6. FOREIGN DIRECT INVESTMENTS, TECHNOLOGY TRANSFER AND ECONOMIC GROWTH. A PANEL APPROACH

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Abstract

This paper calls into question the existing of a direct and positive impact of foreign direct investments on economic growth. Considering that many controversial results have been caused by the use of cross-country or time-series investigations that do not reveal all facets of this complex issue, we resorted to panel data, thus capturing the continuously evolving country-specific differences. Our study, made on seven East-European countries, during 1993-2009, is based on panel OLS / GMM fixed and random effect estimations, panel cointegration and causality analysis. The results not only reveal a direct and positive influence of foreign direct investments on gross domestic product, both in the short and in the long-run, therefore reducing the technological gap with more developed countries, but they also render a reverse causality running from GDP to FDI.

Keywords: economic growth, foreign direct investments, absorption capacity, long-run equilibrium, bi-directional causality
JEL Classification: F21, F43

1. Introduction

FDI is traditionally conceived in Solow-type standard neoclassical growth models as an addition to the capital stock of the target economy (e.g., Brems, 1970). Considering this, we could state that the influence of FDI on growth is similar to that of domestic

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capital: given the diminishing returns on capital, FDI has just a temporary impact on the target country's growth rate. From this perspective, investments may be only a source of short-run economic growth determined by the transitional dynamics to the steady-state growth path, while long-run economic growth may be reached by technological progress, the latter being considered as independent from any investment-related activities.

In endogenous growth models (Romer, 1986, 1987; Lucas, 1988), the potential role of FDI significantly increases. There are several channels by which FDI is able to permanently affect the growth rate, by acting on each argument of the production function. First of all, FDI influences the related output by increasing the stock of capital. Although this impact is likely to be small, given the assumption of perfect substitutability, if foreign and domestic capitals are complements, the final impact of FDI on aggregate output will be obviously higher. If foreign and domestic capitals are differently treated, considering for instance the enlargement of the variety of intermediate goods and capital equipment, FDI can raise productivity in the host country (Borensztein et al., 1998). FDI also affects labour by generating new jobs, even if this could be seen as a short-run effect. More than that, the theory of endogenous economic growth provides an answer to the main issue faced by the neoclassical growth theory, namely the diminishing returns, by positive externalities associated with investments. This allows us to understand the favourable traces of FDI on economic development, generated by technological spillover. This happens when the technological knowledge obtained through investments made in one company causes the technological increase of other companies, the total return on investment being therefore higher. Thus, the capital marginal productivity will not necessarily decrease once the capital-to-output ratio increased (Oxelheim, 1996). The important and long-run effect of FDI is therefore the transfer of technology and know-how that are embodied in human capital. If investments bring sufficient new knowledge, they may lead, according to the endogenous growth theory, to long-run economic growth. As FDI is usually identified itself with such a pattern, it can be seen as a catalyst of the target country's long-run economic growth.

Considering the supposed contribution of foreign direct investments to the economic development of countries, we undertake to analyse in detail in our paper the nature and intensity of the relationships established between such variables, resorting for this purpose to a panel data analysis so as to capture the continuously evolving country-specific differences, thus strengthening the estimations performed. The study is based on data obtained for seven Eastern European countries: Romania, Bulgaria, Hungary, Poland, Moldova, Czech Republic and Slovak Republic, for the period 1993-2009.

2. Literature Review

As we can see hereinafter, unlike the existing theoretical studies, the empirical ones reveal various disputes relating to the effective impact of FDI on economic growth. Even if there are studies showing a positive and strong influence between the variables considered, there are others evidencing a weak and insignificant impact, a reverse or bi-directional relationship or even no causality relationship at all.

The positive effects of FDI on growth or productivity are identified by Bende-Nabende and Ford (1998) who concluds that FDI promotes economic growth, after having resorted to the 3SLS estimator method on time series data for Taiwan for the period 1959-1995 and to a simultaneous equation model founded on a supply side approach to growth, the measure of FDI impact being the difference operator of FDI flow. Soto (2000) dealt with the dynamic approach with control variables suggested by Barro and Sala-I-Martin (1995), FDI being analyzed as a percentage of GDP. Panel data on 44 countries between 1986–1997 were used for the GMM-DIFF estimation that revealed a positive and significant correlation of FDI with growth. A strong complementary connection for both developed and developing countries was also identified by Li and Liu (2005), who resorted to a panel data set of 84 countries ranging between 1970 and 1999 and approached random/fixed effects estimation. Kinoshita and Chia–Hui Lu (2006) highlighted the role of infrastructure as one of the most important determinants for enhancing the efficiency of FDI. In the overlapping generational model, the degree of technology spillovers is determined by FDI inflows and technology gap conditional on the country's infrastructure level. A panel data of 42 non-OECD developing countries for the period 1970-2000 is selected and the empirical analysis is based on a reduced form approach. Albert Wijeweera et al. (2010) analyzed the relationship between FDI and the rate of growth of GDP based on a stochastic frontier model with panel data for 45 countries over the period 1997-2004, and find out that FDI inflows exerted a positive impact on economic growth in the presence of highly skilled labour; corruption has a negative impact on the same; and trade openness increases economic development by means of efficiency gains.

