Forschungsstelle Osteuropa an der Universität Bremen

Research Centre for East European Studies at the University of Bremen

Changing Europe Summer School III
Central and Eastern Europe in a Globalized World

Bremen, 28 July – 2 August 2008

sponsored by the Volkswagen Foundation

www.changing-europe.org

Marius Sebastian Sorin Krammer: Technological Gains from Global Integration via Trade and FDI. The Case of Transition Countries from Eastern Europe and Central Asia

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Publikationsreferat / Publications Dept.

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Language editing: Hilary Abuhove and Christopher Gilley

Abstract

Over the last decades, globalization has increased tremendously the flows of goods and investments around the world. Besides the usual benefits associated with them (a larger variety of products, lower prices, job creation and economic growth) these flows facilitate also technology transfers between developed and developing countries. Over the last 18 years Eastern Europe has made major progress in reintegrating in the world trade and financial structures and this process brought along some technological gains.

This paper explores empirically the effect of research and development (R&D) spillovers from OECD to 27 transition countries (via imports of intermediate goods and direct investment) on domestic productivity. Traditional econometric methods (OLS) along dynamic cointegration techniques (DOLS) are used to quantify and certify the robustness of our results. Overall, we find that trade remains the main driver of R&D spillovers from abroad, while the effects of FDI are smaller in magnitude. As controls, we employ measures of human capital and domestic R&D stocks along investment rates and government expenditure. In addition, the size and efficiency of these factors varies a lot within the sample. While Central and Eastern Europe benefits from both trade and FDI, South Eastern Europe is relying mainly on imports and own R&D. In comparison, the former Soviet Union countries' productivity receives little both from trade and FDI from OECD, due to rather local trade polarization around Russia and low FDI per capita.

Overall, the results open the way for future research in this area and yield some clear policy lessons for transitional countries: enhance their domestic efforts (R&D investment, education), open up more to world trade and attract FDI (preferably high technological content one) by making use of their comparative advantages (high skilled labour, lower costs, growing business environment and reforms). Although many improvements with respect to trade and investment openness have already taken place in Eastern Europe, many CIS countries have yet significant ground to cover. Moreover, the local policymakers need to give special attention towards supporting education, science and research as future engines for sustained growth as validated by the achievements of economic 'growth miracles' like Taiwan, Korea or even China.

1. Introduction

Without a doubt, technology resulting from research and development (R&D) efforts is one of the main drivers of productivity growth as postulated by endogenous growth models (Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991). In this context, R&D spillovers from abroad are a significant source of growth for developing and transition countries that do not perform much R&D domestically[1]. Globalisation has triggered a world-wide surge of trade and investment flows, of which Eastern Europe obtains an increasingly significant share from year to year. Moreover, these links provide access to new-to-the-world innovations that further boost growth.

Technology—and, more generally, knowledge—can flow between countries via many channels. It can be embodied in flows of intermediate goods employed in production processes or arrive via foreign direct investment (FDI) that brings new equipment, know-how and human resources; it can also be disembodied as codified information in the form of patents or de-codified when licenced to a contractor. Furthermore, there is also a strong consensus in the literature that countries that are far from the world's technological frontier tend to gain most from the spillover process, since most of the technologies flowing in are new to them and provide further productivity gains[2]. Thus, developing and transition countries should focus their efforts on opening themselves up to these spillovers in order to maximise their absorptive capacity.

The present study synthesises these technological gains for Eastern European transition countries. Moreover, it takes an in-depth look at the regional differences in terms of foreign R&D impacts on domestic productivity and absorptive capacity. Two main channels for R&D spillovers are considered, namely the import of goods and foreign direct investment from 25 OECD countries, which account for most of the R&D done in the world. Thirdly, it differentiates between three regional groups of transition countries that differ significantly in terms of economic standards (per capita income), proximity to the West (geographical, cultural and technological), EU affiliation (EU members that joined in 2004 or 2008, countries scheduled for accession and non-EU countries) and political systems (democracies and non-democracies). Finally, it uses the latest econometric techniques and tools to properly analyse these impacts.

This paper is organised as follows. Section 2 defines globalisation and its impact on this part of the world, focusing on trade and FDI. Section 3 provides a brief review of the literature dealing with international R&D spillovers, while Section 4 describes the analytical framework, data and econometric issues. Finally, Section 5 concludes.

2. Globalisation and Its Impact on Eastern Europe

Globalisation is broadly defined as the process of liberalisation and integration of markets (for goods, labour and capital) into single world-wide entities. Despite the attention it has received in the last decade, globalisation is not a new phenomenon; one can speak about its permanent character as well as different chapters[3].

The last phase of this process took place after the 1980s and can be described as the one most intensively fueled by technology and communication breakthroughs. There is ample evidence for this ongoing acceleration. First, the *volume of world trade* has increased a lot faster than output. Second, apart from some temporary disturbances, *capital flows* around the globe have expanded steadily. Third, *migration* has stepped up both within and between countries, despite barriers imposed by all developed countries to hinder foreign workers from entering their labour markets. Fourth, a huge *technological revolution* is under way at the global level. Knowledge diffuses rapidly in this era of information and computer technol-

1 A spillover represents the side benefits of one entity's R&D efforts on another's activities; the former entities could be firms, sectors or countries.

