDI, the specifications with imports revealed a different picture: the coefficients of this variable are positive and robustly significant regardless of the estimation technique. The combined specification featuring simultaneously the FDI and imports also confirmed the significance of imports and insignificance of FDI[9]. In general, a short-run

[8] Lagged productivity was insignificant in all specifications, and was therefore dropped in the GMM regressions, in order to decrease the number of potentially endogenous variables and, therefore, of the instruments.

[9] Apart from the reported specifications, a large number of alternative ones were attempted. Some

Table 3.2: Error-correction equations: Solow - type model, OLS

	1.1.	1.2.	1.3.	1.4.	1.5.	1.6.
Constant	3.915***	4.044***	3.463***	3,343***	2.650***	3.569***
	(0.630)	(0.513)	(0.544)	(0.473)	(0.082)	(0.488)
Investment	0.979***	0.855***	0.892***	0.651***	1.013***	0.562***
	(0.087)	(0.068)	(0.098)	(0.088)	(0.082)	(0.107)
Inward FDI stock (-1)	0.218***					0.066*
	(0.058)					(0.035)
Inward FDI manufacturing stock (-1)		0.830***				
		(0.107)				
FDI stock from G6 (-1)			0.326***			
			(0.075)			
Secondary education	0.063***	0.059***	0.074***	0.046***	0.059***	0.042**
	(0.018)	(0.015)	(0.016)	(0.016)	(0.017)	(0.018)
Imports				7.804***		7.830***
				(0.984)		(1.198)
Imports from G6					20.614***	
					(5.432)	
Observations	81	92	93	118	118	92

Note: 1. Residuals are stationary (Panel unit root test with trend and 2 lags).
2. One, two and three asterisks denote values significant correspondingly at the 10, 5 and 1 % levels.

relationship between FDI and productivity was not established and FDI appears to be associated with labour productivity only in the long run, whereas capital goods imports have both a long- and a short-run relationship with productivity. The latter appears to be quite robust with respect to the estimating technique.

Next, we turned to the Borensztein-type model. The estimates of the long-run components (not reported) were rather disappointing: residuals were nonstationary; the cross terms of human capital and FDI or imports stocks, although with positive signs, were insignificant regardless of which of the two human capital measures we used. Due to the absence of established long-run relationships, only simple short-run specifications were estimated instead of error-correction equations. The results, reported in Table 3.4, reveal a picture similar to the long-run results : insignificant coefficients of the FDI measures, as well as the interaction terms, and mostly negative signs of the latter. In the GMM regressions with interaction terms the diagnostic tests for instrument validity often signalled problems with the specification. In general, there is no evidence that the magnitude of the effect of FDI or imports depends on the level of human capital in our sample.

Finally, we consider the bilaterally weighted model. It was estimated only in a long-run version, due to the long-run nature of the relationship. Its results are reported in Table 3.5. Although the coefficients of the two composite variables (FDI- and import-weighted R&D stocks) are significant, the residuals are non-stationary, suggesting that a long-run relationship can not be identified. Since we already established long-term links between productivity and correspondingly the FDI and imports, the negative results with these weighted measures are probably attributable to the newly introduced R&D stocks. As a check, we considered a specification, where instead of the weighted measures we

of these included time fixed effects (in OLS), human capital variables (secondary or higher education indicators), lagged instead of contemporaneous FDI, as well as FDI to services, further differentiated by sector (e.g. real estate, financial sector etc.). However, none of these alternative regressions produced any significant results.