As below mentioned, several authors did not find a clear or significant relationship between foreign direct investments and economic development. De Mello (1999) analyzed 15 OECD and 17 non-OECD countries for the period 1970-1990, by using panel and time series data and by applying stationary tests. His goal was to find out FDI effects coming from technology and improved management and organization on the target country economic development, but the results of his analysis indicated only weak evidence of such influence. Laureti and Postiglione (2005) resumed the Soto framework, using FDI as percentage of GDP and calling a panel data set 11 Mediterranean countries, between 1990 and 2000, while applying GMM-DIFF estimation. In their study, FDI variable proved to be poorly significant in explaining growth. Carkovic and Levine (2005) criticized the existing empirical studies as not fully controlling the simultaneity bias, country-specific effects and the use of lagged dependent variables in their growth regressions. They used OLS and GMM techniques on cross-section and panel data and assessed the FDI-growth relationship for 72 countries covering the period 1960-1995, their findings suggesting that FDI does not exert a robust, independent influence on economic growth. By applying techniques of panel cointegration and panel error correction models for a set of 37 countries and using annual data for the period 1970-2002, Lee, Chang (2009) have explored the directions of causality among FDI, financial development, and economic growth and obtained solid evidence of a strong long-run relationship. Besides, the financial development indicators proved to have a larger effect on economic growth than FDI. Overall, the findings underscored the potential gains associated with FDI when coupled with financial development in an increasingly global economy.

Moreover, different papers have revealed the reverse or the bi-directional causality between FDI and economic growth. Zhang (1999) investigated the causality between FDI and economic growth in 10 East Asian economies and found that FDI seemed to augment economic growth in the long-run in China, Hong Kong, Indonesia, Japan, and Taiwan and in the short-run for Singapore. In another study conducted the same year, Zhang applied cointegration and error-correlation models to investigate the long-run relationship and short-run dynamics between FDI and economic growth in China. The findings support the existence of both a long-run equilibrium link and a two-way Granger causal relationship between FDI and Chinese economic growth. The two-way link between foreign direct investment and growth for India was also explored by Chakraborty and Basu (2002) who resorted to a structural cointegration model with vector error correction mechanism. The results suggested that GDP in India was not Granger caused by FDI, and the causality was running mostly from GDP to FDI. Using data on 80 countries for the period 1971-1995 and implementing Granger causality tests in a bi-variate framework, Choe (2003) detected a two-way causation between FDI and growth, but the effects are more apparent from growth to FDI. The results from these bilateral causality tests were highly mixed. While the tests used are computationally easy, the omission of other relevant variables could result in spurious causality (Granger, 1969; Lutkepohl, 1982; Sims, 1972). Chowdhury and Mavrotas (2006) resort to an innovative econometric methodology based on the Toda-Yamamoto test, in order to study the causality between the FDI and economic growth. Time-series data covering the period 1969-2000 are used for three developing countries, namely Chile, Malaysia and Thailand, all of them major recipients of FDI with a different history of macroeconomic episodes, policy regimes and growth patterns. The results indicate that it is GDP that causes FDI in the case of Chile and not vice versa, while for both Malaysia and Thailand, there is a strong evidence of a bi-directional causality between the two variables. The robustness of the such findings is confirmed a bootstrap test that confirm their validity. Andraz and Rodrigues (2010) analyze possible causality between exports, inward foreign investment and economic growth in Portugal by using a three-stage procedure based on unit root, cointegration and causality tests applied to annual data from 1977 to 2004. Exports and FDI seem to foster growth in the long-run while in the short-run there is a bi-directional causal relationship between FDI and growth and a uni-variate causal relationship running from FDI to exports. FDI is viewed as a major determinant of economic growth, both directly and indirectly, via exports for both long and short-run cases.