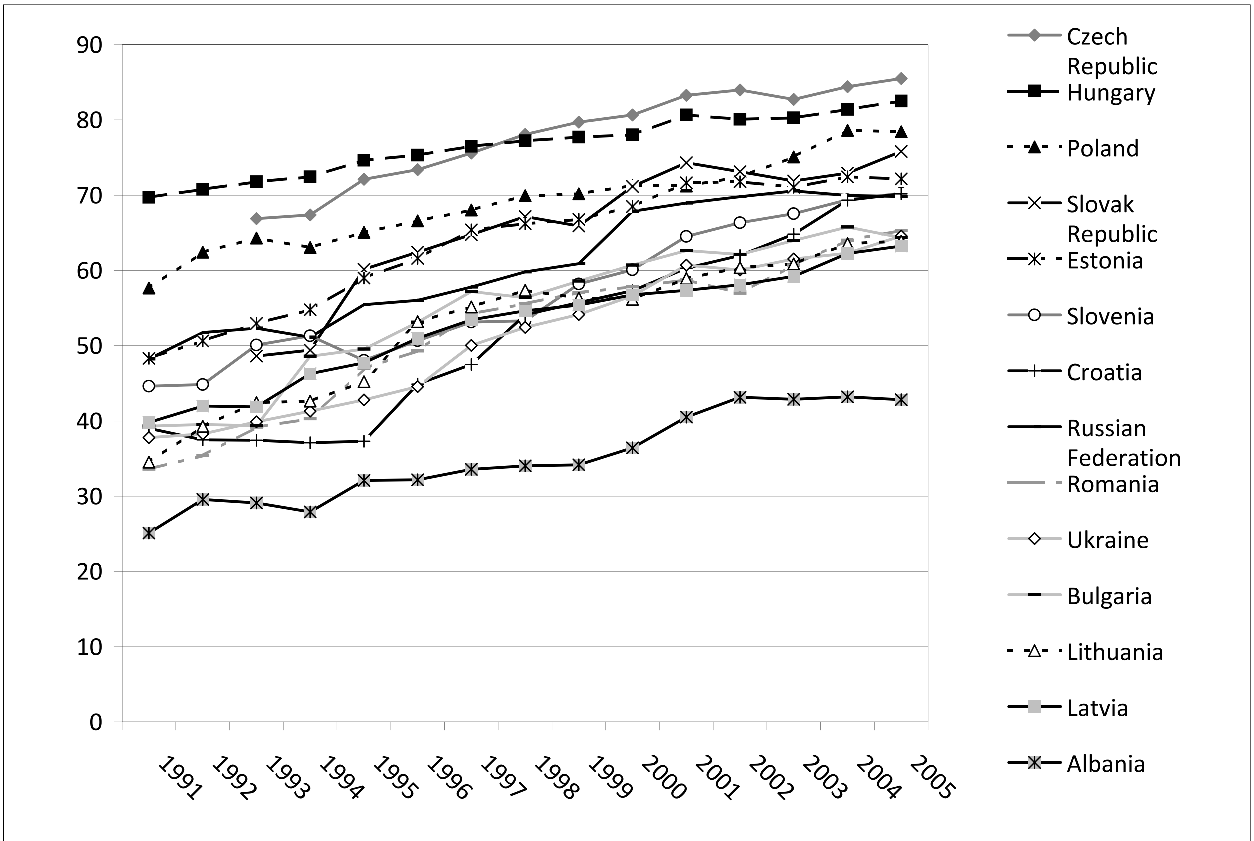
2 In the literature, this is recognised as the Veblen-Gerschenkron effect of catching up.

3 Early forms of globalisation can be found in the ascent of the Roman and Parthian Empires, the Han Dynasty and the Ottoman Golden Age.

ogy (ICT) and innovation may help low income nations to leapfrog some years in the catching-up process. *Politically*, the creation of international institutions that regulate the relations among countries proves that globalisation is developing rapidly and on a world-wide scale. In recent years, environmental issues have introduced an *ecological dimension* to globalisation as well, with problems like climate change, cross-border pollution or over-exploitation of natural resources requiring international cooperation for resolution. Finally, this gradual transformation of economic and financial institutions imposes *cultural change*[4]. The idea of openness to flows of goods, finance and people from the rest of the world deeply impacts the home country, which now bears a much greater resemblance to the 'global village' envisioned by Wyndham Lewis in his book 'America and Cosmic Man' (1948).

Eastern European countries are among the forerunners of globalisation in that they have made significant progress over a relatively short period of time in aligning their social, political and economic policies with an increasingly integrated world. Based on an evaluation of economic flows and restrictions, information flows and cultural proximity, Figure 1 graphs this process. Led by early reformers that benefited from geographical and historical proximity to the West (Czech Republic, Hungary and Poland), these countries tend to exhibit a high degree of globalisation, comparable to levels found in more developed Western economies (Belgium – 92.09, United Kingdom – 86.67 or Germany – 83.01). These data suggest that globalisation does not discriminate between developed and developing or transition countries.

Figure 1: Globalisation Index in Transition Economies



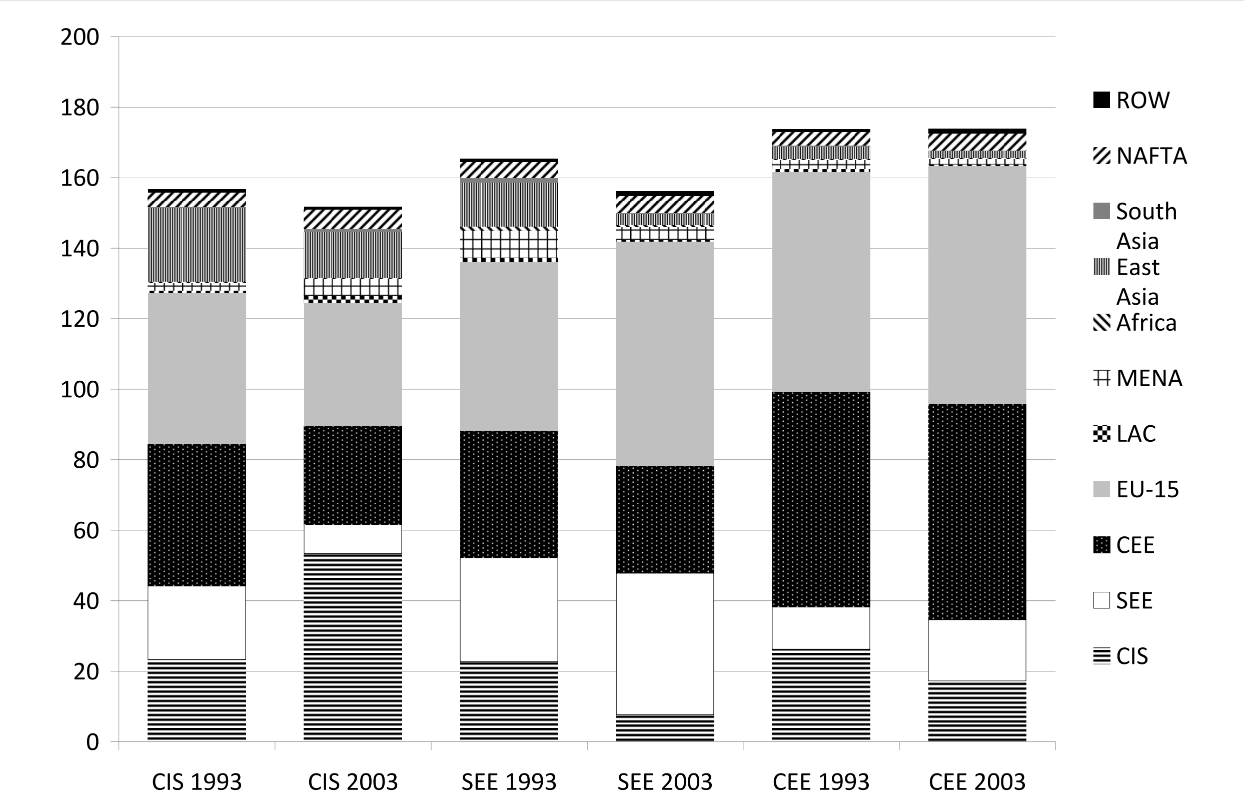
Source: author's calculations based on KOF Index of globalization (http://globalization.kof.ethz.ch)