Table 3.3: Error correction equations: Solow - type model, GMM

	GMM estimation				
Independent variables	2.7.	2.8.	2.9.	2.10.	2.11.
Constant				-0,126***	
				(0.218)	
Lagged productivity					
D(Investment)	0,856**	0,830***	0,831***	0,359*	0,966***
	(0.280)	(0.218)	(0.197)	(0.181)	(0.238)
FDI variables					
FDIinflow/worker	0,131*				
	(0,66)				
FDI to manufacturing/worker		0,513**			
		(0,199)			
FDI from G6/worker			0.079		
			(0,102)		
Capital goods imports					
Imports/worker				10,921**	
				(4,97)	
Imports from G6/worker					-22.893
					(35,757)
Error correction term (-1)	-0.359	-0.188	-0,385	-1.334***	-0.350
	0.322	0.186	0.321	0.216	0.536
F-statistic	10.56	11.32	42.49	21.71	25.69
Observations	84	84	95	118	107
Type of GMM method	diff	diff	system	system	diff
Number of lags used as instruments	1 to 5	1 to 4	1 to 4	2 to 4	2 to 6
Number of instruments	10	8	11	9	10
Arrelano-Bond test for AR(2) (p-value)	0.219	0.233	0.130	0.692	0.064
Sargan overidentif. restriction test (p-value)	0.490	0.535	0.062	0.140	0.486
Hansen test (p-value)	0.312	0.329	0.450	0.204	0.637

Notes:
1. Standard errors in parentheses
2. Robust standard errors in all specifications
3. Light shaded cells contain instrumented (potentially endogenous) variables
4. One, two and three asterisks denote values significant correspondingly at the 10, 5 and 1 % levels.

Table 3.4: Short-run Borensztein-type model, OLS and GMM

	OLS (fixed country effects)				GMM estimation		
Independent variables	3.1.	3.2.	3.3.	3.4.	3.5.	3.6.	3.7.
Constant				0.123	0.037***	0.028***	0.052
				(0.114)	(0.005)	(0.008)	(0.109)
Lagged productivity	-0.162*	-0.207*	-0.151	-0.156*			
	(0.095)	(0.106)	(0.096)	(0.091)			
D(Investment)	0.557***	0.572***	0.561***	0.458***	0.509	0.516***	0.435***
	(0.096)	(0.093)	(0.961)	(0.037)	(0.052)	(0.096)	(0.084)
FDI variables							
FDI inflow/worker	0.033						
	(0.056)						
FDI in manufacturing/worker		0.712*			-0.037	0.364	
		(0.386)			(0.045)	(1.104)	
FDI from G6/worker			0.04				
			(0.277)				
Interaction (HC*Measure of FDI) (high)	0.000	-0.010	-0.0001		0.001	-0.002	
	(0.001)	(0.008)	(0.005)		(0.001)	(0.025)	
Capital goods imports							
Imports/worker				12.065**			8.376
				(0.114)			(6.185)
Interaction (HC*imports)				-0.141			-0.049
				(0.104)			(0.155)
F-statistic	9.43	10.85	8.9	11.53	3.46	29.29	2.99
R-sq within	0.32	0.36	0.31	0.36			
Observations	95	94	94	96	90	100	107
Type of GMM method					system	system	system
Number of instruments					11	9	9
Number of lags					1 to 3	1 to 3	1 to 3
Sargan test on overident restr. (p-value)					0.31	0.15	0.12
Hansen test (p-value)					0.561	0.83	0.19
Arellano-Bond sttaistic for AR(1)					0.073	0.19	0.22
Arellano-Bond sttaistic for AR(2)					0.195	0.36	0.18

Notes: 1. Standard errors in parentheses

2. Heteroskedasticity-consistent standard errors in all specifications

3. Country fixed effects are jointly significant in all OLS specifications

4. One, two and three asterisks denote values significant correspondingly at the 10, 5 and 1 % levels.

5. In the GMM estimation, shaded cells contain instrumented (potentially endogenous) variables

Table 3.5: Long-term relationships: bilaterally-weighted model

	4.1.	4.2.
Constant	4.709***	1.962***
	(0.584)	(0.428)
Investment	1.458***	1.019***
	(0.081)	(0.069)
FDI-weighted R&D stocks of G6	0.011**	
	(0.005)	
IM-weighted R&D stocks of G6	-0.007	
	(0.013)	
R&D stocks of G6		0.28***
		(0.032)
Observations	113	130

Notes: 1. Non-stationary residuals.
2. One, two and three asterisks denote values significant correspondingly at the 10, 5 and 1 % levels.

regressed productivity on a simple sum of the R&D stocks of the 6 countries, in order to see whether they are related to productivity directly, without a specific weighting scheme. As expected, such a link was not found: the residuals were again non-stationary.