As we can see, the impact of FDI on economic growth remains a controversial issue, due, on one hand, to the miscellaneous samples used, for various countries at different levels of development and facing different circumstances and, on the other hand, to the use of a multitude of methodological instruments, some of them not very relevant or already contested. Therefore, the relationship between FDI and economic development is far from being conclusive. The role of FDI appears to be country or period-based, and it can be positive, contradictory, or insignificant, depending on the economic, institutional, and technological conditions characterizing the target economy.

3. Model

Hereinafter we try to analyse the possible impact of FDI on economic growth, considering for this purpose, other different important variables of influence and some terms of interaction between the same.

We begin by constructing several models, relevant according to the literature in the field, selecting thereafter the most appropriate of them in order to deepen our econometric study.

The models considered are as follows:

$$GDP_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 DI_{it} + \beta_3 TG_{it} + \beta_4 INF_{it} + \beta_5 TO_{it} + \varepsilon_{it} \quad (1)$$

$$GDP_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 DI_{it} + \beta_3 TG_{it} + \beta_4 INF_{it} + \beta_5 EDU_{it} + \varepsilon_{it} \quad (2)$$

$$GDP_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 DI_{it} + \beta_3 TG_{it} + \beta_4 INF_{it} + \beta_5 EDU_{it} + \beta_6 (FDI_{it} \times TG_{it} \times EDU_{it}) \div \varepsilon_{it} \quad (3)$$

$$GDP_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 DI_{it} + \beta_3 TG_{it} + \beta_4 INF_{it} + \beta_5 EDU_{it} + \beta_6 (FDI_{it} \times TG_{it} \times INF_{it}) \div \varepsilon_{it} \quad (4)$$

$$GDP_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 DI_{it} + \beta_3 TG_{it} + \beta_4 INF_{it} + \beta_5 EDU_{it} + \beta_6 (FDI_{it} \times TG_{it} \times EDU_{it} \times INF_{it}) \div \varepsilon_{it} \quad (5)$$

$$GDP_{it} = \alpha + \beta_1 FDI_{it} + \beta_2 DI_{it} + \beta_3 TG_{it} + \beta_4 INF_{it} + \beta_5 EDU_{it} + \beta_6 (FDI_{it} \times TG_{it} \times EDU_{it}) \div \beta_7 (FDI_{it} \times TG_{it} \times INF_{it}) + \varepsilon_{it} \quad (6)$$

where ε_{it} is the stochastic error term, and $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ and β_7 are parameters to be estimated.

4. Data and Methodology

4.1. Data

The annual data used in this paper concern six variables of interest, as follows:

- *Gross domestic product (GDP)* – Gross domestic product per capita is more useful that GDP in absolute value or GDP rate when comparing the economic standing across countries, and for this reason it was selected for this analysis.
- *Foreign direct investments (FDI)* - There are two types of FDI: inward foreign direct investment and outward foreign direct investment, resulting in a net FDI inflow (positive or negative) which is going to be used in the paper.
- *Domestic investments (DI)* - It comprises replacement purchases plus net additions to capital assets plus investments in inventories, included in our model, as gross capital formation.
- *Technological gap (TG)* - It represents the convergence of countries to the most developed ones, therefore, being rendered by the economic gap, computed as the difference between the output level per capita of a leading country and that of country *i*, all divided by the GDP per capita of country *i* (Li and Liu (2004)).

$$TG_{it} = \frac{GDP_{USAt} - GDP_{it}}{GDP_{it}}$$

- *Infrastructure (INF)* – Infrastructure typically refers to the technical structures that support a society, such as roads, electrical power supply, water distribution, *telecommunications*, education, health care and so forth, which are essential for any country's economic development. Due to lack of data, we will select just three variables to define infrastructure. We will compute infrastructure by principle component analysis, based on road density, energy consumption and telephone lines.
- *Level of education (EDU)* – It stands for the capacity of countries to absorb and benefit by any external information and technology. Here it is rendered by the percentage of high school graduates out of the total labour force of each country.
- *Trade Openness (TO)* – This variable reflects the degree of economic interconnections between countries and it is rendered by the weight of exports (E_{it}) and *imports* (I_{it}) in GDP.

$$TO_{it} = \frac{E_{it} + I_{it}}{GDP_{it}}$$

Beside, in order to reveal the indirect impact on GDP, we used the following interaction terms:

- $FDI \times TG \times INF$ - The term of interaction between FDI, TG and INF represents the technological spillover of FDI conditional on infrastructure.
- $FDI \times TG \times EDU$ - The term of *interaction* between FDI, TG and EDU renders the technological spillover of FDI conditional on educational level.
- $FDI \times TG \times INF \times EDU$ - The term of interaction between FDI, TG, INF and EDU suggests a technological spillover of FDI conditional on infrastructure and educational level at the same time.