The former Eastern communist bloc began the globalisation process after the 1990s, when the introduction of profound liberalisation and privatisation measures allowed the restoration of trade relationships within the European sphere and beyond it. Over the past decade in Eastern Europe, exports have tripled,

4 This includes the influx of multiculturalism (via arts, sports, music and films), consumer products (food, clothes, goods) from other countries, tourism and the establishment of universal values.

imports have increased two and one-half times, and trade has grown at a faster pace than in any other region of the world (Broadman, 2006). Trade liberalisation, combined with institutional and structural reforms, yields superior performances in growth rates, as in the case of Central Eastern European (CEE) states. Meanwhile, trade in the Commonwealth of Independent States (CIS) tend to take place within the region and revolves around the Russian Federation (see Figure 2). However, Russia and Ukraine are far more integrated into the world economy than their neighbours, and are thus less insular.

Figure 2: Global Distribution of the Region's Imports

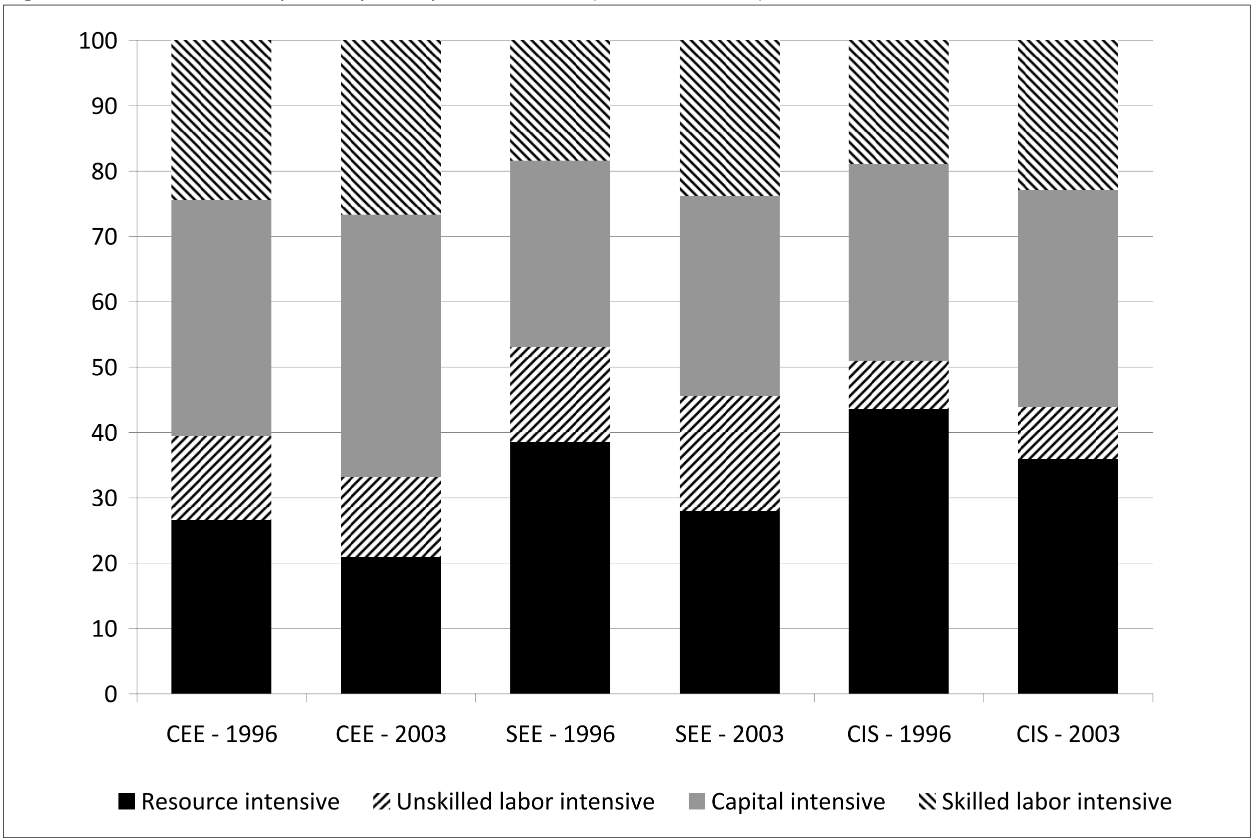


ROW – Rest of the world; NAFTA – North American Free Trade Agreement; MENA – Middle East and North Africa; LAC– Latin American countries

Source: author's calculations based on DOTS 2007

The trade data shows the emergence of regional blocs in which all CIS, SEE and CEE states traded more among themselves in 2003 compared to 1996. Second, for EEC and CEE countries, the import shares with the core European Union member states (EU-15) have increased, while CIS countries have experienced a mild decline. The latter trend could signify a possible future split among the former Eastern-bloc states around the two current poles of power, namely Russia and the EU. Trade theory postulates differences in factor endowments as determinants of trade flows between countries. This aspect can also be verified for Eastern Europe by looking at the detailed composition of imports into the region. Consistent with the Heckscher-Ohlin paradigm, capital and high-skilled-intensive products dominate the structure of imports and have increased substantially in all transition countries (see Figure 3 overleaf). Their contribution to productivity increases, which is widely acknowledged in theory, will be one of the empirical questions addressed in this study.