3.8 Discussion and conclusions

In this chapter, we investigated FDI and capital goods imports as carriers of technological and knowledge spillovers to 11 Central and Eastern European countries, and their influence on domestic labour productivity. We found certain evidence for both FDI and imports effects, similarly to the earlier literature. However, our approach showed that these are quite different in nature. The effect of FDI is only a long-run one, i.e. the cumulative amount of FDI exercises a positive effect on the level of labour productivity, whereas a short-run relationship between these variables was not established. Moreover, as could be expected, it is a lagged effect, i.e. a recorded unit of FDI translates into domestic labour productivity with one period lag. The magnitude of the effect seems higher in the manufacturing sector than in the rest of the sectors, and also if the source country has a larger technological advantage over the host country.

In contrast, capital goods imports were found to exercise both a long-run and short-run effect, and the long-run effect involves contemporaneous import stocks, implying a faster effect as compared to FDI. Again, imports from technologically more advanced countries leads to a larger effect on domestic productivity. The above findings are relatively robust to variation in the specifications.

In general, considering both the long-run and the short-run horizons, we found more evidence of the influence of imports on productivity than that of FDI. This difference between the measured effects of FDI and imports might be due to the different nature of these effects. Imports provide new intermediate goods, which embody a certain technology and are available for immediate use; the effects of FDI however are much broader and diffuse, impacting broadly efficiency, organization and managerial practices. These are structural factors that might take much longer to change and translate into measurable aggregate improvements, but the effects of these, due to the broader scope, might well be larger in magnitude, particularly in the first part of the period (Campos and Kinoshita, 2002).

We can also compare the Solow-type and endogenous growth models. The long-term nature of the established relationships suggests that technology spillovers might have an impact on total factor productivity, i.e. that FDI and trade are indeed channels for technology transmission which increase the technology level in the host economy. Based on this evidence, it could be argued that the data provides more support for the endogenous growth model. However, the evidence is mixed on the other important criterion for distinguishing the models: the crucial role of human capital for the economy's absorption capacity. The human capital variable is significant in some specifications when included independently[10], suggesting a general positive effect on labour productivity, not necessarily related to the impact of FDI or imports. The interaction terms involving human capital do not play a role neither in the short nor in the long run in our case. This result may be due to our rather general human capital measure, which might be inadequate for our purpose. The studies which employed interaction terms often relied on a more business-relevant measure of human capital, like the share of workers in a certain sector with secondary or higher education (Bijsterbosch and Kolasa 2009), which was however not available for our full sample.

The lack of relation between the R&D stocks of the technological leaders and productivity levels in our sample is at odds with previous findings of the literature on other countries (e.g. Coe and Helpman 1995 on OECD countries), and has at least two possible reasons. To start with, our calculated R&D stocks can actually be poor proxies of the actual accumulated amount of technology know-how in a country. R&D expenditures only reflect domestic innovative activity and do not capture efforts towards adoption or imitation of a technology developed abroad. An intermediate good imported from a particular country, even if it is produced in the latter, may embody technology invented in a third country, i.e. it is a result of the third country's R&D activity. In this way, our measure does not take into account that the overall technological level in the source country may be also a function of international trade.

Second, it was already mentioned that while international economic linkages might indeed have positive influence on domestic productivity, it might be driven less by the inflow of superior intermediate goods, and more by improvements in management, organization and efficiency. R&D stocks are too narrow to capture the latter factors since they are a purely technology-related characteristic. It would be insightful to consider broader measures of knowledge, which would however be hard to find in practice. One possibility could be the labour productivity in the technologically leading countries, since it is likely to incorporate the influence both of technology and of other factors, which are hard to observe or measure, but could constitute a part of the knowledge spillover associated with trade or FDI. This investigation might be an object of further research in the area.

The time period encompassed in the current study has been a period of robust growth for the Central and Eastern European economies. However, in 2008 the region has entered a period of economic downturn, accompanied by a sharp decrease in the volume of foreign investment and trade worldwide. An interesting question would be to investigate whether

[10] Without the time dummies, the human capital variable was significant in all long-run specifications.

the changed economic conditions have brought about a change in the relationship between these technology transfer channels and labour productivity. Moreover, since international capital flows are a phenomenon with a clear space dimension, another area of future work is revisiting the link between foreign capital and productivity taking into consideration the dependencies among countries through spatial econometric techniques, similar to those used in Chapter 2.