GDP, FDI, DI, TG and TO are expressed in U.S. dollars, constant prices. For standardisation we used some variables in natural logarithm (l_GDP, l_FDI and l_DI). The data employed in this paper are obtained from World Development Indicators 2010 - World Bank. All estimates are obtained by means of Eviews 7.0 software.

4.2. Methodology

4.2.1. Panel unit root tests

There is a large range panel unit root tests: Levin, Lin and Chu (2002), Breitung (2000), Im, Pesaran and Shin (2003), Fisher-type tests using ADF and PP tests (Maddala and Wu (1999) and Choi (2001)), and Hadri (2000). Such tests are in fact multiple-series unit root tests applied to panel data structures (the existing cross-sections generating multiple series out of one series).

Maddala and Wu (1999) resorted to a comparison between these tests and found that, on one hand, when there is no cross-sectional correlation in the errors, the IPS test is more powerful than the Fisher one and, on the other hand, when dealing with heteroscedasticity and serial correlation of errors, the Fisher test is better than the LL or IPS test. Besides, for medium values of T and large N, the scale of distortion of the Fisher test is of the same level as that of the IPS test. In cases of a mixture of stationary and non-stationary series in the group, the Fisher test is the best. One of the Fisher test disadvantages is that the critical values are to be derived by Monte Carlo simulation. The IPS test is easy to be used as tables of the critical values are made available in the same framework. Therefore, we have decided to use in our paper the IPS test in order to see if our series are stationary.

Im, Pesaran, and Shin first specify a separate ADF regression for each cross section:

$$\Delta y_{it} = \alpha y_{it-1} + \sum_{j=1}^{\theta_i} \beta_{ij} \Delta y_{it-j} + X'_{it}\, \omega + \varepsilon_{it}$$

where the null hypothesis (the series contains a unit root I(1)) might be rendered as follows:

$$H_0 : \quad \alpha_i = 0 \quad for \quad i = 1,2,\ldots N$$

while the alternative hypothesis (some cross-sections do not have unit root) shall be:

$$H_1 : \begin{cases} \alpha_i = 0 & for \quad i = 1,2,\ldots N_1 \\ \alpha_i < 0 & for \quad i = N_{1+1}, N_{1+2},\ldots N \end{cases}$$

IPS calculates ADF t-stat separately for each individual group and then it averages across these groups.

4.2.2. OLS and GMM estimations with no / fixed / random effects

If data are stationary or rendered stationary by resorting to differences of various orders, the model may be estimated by using several econometric methods, among which the panel ordinary least squares (OLS) or the generalized method of moments (GMM), with no, fixed or random effects. Considering the specific features characterizing each country, it is not quite suitable to use panel estimation methods with no effects. For this reason, we also resort to fixed effects (FE) and random effects (RE) estimates for both OLS and GMM methods, followed by a Hausman test which may help us in selecting the most appropriate model.

In order to see how the fixed effects model works, we can decompose the disturbance term, into an individual specific effect (encapsulating all of the variables that affect the endogenous variables cross-sectionally but without varying over time) and the ‘remainder disturbance’, which varies over time and entities (capturing everything that is left unexplained about the dependent variables). This is the equivalent of generating dummy variables for each cross-section and including them in a standard linear regression to control these fixed "cross-section effects". It usually works best when there are relatively fewer cross-sections and more time periods, as each dummy variable removes one degree of freedom from the model.

$$y_{it} = \alpha + \beta x_{it} + \lambda_1 D1_i + \lambda_2 D2_i + \lambda_3 D3_i + \ldots + \lambda_N DN_i + v_{it}$$

An alternative to the fixed effects model is the random effects model. As with fixed effects, the random effects approach implies different intercept terms for each entity, these intercepts being constant over time. Yet, the difference is that under the random effects model, the intercepts for each cross-sectional unit are assumed to arise from a common intercept (the same for all cross-sectional units and over time), plus a random variable that varies cross-sectionally but is constant over time, variable that measures the random deviation of each cross-section's intercept term from the common intercept term.

Unlike the fixed effects model, the random effects one does not capture the heterogeneity in the cross-sectional dimension by means of dummy variables but via the random variable terms.

The fixed effect assumption is that the individual specific effects are correlated with the independent variables. On the contrary, the random effects assumption regards the uncorrelation between the above-mentioned. Therefore, if the random effects assumption holds, the random effects model is more efficient than the fixed effects model.