Figure 3: Factor Use in Imports by Group of Countries (1996 and 2003)

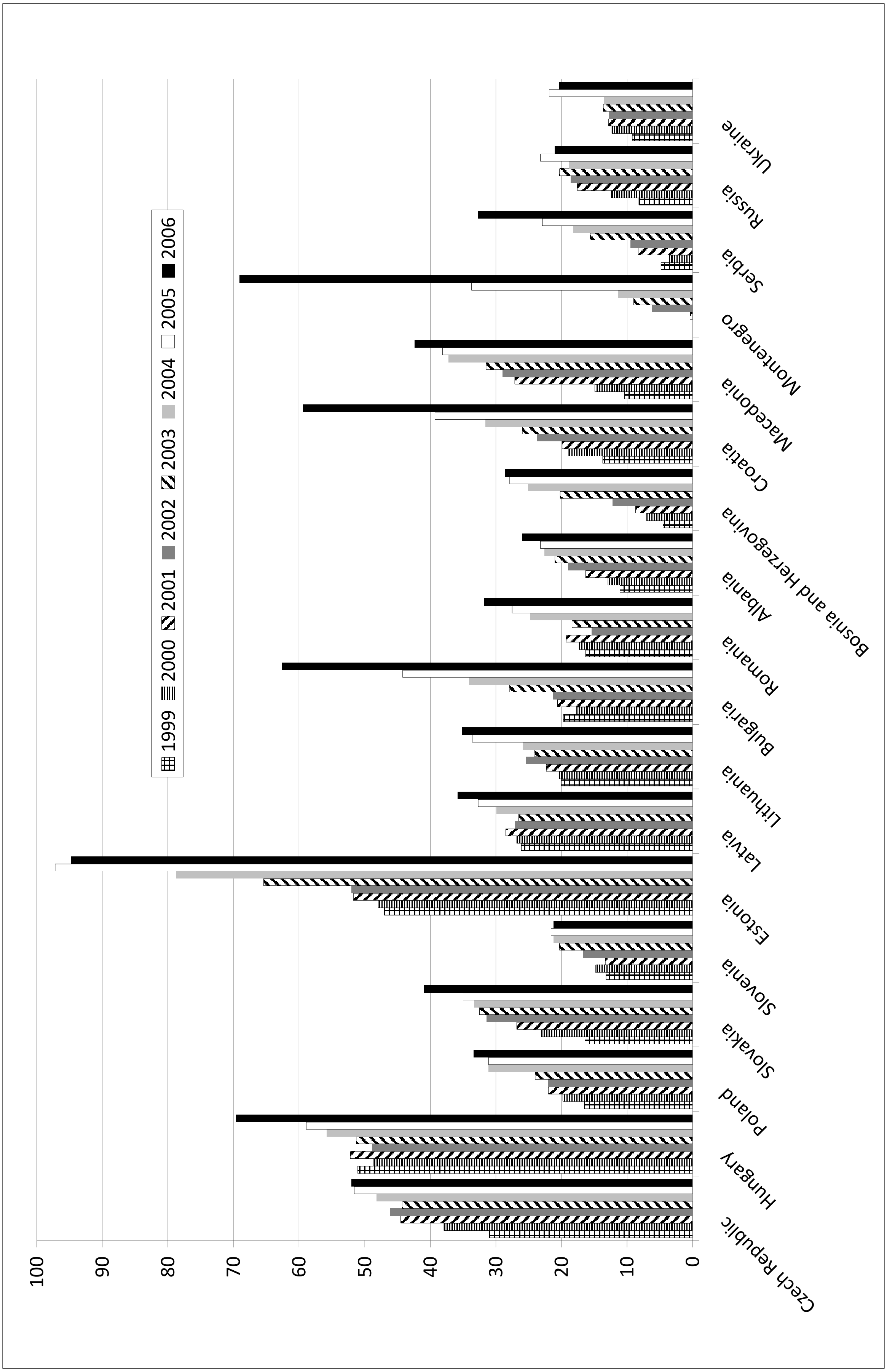


Source: based on Broadman (2006)

Parallel to the expansion of trade, FDI flows followed a similar path. Over the last decade, Eastern European countries have increasingly entered this arena and have been very successful in attracting foreign direct investment, as reflected in strong inward FDI flows and stocks.

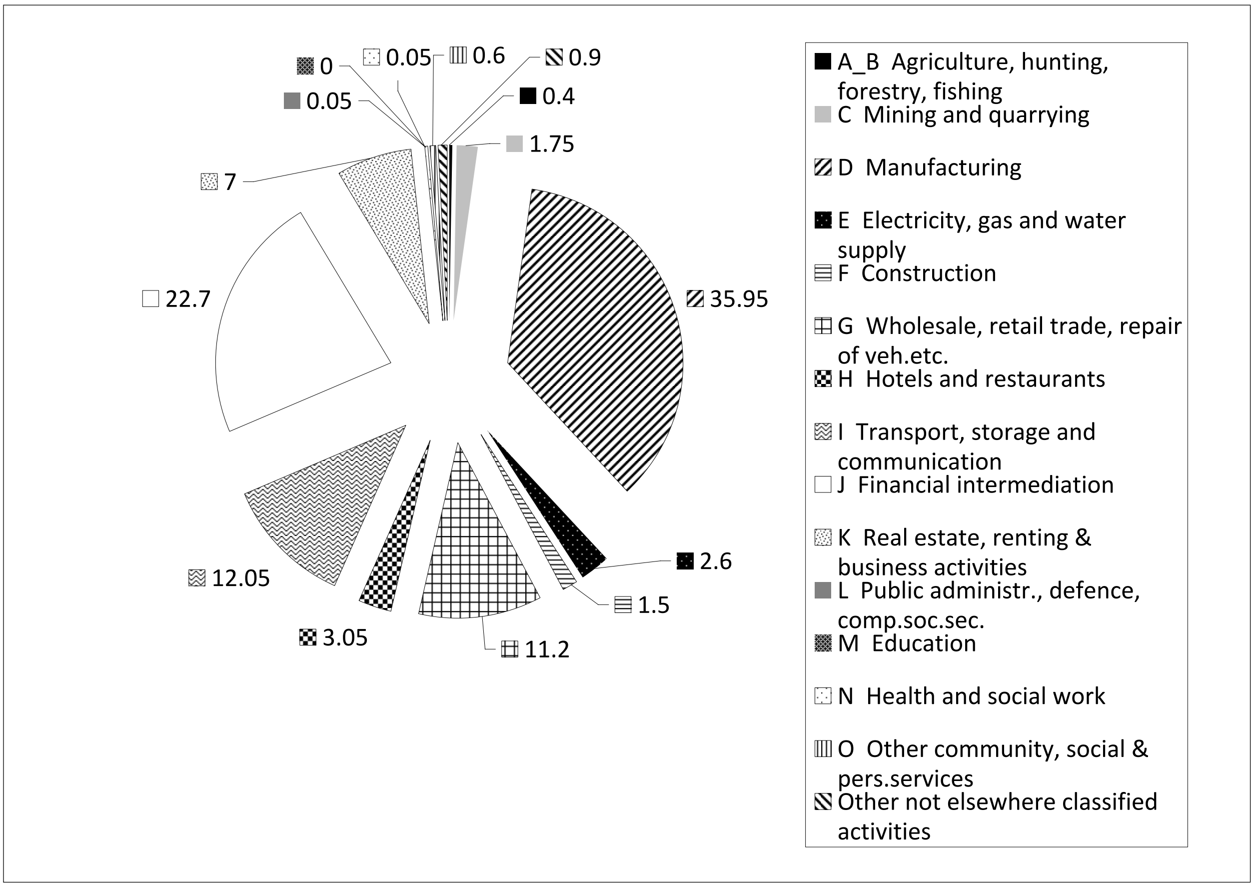
Until very recently, the countries most targeted for FDI were in Central Europe, namely the Czech Republic, Hungary and Poland. However, this trend is starting to change. According to UNCTAD (2007), in 2006 the inflows grew by 68 percent to $69 billion. The most targeted countries were the resource-rich (the Russian Federation, Kazakhstan, Ukraine) and new EU members (Romania and Bulgaria). Overall, FDI inflows have retained a stable share of 5% of the GDP while the FDI stocks in absolute numbers have grown significantly. Turning to the sectoral composition of foreign investments, we notice that manufacturing (over 35 percent of the total) and financial intermediation (22 percent), followed by transport and communication (12 percent) and wholesale and retail activities (11 percent), are prominent in Central and South Eastern Europe (see Figure 5 on p. 8). The top investors in the region are West European countries like Germany, the Netherlands and Austria, followed by the USA. Outward flows from the region have also skyrocketed in the last few years due to the expansion of Russian multinationals seeking to become key players abroad.

Figure 4: Inward FDI Stock as a Percentage of GDP



Source: based on data from World Development Indicators 2007

Figure 5: Inward Stock by Economic Activity (as of December 2005)



Source: based on data from WIIW on Foreign Direct Investment in Central, East and Southeast Europe (2007)

3. International R&D Spillovers via Trade and FDI

A research and development *'spillover'* is defined in economic terms as the benefits accrued by an entity as a result of another entity's R&D efforts. Thus, a positive externality arises from such spillovers, and this study will attempt to quantify the most important two channels of this process in the Eastern European context, namely trade and foreign direct investment.

Trade has been deemed an important channel for technology diffusion both at the macro and mezzo levels by numerous studies. As opposed to autarky, trade contributes to technology diffusion by (i) increasing the number of intermediates available for production; (ii) stimulating competition and efficiency among producers; (iii) opening up the channels for informational exchange and imitation and (iv) reducing the duplication of R&D efforts across countries. Building on a horizontal differentiation endogenous growth model, Coe and Helpman (1995) show that a country's productivity depends on both domestic and foreign R&D. Their findings have been corroborated by other contributions employing different specifications, econometric methodologies or samples of countries (Coe et al., 1997; Kao et al., 1999; Ciruelos and Wang, 2005; Lee, 2005). The latest studies use sectoral data to confirm the importance of trade-related R&D spillovers, after controlling also for intra- and inter-industry effects (Frantzen, 2002; Shiff et al., 2002; Acharya and Keller, 2007).

Foreign direct investment is emphasised in theoretical literature as a major carrier of technology through the activities of multinational companies (MNCs) around the world. MNCs possess competitive advantages over domestic firms in terms of equipment, technology, human capital and know-how. Saggi (2004) identifies three channels through which foreign R&D can spill over in the destination country of the multinational: (i) demonstration effects (adoption or imitation of MNC technology by domestic firms); (ii) labour turnover (after acquiring the new knowledge, workers start new businesses or go to work for domestic firms); (iii) vertical linkages (MNCs transfer technology to their suppliers or their customers). Empirically, the evidence is not extremely robust. While some studies (Aitken and Harrison, 1999; Kinoshita, 2000; Van Pottelsberghe de la Potterie and Lichtenberg, 2001) find no or even negative spillovers, others (Keller and Yeaple, 2005; Griffith et al. 2004) prove the opposite. There is also a big discrepancy with respect to the level of analysis: most micro-level studies tend to suffer from lack of generality while the macro-level efforts do not have quality and detailed data for FDI, especially for developing countries.

In the case of Eastern Europe there is a real need for quantitative studies on these issues. While various datasets have been used at the micro level to analyse the effect of FDI over domestic firms and sectoral productivity (Damijan et. al, 2003; Torlak, 2004), the lack of comparable and complete data has been a serious impediment in carrying out extended cross-country studies. Chinkov (2006) takes a simple look at the foreign R&D spillovers without differentiating or identifying channels through which these occur. Krammer (2008b) and Krammer (2008c) provide a more comprehensive analysis by focusing on bilateral cross-country flows of imports and FDI, respectively patents and licencing, relating them to the R&D efforts of OECD countries. All studies find significant spillover effects on Eastern European productivity.

4. Empirical Analysis

4.1. Analytical Framework

In order to analyse the impact of technological spillovers, we start with the following open economy specification in log linear form:

$$\log TFP_{it} = \alpha_i + \beta_1 \log S_{it}^{FDI} + \beta_2 \log S_{it}^{TRADE} + \beta_3 X_{it} + \varepsilon_{it} \qquad (1)$$

where TFP_{it} represents the total factor productivity, α_i are country-fixed effects, S_{it}^{FD} and S_{it}^{TRADE} are the FDI- and trade-related spillovers while X_{it} is a vector of control variables. The vector X includes measures of domestic R&D stock, human capital, investment propensity and government expenditure, which exercise a major influence on TFP and growth. Since it would be econometrically impossible in practice to estimate spillovers from all countries separately due to severe multicollinearity issues, weighting schemes are commonly applied to measures of R&D stocks. Krammer (2008c) discusses the available schemes while Krammer (2008b) shows that the results are robust between the two most common weighting schemes in practice, namely the Coe and Helpman (1995) and the Lichtenberg and Van Pottelsberghe de la Poterie (1998) specifications. Since the former arguably could suffer from an aggregation bias (a merger between two countries will increase the stock of available R&D, thus the spillovers), we will use the latter:

$$S_{it}^{TRADE} = \sum_{j=1}^{n} M_{ijt} * \frac{FRD_{jt}}{Y_{jt}} \qquad (2)$$

$$S_{it}^{FDI} = \sum_{j=1}^{n} FDI_{ijt} * \frac{FRD_{jt}}{Y_{jt}} \qquad (3)$$

where FDI_inw_{jit} (m_{jit}) represents the inward flow of FDI (imports) from country j to country I, FRD_{jt} is the stock of R&D in the donor country j, and y_{jt} is its aggregated output (GDP). Hence, S_{it}^{FDI} (S_{it}^{TRADE}) are the FDI (trade) weighted foreign R&D stock that accounts for the technological spillovers through inward FDI (imports). According to this weighting scheme, a country i will 'receive' from country j a fraction of its output that is exported (directly invested) to i times j's R&D stock at time t. Another interpretation could be that i receives the amount of knowledge embodied in the flows of FDI and trade coming from j times its *R&D intensity* at time t. As expected, this intensity varies a lot within the sample and over time. Overall, Eastern Europe shows a decline (from 0.15 to 0.06) while the Central Asian countries remain stagnant at 0.02 throughout the period.

4.2. Data

This paper uses a panel of 27 transition countries from 1990 to 2006. These can be further classified into *Central and Eastern European (CEE) countries* (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia), *South Eastern European (SEE) countries* (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Macedonia, Romania and Serbia) and members of the *Commonwealth of Independent States (CIS)* (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine and Uzbekistan). The technology spillovers originate from the 25 OECD countries that account for most of the R&D investment in the world (about 82% in 2004). This subsection provides details on the variables employed and data sources.

TFP is measured as the residual from the aggregated output production function using the country's stock of capital, labour force and output. More specifically, $\log A_{it} = \log Y_{it} - \alpha \log K_{it} - \beta \log L_{it}$. Assuming constant returns to scale, I use the labour and capital shares of 0.65 (β) and 0.35 (α), which are frequently employed in the literature. Moreover, Krammer (2008b) shows that this is a reasonable approximation and that the results are robust with the alternative of using the actual values for α and β. Data on total GDP and employment comes from the Groningen Growth and Development Centre and the Conference Board, Total Economy Database. The physical capital stock values are computed using data on aggregate investment share as a percentage of GDP from the World Table Version 6.2 using the perpetual inventory method and a rate of depreciation set at 10%.

The estimates of domestic R&D capital stock are based on the gross expenditure on R&D (GERD), which includes both business sector spending and the public R&D from universities or research institutes. In the case of the countries of origin for the spillovers (OECD 25), the data comes from OECD's Main Science and Technology Indicators 2007, while for transition countries I reconstruct the R&D stocks using data from UNESCO Statistical Yearbooks, Eurostat and national statistics offices. For computations of these stocks I again employ the perpetual inventory method with a rate of 15%, on the premise that the economic life cycle of technology is much shorter than that of capital.

Bilateral trade flows are taken from the IMF's Direction of Trade Statistics 2007 (DOTS). Openness to trade is computed as the ratio of imports to gross domestic product using DOTS data on imports and GDP data from World Development Indicators 2007. Detailed inward FDI flows are procured from the individual statistics of each of these 25 OECD countries as reported in the annexes of the UNCTAD World Investment Report 2007. I allow only for positive spillovers, claiming that disinvestment does not generate any negative effects.

As a proxy for the human capital available in a country I use two measures. The first is from the widely employed Barro and Lee (1996) dataset and its updated 2000 version. This index also covers some of the transitional countries and reports the average years of secondary schooling in male populations over 25 years old over five-year periods. The second measure of human capital that I use is the tertiary enrollment as a percent of the gross. Yearly values of this indicator come from World Development Indicators 2007. The investment and government shares of GDP are taken from World Penn Tables 6.2 between 1990 and 2004. These shares are obtained by dividing each of these components by the real gross domestic product.

4.3. Econometric Issues

Taking into account the close movements of all these aggregated time series, one cannot ignore the problem of spurious regression, which might arise when non-stationary variables are used. Thus, we need to explore this property for our variables by employing panel unit root tests. These have a higher power than the usual tests based on individual time series, especially when the latter are not very long. The last four columns in Table 3 on p. 15 show the results of several panel unit root tests suggested by Levin et al. (2002), Im et al. (2003), Breitung (2000) and Hadri (2000). Computational and statistical details about these tests can be found in the original papers. The results clearly indicate that most of these variables are not stationary. Thus, in order to estimate Equation 1, one needs to establish if there is a cointegrational relationship between them.

To test whether there is a cointegrating relationship I employ the tests proposed by Pedroni (1999). These seven residual-based tests are based on the null hypothesis of no cointegration and allow for heterogeneous cross-sectional variance. Pedroni (2004) runs various Monte Carlo experiments and suggests that the parametric *group-t statistic* and *panel-t statistic* appear to have the highest power, followed by the *panel-rho statistic*. These values and their significance levels are reported in Table 5 on p. 16. Overall, one can reject the null hypothesis of no cointegration most of the time, which makes our estimation by OLS (Ordinary Least Squares) legitimate since in this case the OLS estimator is 'super-consistent'.

Moreover, to deal with possible biases arising from endogeneity and serial correlation, I also perform regressions using a dynamic OLS estimator (DOLS). For this purpose, the DOLS introduces lags and leads of first differenced regressors in each cointegrated equation and has a smaller bias than other alternatives in small panels (OLS, FMOLS).

4.4. Estimations

Table 5 on p. 16 summarises the results of our estimation. Equations 1 to 7 report the OLS estimations, while Equations 8 to 14 present robustness checks using a DOLS estimator. I begin with including only the import-related spillovers (Eq. 1) and then I add the FDI-related ones in Equation 2. In Equation 3 I include all the variables in my model comprising the domestic R&D stock, governmental expenditures and investment rates as well as a proxy for human capital (tertiary enrollment as a percentage of the total). Finally, Equation 4 uses a second proxy for human capital, the average years of schooling in male populations over 25 in various countries, as reported by Barro and Lee (2000). Overall, trade seems to have the biggest impact on productivity, with estimated elasticities between 0.090 and 0.129; these are highly significant[5]. FDI's influence is lower (0.006 to 0.008) and less robust, perhaps due to the lower quality of the FDI data, especially for the CIS countries. Education levels have a positive impact on TFP but do not achieve statistical significance in most cases.