The generally accepted way of choosing between fixed and random effects is running a Hausman test. The Hausman test checks a more efficient model against a less efficient but consistent model to ensure that the more efficient model also produces consistent results.

H_0: both estimators are consistent, but the random effect estimator is more efficient (has smaller asymptotic variance) than the fixed effect one.

H_1: one or both of these estimators is/are inconsistent.

If we accept the null hypothesis, the random effects model shall prevail.

4.2.3. Panel Cointegration Tests

Recent literature has centered its attention on tests of cointegration in a panel setting, among which the following could be mentioned: Pedroni (1999), Pedroni (2004), Kao (1999) and a Fisher-type test using an underlying Johansen methodology (Maddala and Wu 1999). Cointegration means that if there are two or more non-stationary variables and there is a linear combination between them that is stationary, then these variables are cointegrated. This concept of cointegration is of much interest for the economic theory as the idea behind it corresponds to stable long run equilibrium.

Once the order of integration established, we can move to a panel cointegration approach. Our analysis will be based on the Pedroni cointegration test which has extended the framework of Engel-Granger in order to test cointegration in panel data in two steps. Pedroni residual based cointegration starts by computing the residual from the regression equation:

$$yit = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + \ldots \beta_n X_{nit} + \varepsilon_{it}$$

where i - cross-sections i = 1, 2, …. N

t - time periods t = 1, 2, …. T

n - number of variables

ε_{it} - deviation from the modelled long-run relationship

If the series are cointegrated, this term should be a stationary variable. Thus, stationarity is achieved by testing whether ρ_i is unity in:

$$\varepsilon_{it} = \rho_i \varepsilon_{it-1} + v_{it}$$

Pedroni developed seven tests for cointegration in panel data, where there was more than one independent variable in the regression equation. Four such tests are based on within dimension statistics (panel v-stat, panel rho-stat, panel pp-stat and panel adf-stat) and the other three on between dimension statistics (group rho-stat, group pp-stat and group adf-stat).

The null hypothesis, associated with Pedroni's test procedure is:

$$H_0 : \quad \rho_i = 1 \quad for \quad i = 1,2,\ldots N$$

This implies that the null hypothesis associated with Pedroni's test procedure is equivalent to testing the null of no cointegration for all i.

The alternative hypothesis for between dimension would be:

$$H_1 : \quad \rho_i < 1 \quad for \quad i = 1,2,\ldots N$$

while the within dimension statistics would be rendered by:

$$H_1 : \quad \rho_i = \rho < 1 \quad for \quad i = 1,2,\ldots N$$

The variance (panel v-stat) and rho (panel rho-stat, group rho-stat) statistics are more reliable when the time dimension is at least equal to 100 (Simone Salotti (2008)). The panel pp-stat and group pp-stat as well as the panel adf-stat and group adf-stat tests are certainly more powerful for smaller time dimensions (Bonham and Gangnes (2007)). Given that our time series observations are restricted to 16 years (1993-2008), we shall relate hereinafter to the above mentioned parametric and non-parametric results.

4.2.4. Panel causality

The approach of Granger (1969) relating to whether *x* causes *y* is to see how much of the current *y* may be explained by the past values of *y* and subsequently to see whether, by adding lagged values to *x*, we succeed in improving the explanation of *y*. We state that *x* Granger causes *y* if *x* helps us in correctly predicting *y*, respectively if the coefficients of the lagged *x* are jointly statistically significant.

Granger causality runs, for all possible pairs of (x,y) series in the group, bi-variate regressions of the form:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_j y_{t-j} + \beta_1 x_{t-1} + \ldots + \beta_j x_{t-j} + \varepsilon_t$$

$$x_t = \alpha_0 + \alpha_1 x_{t-1} + \ldots + \alpha_j x_{t-j} + \beta_1 y_{t-1} + \ldots + \beta_j y_{t-j} + v_t$$

The reported F-satistics are Wald statistics for each equation, for the joint hypothesis:

$$\beta_1 = \beta_2 = \ldots = \beta_j = 0$$

Therefore, the null hypothesis is, for the first regression, that *x* does not Granger–cause *y* and, for the second regression, that *y* does not Granger–cause *x*.