In an attempt to differentiate the effects of these factors among sub-regional groups of countries, I perform the full specification regression in these sub-samples. The results confirm that trade remains significant and exhibits the highest coefficient, while FDI is significant only for the CEE countries. Domestic R&D and human capital contribute significantly to the SEE nations' productivity. The rest of the control variables are not the object of study here and their effects are very small. Comparatively speaking, SEE countries gain the most from trade-related spillovers, followed by CEE countries and CIS. In turn, FDI is a profitable channel for CEE and SEE countries but not for the CIS.

The second part of Table 5 (Equations 8 to 14) presents the DOLS estimations, which basically tell a similar story with higher estimations for both elasticities of import (0.204 to 0.282) and FDI spillovers (0.003 to 0.016). These two channels matter for CEE countries, while for SEE countries only trade and domestic R&D contribute, and for the CIS, neither one applies. However, in the case of the CIS, lack of data might influence the results, since the DOLS estimator is a more demanding procedure[6].

5 Thus, a 10 pecent increase in the trade spillovers will yield an increase in productivity of between 9 and 12 percent.

6 Taking first differences and using lags and leads significantly decreases the degrees of freedom available and reduces the explanatory power of some regressors.

5. Conclusions

Over the last decades, globalisation has become a force that is completely changing our world via economic, cultural and social dimensions. This paper explores the gains from this process by analysing the impact of R&D spillovers from abroad on domestic productivity of 27 transition countries in three groups: CEE, SEE and CIS. Moreover, it utilises the latest panel data cointegration techniques and estimation methods.

The main findings confirm that the impact of trade- and FDI-related spillovers varies substantially within the groups. While CEE countries gain from both channels significantly, SEE countries are receiving spillovers mostly via trade and complement them with domestic R&D efforts. For the CIS, trade also plays the main role, while the evidence in the case of other factors is quite weak and sometimes negatively correlated with growth. This could be driven by the general reduction trend in R&D efforts while economic growth has resumed, mainly driven by resource intensive activities. Education has a positive impact, but is not statistically significant in most of the cases. Overall, imports seem to play the most important role in the process of technology diffusion. Their estimated elasticities are robust across specifications and provide evidence of a significant effect on TFP, which in turn drives economic growth in the region. The impacts from FDI-related spillovers are smaller in magnitude and inconsistent across countries, possibly due to data limitations.

These results also have policy implications at the national level. The globalisation of goods and financial markets has brought positive spillovers to Eastern Europe via imports and FDI. This process can be amplified by engaging in trade and investment activities with R&D-intensive countries. Such efforts require further liberalisation measures and the stimulation of foreign investors via incentives and strong property rights, especially for intellectual assets. There is a real need for Eastern Europe to take advantage of its high skilled human capital and complement it with the right policy measures to attract high tech FDI in the region. Such measures will raise the level of technological spillovers in domestic markets, stimulate competition and create wealth. Moreover, Eastern European countries urgently need to invest in domestic R&D in order to rebound from the transitional depression that continues to plague them.

Appendices

Tables

Table 1: Macroeconomic Factsheet for Selected Transition Countries

Country	**Population** *(millions)*	**GDP per capita** *($ US 2006)*	**GDP per capita*** *($ US PPP)*	**Recent real GDP growth** *(2001–2005)*	**FDI inflows (% GDP)** *(2001–2005)*	**Current account balance (% GDP)** *(2001–2005)*
Bulgaria	7.7	3,683	9,975	4.9%	8.2%	-5.72%
Belarus	10.3	3,552	8,688	6.9%	0.1%	-3.08%
Czech Republic	10.2	13,035	20,563	3.2%	7.2%	-5.10%
Estonia	1.3	9,882	17,672	6.2%	8.1%	-10.76%
Georgia	4.7	986	3,277	7.2%	6.5%	-7.02%
Croatia	4.5	8,422	13,186	4.3%	5.9%	-5.44%
Hungary	10.0	11,885	17,733	3.6%	5.1%	-8.00%
Lithuania	3.6	7,342	15,464	7.3%	3.4%	-7.00%
Latvia	2.3	7,175	13,938	7.4%	3.6%	-9.14%
Poland	38.5	8,602	14,137	3.0%	3.1%	-2.20%
Romania	22.3	3,985	8,602	6.0%	5.2%	-6.42%
Russia	142.9	6,143	12,142	6.1%	1.7%	9.70%
Serbia	8.0	3,383	5,549	4.8%	2.7%	-8.98%
Slovakia	5.4	10,326	17,266	4.6%	6.6%	-5.80%
Slovenia	2.0	18,816	23,102	3.4%	2.6%	-0.06%
Ukraine	46.7	2,245	7,802	8.6%	2.2%	6.50%
USA	296.4	42,024	42,024	2.4%	1.0%	-5.00%

*GDP per capita in current prices

Source: authors own calculations based on IMF, World Economic Outlook database 2006, CIA Factbook and UNCTAD FDI online database

Table 2: The relative magnitude of the spillovers in the region

Country	**log TFP**	**log S_{it}^{TRADE}**	**log S_{it}^{FDI}**
Central Eastern Europe			
Poland	1.76	8.46	6.56
Hungary	1.75	7.94	7.27
Czech Republic	1.75	8.30	6.35
Slovakia	1.76	7.03	4.36
Estonia	2.12	5.96	4.24
Slovenia	2.06	7.13	3.11
Latvia	2.06	5.82	3.46
Lithuania	1.68	6.08	2.03
Regional average	*1.87*	*7.09*	*4.67*
South Eastern Europe			
Romania	1.15	7.01	3.92
Croatia	2.01	6.74	3.57
Bulgaria	2.04	6.17	3.25
Serbia	1.40	5.25	1.84
Bosnia Herzegovina	2.27	4.84	-0.15
Macedonia	1.55	4.95	0.73
Albania	0.93	4.29	-0.42
Regional average	*1.62*	*5.61*	*1.82*
Commonwealth of Independent States			
Russian Federation	1.16	8.56	6.17
Ukraine	0.80	6.61	3.16
Kazakhstan	1.65	5.48	3.49
Uzbekistan	1.52	5.04	1.27
Azerbaijan	1.52	4.38	3.30
Belarus	1.49	5.29	-0.43
Turkmenistan	0.79	3.86	1.52
Kyrgyzstan	1.10	2.89	1.83
Moldova	0.75	3.83	
Armenia	1.61	3.63	0.68
Georgia	1.65	3.93	-0.95
Tajikistan	0.42	2.50	
Regional average	*1.20*	*4.67*	*1.67*

Source: author's own calculations

Table 3: Descriptive Statistics and Panel Unit Root Tests

Variable	Description	Obs	Summary Statistics				Unit Root Tests			
			Mean	St.Dev	Min	Max	LLC	IPS	B	H
log TFP_{it}	Log Total Factor Productivity	459	1.50	0.53	-0.02	2.58	18.44	-0.99	1.57	9.92***
log S_{it}^{TRADE}	Log Trade Spillovers	408	5.64	1.87	-1.13	9.77	33.46	-0.20	1.78	6.53***
log S_{it}^{FDI}	Log FDI spillovers	267	3.29	2.82	-5.36	8.74	3.00	-0.61	-2.52	17.56***
log DRD_{it}	Log Domestic R&D	451	7.43	1.95	4.05	12.51	9.08	2.10	3.66	11.45***
ki	Investment (% GDP)	459	14.03	8.58	0.38	51.50	0.47	-3.24***	-0.15	8.73***
gov	Gov. expenditure(% GDP)	388	29.67	8.17	8.56	78.64	-14.67***	-3.31***	-1.59*	16.92***
log $school_{it}$	Log Avg. School years	323	2.18	0.14	1.79	2.35	-1.2e^12***	-1.3e^9***	-8.89***	6.37***
log $tertiary_{it}$	Log Tertiary (% of total)	442	3.40	0.50	1.94	4.30	5.35	1.10	-2.01**	7.44***

Note: *, ** and *** indicate parameters that are statistically significant at 10%, 5% and respectively 1%; for unit root tests, LLC, IPS and B have the null of unit root; H has stationarity; all tests have been performed using a 4 lag specified structure and intercept and trend; for H test I report the heteroscedastic consistent Z stat.

Table 4: Correlation Matrix

Variable	log TFP	log S_{it}^{TRADE}	log S_{it}^{FDI}	log DRD_{it}	ki	gov	log $school_{it}$	log $tertiary_{it}$
log TFP_{it}	1.00							
log S_{it}^{TRADE}	0.00	1.00						
log S_{it}^{FDI}	0.15	0.72	1.00					
log DRD_{it}	-0.49	0.62	0.31	1.00				
ki	0.26	0.46	0.33	0.11	1.00			
gov	0.16	-0.27	-0.15	-0.18	-0.18	1.00		
log $school_{it}$	-0.35	0.19	0.19	0.39	-0.06	0.00	1.00	
log $tertiary_{it}$	0.09	0.05	0.04	-0.00	0.01	0.24	0.21	1.00

Table 5. Estimation results (OLS and DOLS)

Estimator	OLS							DOLS						
sample	***trc***	***trc***	***trc***	***trc***	***cee***	***see***	***cis***	***trc***	***trc***	***trc***	***trc***	***cee***	***see***	***cis***
equation	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***
log S_{it}^{TRADE}	0.109**	0.119***	0.129***	0.148***	0.090***	0.165***	0.078*	0.282***	0.255***	0.269***	0.204***	0.140***	0.362***	-0.066*
	(0.053)	(0.036)	(0.039)	(0.265)	(0.027)	(0.028)	(0.041)	(0.012)	(0.034)	(0.038)	(0.035)	(0.050)	(0.047)	(0.036)
log S_{it}^{FDI}		0.007	0.008*	0.006***	0.019***	0.012	-0.002		0.003	0.016**	0.008	0.035***	0.011	-0.020*
		(0.005)	(0.004)	(0.002)	(0.007)	(0.010)	(0.009)		(0.011)	(0.007)	(0.008)	(0.005)	(0.012)	(0.010)
log DRD_{it}			0.063	0.062***	-0.002	0.254***	-0.330***			0.204***	0.081	0.059	0.325***	-0.347***
			(0.049)	(0.013)	(0.050)	(0.037)	(0.090)			(0.059)	(0.065)	(0.056)	(0.054)	(0.082)
ki			0.000	-0.008***	-0.004**	0.006***	0.009**			-0.015***	-0.182***	-0.014***	-0.004	0.005
			(0.003)	(0.001)	(0.002)	(0.002)	(0.003)			(0.003)	(0.002)	(0.002)	(0.006)	(0.006)
gov			-0.014***	-0.008	-0.009**	0.004	-0.026***			-0.016***	-0.006	-0.021***	0.005	-0.039***
			(0.003)	(0.006)	(0.004)	(0.002)	(0.008)			(0.005)	(0.004)	(0.002)	(0.004)	(0.004)
log $school_{it}$				0.019							0.497			
				(0.053)							(1.013)			
log $tertiary_{it}$			0.053*		0.047	0.187***	-0.139			-0.031		-0.039	0.106*	-0.198
			(0.030)		(0.031)	(0.044)	(0.124)			(0.036)		(0.060)	(0.056)	(0.149)
Pedroni tests														
Panel rho-stat	4.08***	5.25***	6.31***	8.89***	13.06***	-0.48	2.96***	4.08***	5.25***	6.31***	8.89***	13.06***	-0.48	2.96***
Panel t-stat	1.95*	3.05***	-10.14***	-5.79***	-4.55***	-5.56***	2.40**	1.95*	3.05***	-10.14***	-5.79***	-4.55***	-5.56***	2.40**
Group t-stat	-3.24***	-2.87***	-22.67***	-3.45***	-2.27***	-2.18**	-0.96	-3.24***	-2.87***	-22.67***	-3.45***	-2.27***	-2.18**	-0.96
R squared	0.89	0.928	0.944	0.918	0.918	0.977	0.921	0.953	0.964	0.981	0.987	0.987	0.997	0.998
Cross-sections	27	25	24	19	8	6	10	27	21	20	16	8	5	7
N	408	254	238	268	93	68	77	327	172	162	137	69	48	45

Notes: The dependent variable is logarithm total factor productivity; 'trc' represents all transition countries, 'cee'-Central and Eastern Europe, 'see'- South Eastern Europe, 'cis'- Commonwealth of Independent States. *, ** and *** indicate parameters that are significant at the 10%, 5% and respectively 1%; Standard errors are reported in parenthesis below the coefficients; All estimated models contain unreported fixed effects and use White standard errors; For the Pedroni unit root tests, the null hypothesis for both tests is no cointegration; the lag selection is automatic based on Schwarz information criterion; the tests use a Newey-West bandwidth selection with Bartlett kernel. The DOLS estimator contains one lag and one lead of first differenced regressors.

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