5. Empirical results

5.1. Preliminary Analysis

Before rendering the actual econometric results, we take a closer look to the variables used in this paper, based on the related statistic data. They reveal that the studied countries have mainly registered an ascending trend in time for both gross domestic product and foreign direct investments from 1993 to 2008, when, due to the world financial crisis, a significant drop-down occurred, such decrease continuing in 2009, a year also included in our analysis. As regards GDP increase, the highest one is to be attributed to Slovak Republic and the lowest to Moldova, while concerning FDI increase, the top position comes to Bulgaria, the lowest position belonging to Poland. These results are confirmed by descriptive statistics (Table 1):

Table 1

GDP and FDI - yearly average increase rate for the period 1993-2009

Country	GDP - yearly avg. increase rate	FDI - yearly avg. increase rate
RO	3.72 %	21.88 %
BL	3.47 %	27.20 %
HU	3.34 %	15.17 %
PO	4.51 %	*6.50 %*
MO	*0.63 %*	18.47 %
CH	2.86 %	9.04 %
SL	4.84 %	11.12 %

Hereinafter we present the correlation between the variables considered in this paper, that is l_GDP, l_FDI, l_DI, TG, INF, TO and EDU. As we can see in Table 2, there is a positive and significant correlation between gross domestic product and foreign direct investments and domestic investments. A lower but still positive correlation appears also between gross domestic product and infrastructure, respectively education while, as expected, as the technological gap increases, the gross domestic product decreases and vice versa. Instead, trade openness appears to be negatively correlated with GDP, FDI and DI.

Table 2

Correlation between variables

Variables	L_GDP	L_FDI	L_DI	TG	INF	TO	EDU
L_GDP	1.000000	0.725121	0.891566	*-0.855386*	0.155951	*-0.770957*	0.207055
L_FDI	0.725121	1.000000	0.812137	*-0.781205*	0.208964	*-0.593456*	0.188266
L_DI	0.891566	0.812137	1.000000	*-0.969349*	0.153737	*-0.773822*	0.127636
TG	-0.855386	-0.781205	-0.969349	1.000000	*-0.048188*	0.824858	*-0.014745*
INF	0.155951	0.208964	0.153737	-0.048188	1.000000	0.040615	0.223250
TO	-0.770957	-0.593456	-0.773822	0.824858	0.040615	1.000000	0.181721
EDU	0.207055	0.188266	0.127636	-0.014745	0.223250	0.181721	1.000000

5.2. Series Stationarity

Given that usually the macroeconomic time series are not stationary, we have started by graphically representing the level and 1st difference series and then by performing a panel unit root test – Im, Pesaran, Shin (IPS) (1997). This test, based on the Augmented Dickey-Fuller (ADF) statistic (Dickey and Fuller, 1981), allows each member of the cross section to have a different autoregressive root and different autocorrelation structures under the alternative hypothesis. The results of the unit root in panel data are presented in Table 3:

Table 3

IPS Panel Unit Root Test

Variables	IPS panel unit root test	
	Level	1st difference
l_GDP	0.38857 (0.6512)	-2.60879 (0.0045)***
l_FDI	-0.09348 (0.4628)	-7.77116 (0.0000)***
l_DI	-1.03638 (0.1500)	-3.12216 (0.0009)***
TG	-0.25910 (0.3978)	-3.30387 (0.0005)***
INF	0.41560 (0.6612)	-4.93499 (0.0000)***
TO	1.88318 (0.9702)	-4.43091 (0.0000)
EDU	0.08243 (0.5328)	-5.08177 (0.0000)***

*P-values are in parenthesis. *** shows significance at 1% level. The null hypothesis is that series are non stationary.*

The hypothesis that the variables l_GDP, l_FDI, l_DI, TG, INF, TO and EDU contain a unit root cannot be rejected. When first difference is used, unit root non-stationarity is rejected at the 1% significance level, the result is all series being I(1). Such a result opens the possibility of a cointegrating relationship among variables.

5.3. Parameter estimation

After analyzing the series stationarity, we have proceeded to the analysis of the parameter significance while resorting to Ordinary Least Squares (OLS) for every single model mentioned above (Table 4).

The results indicated that, in terms of parameter significance, *Model 2* is the most representative one (all its parameters being significant at 5% and 10%), and for this reason our analysis is further based on it.

Table 4

Basic Panel OLS Estimation for the six models considered

Dependent variable: d_ l_GDP						
Variables	OLS estimation					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
1	2	3	4	5	6	7
d_l_FDI	2.864542 (0.0050)***	0.007605 (0.0131)**	5.400551 (0.0000)***	4.672989 (0.0000)***	5.449721 (0.0000)***	4.618337 (0.0000)***
d_l_DI	3.587932 (0.0005)***	0.075714 (0.0001)***	5.208705 (0.0000)***	5.173364 (0.0000)***	5.205653 (0.0000)***	5.149384 (0.0000)***
d_TG	-10.96346 (0.0000)***	-0.748159 (0.0000)***	-23.26597 (0.0000)***	-22.98330 (0.0000)***	-22.03416 (0.0000)***	-23.02099 (0.0000)***
1	2	3	4	5	6	7
d_INF	4.260788 (0.0000)***	0.011324 (0.0000)***	1.109944 (0.2696)	1.122168 (0.2644)	1.240510 (0.2176)	0.970361 (0.3341)
d_TO	1.388793 (0.1678)	-	-	-	-	-
d_EDU	-	0.001390 (0.0440)**	1.401266 (0.1641)	0.375063 (0.7084)	0.346287 (0.7298)	1.413786 (0.1604)
d_FDI*d_TG* d_EDU	-	-	-1.378130 (0.1711)	-	-	-1.365654 (0.1750)
d_FDI*d_TG* d_INF	-	-	-	-0.745604 (0.4576)	-	-0.731224 (0.4663)
d_FDI*d_TG* d_EDU*d_INF	-	-	-	-	0.215640 (0.8297)	-
*P-values are in parenthesis. *, ** and *** show significance at 10%, 5% and 1% level,*						

For the selected model, we have used Ordinary Least Squares (OLS) and Generalized Method of Moments (GMM) estimation respectively so as to control for the endogeneity-related issue. As we shall see hereinafter in Tables 5, 6 and 7 (no, fixed and random effects OLS and GMM estimations), foreign direct investments, direct investments, infrastructure and educational level exert a positive influence on the gross domestic product, while a higher technological gap between a leading country and country i determines, as expected, a lower gross domestic product per capita.

Therefore, for estimations with no effects, we have estimated the regression:

$$d\_l\_GDP_{it} = \alpha + \beta_1 d\_l\_FDI_{it} + \beta_2 d\_l\_DI_{it} + \beta_3 d\_TG_{it} + \beta_4 d\_INF_{it} + \beta_5 d\_EDU_{it} + \varepsilon_{it}$$

while for estimations with fixed and random effects we had resorted to:

$$d\_l\_GDP_{it} = \alpha + \lambda_i + \beta_1 d\_l\_FDI_{it} + \beta_2 d\_l\_DI_{it} + \beta_3 d\_TG_{it} + \beta_4 d\_INF_{it} + \beta_5 d\_EDU_{it} + v_{it}$$

where : $\varepsilon_{it} = \lambda_i + v_{it}$

and:

$$d\_l\_GDP_{it} = \alpha + \beta_1 d\_l\_FDI_{it} + \beta_2 d\_l\_DI_{it} + \beta_3 d\_TG_{it} + \beta_4 d\_INF_{it} + \beta_5 d\_EDU_{it} + \omega_{it}$$

where : $\omega_{it} = \eta_i + v_{it}$

Table 5

OLS and GMM Estimation with no effects

Dependent variable: d_ l_GDP		
Variables	OLS estimation	GMM estimation
d_l_FDI	0.007605 (0.0131)**	0.004435 (0.0614)*
d_l_DI	0.075714 (0.0001)***	0.176722 (0.0000)***
d_TG	-0.748159 (0.0000)***	-0.952117 (0.0000)***
d_INF	0.011324 (0.0000)***	0.009388 (0.0374)**
d_EDU	0.001390 (0.0440)**	0.001831 (0.0908)*
*P-values are in parenthesis. *, ** and *** show significance at 10%, 5% and 1% level*		

Table 6

OLS and GMM Estimation with fixed effects

Dependent variable: d_ l_GDP		
Variables	OLS estimation	GMM estimation
d_l_FDI	0.009055 (0.0148)**	0.006517 (0.0000)***
d_l_DI	0.054294 (0.0022)***	0.087814 (0.0058)***
d_TG	-0.791421 (0.0000)***	-0.719430 (0.0000)***
d_INF	0.002371 (0.0440)**	0.014554 (0.0040)***
d_EDU	0.000168 (0.0593)*	0.003280 (0.0308)***
c	0.024745 (0.0000)***	0.017057 (0.0000)***
*P-values are in parenthesis. *, ** and *** show significance at 10%, 5% and 1% level.*		

Table 7

OLS and GMM Estimation with random effects

Dependent variable: d_ l_GDP		
Variables	OLS estimation	GMM estimation
d_l_FDI	0.009067 (0.0000)***	0.006678 (0.0000)***
d_l_DI	0.053186 (0.0000)***	0.114986 (0.0000)***
d_TG	-0.794379 (0.0000)***	-0.717504 (0.0000)***
d_INF	0.001923 (0.0012)***	0.009532 (0.0000)***
d_EDU	0.000115 (0.06716)*	0.0013616 (0.0000)***
c	0.025017 (0.0000)***	0.016241 (0.0000)***
*P-values are in parenthesis. * and *** show significance at 10% and 1% level.*		

As it can be seen in the tables above, the results are highly similar and significant for both OLS and GMM estimation, no matter if none, fixed or random effects are used, therefore indicating the robustness of such results.

Yet, we have tried to see whether the fixed or random effects models are more appropriate for our analysis, resorting for this purpose to the Hausman test (1978). The Hausman test (Table 8) checks a more efficient model against a less efficient but consistent one to make sure that the more efficient model also produces consistent results.

Table 8

Hausman test for OLS and GMM estimation

Hausman test	*OLS estimation*	*GMM estimation*
Cross-section random	0.000000 (1.0000)	1.496046 (0.9135

As p-value indicates us that in both cases the null hypothesis is to be accepted, we assume that the random effect model is both consistent and more efficient and it shall be used.

5.4. Panel Cointegration Testing

Given that all series considered are I(1), we have tested, by means of the Pedroni cointegration test, for a cointegration relationship between variables (Tables 9 and 10). We have started from the following regression equation in order to compute the residual and to find out whether the deviation of the modelled long-run relationship is indeed a stationary variable:

$$l\_GDP_{it} = \alpha + \beta_1 l\_FDI_{it} + \beta_2 l\_DI_{it} + \beta_3 TG_{it} + \beta_4 INF_{it} + \beta_5 EDU_{it} + \varepsilon_{it}$$

Table 9

Pedroni Residual Cointegration Test (within-dimension)

	Statistic Probability
Panel v-stat	-1.466005 (0.9287)
Panel rho-stat	0.616444 (0.7312)
Panel PP-stat	-1.341520 (0.0899)*
Panel ADF-stat	-1.653398 (0.0491)**

Regressors: l_GDP, l_FDI, l_DI, TG, INF, EDU
*P-values are in parenthesis. * and ** show significance at 10% and 5% level.*

Table 10

Pedroni Residual Cointegration Test (between-dimension)

	Statistic Probability
Group rho-stat	1.455169 (0.9272)
Group PP-stat	-1.736107 (0.0413)**
Group ADF-stat	-2.879533 (0.0020)***

Regressors: l_GDP, l_FDI, l_DI, TG, INF, EDU
*P-values are in parenthesis. ** and *** show significance at 5% and 1% level.*

As panel pp-stat and group pp-stat, respectively panel adf-stat and group adf-stat are deemed to be, according to the literature in the matter, more significant for smaller time dimensions, we have taken these values into account, drawing the conclusion that, for a significance level of 1%, 5%, respectively 10%, the null hypothesis of no cointegration is to be rejected, resulting in a cointegration relationship of the variables concerned.

5.5. Panel Causality

Once these variables are cointegrated, the next step is to use the causality tests. As our interest was to discover the direction of the long-run relationship between GDP and FDI, we have tested the Granger causality for the variables considered, taking one lag length:

$$l\_GDP_{it} = \alpha_0 + \alpha_1 l\_GDP_{i(t-1)} + \beta_1 l\_FDI_{it} + \beta_2 l\_FDI_{i(t-1)} + \varepsilon_{it}$$

$$l\_FDI_{it} = \alpha_0 + \alpha_1 l\_FDI_{i(t-1)} + \beta_1 l\_FDI_{it} + \beta_2 l\_FDI_{i(t-1)} + v_{it}$$

Table 11

Granger Causality

Null hypothesis:	F-statistic Probability
l_FDI does not Granger cause l_GDP	4.62520 (0.0337)***
l_GDP does not Granger cause l_FDI	1.98780 (0.0614)*
*P-values are in parenthesis. * and *** show significance at 10% and 1% level.*	

As revealed by Table 11, there is a bi-directional causality between GDP and FDI, this being in compliance with the economic theory grounds: more foreign direct investments cause economic growth, as, on one hand, there is an increase of capital stock accumulation and, on the other hand, there is a diffusion of technology and know-how from the more developed countries to the targeted ones, but, at the same time, as countries develop economically there will be a higher temptation for the foreign investors to direct their financial resources to those countries.

6. Conclusions

This study focuses on the relationship existing between foreign direct investments and economic growth for seven Eastern European countries, namely Romania, Bulgaria, Hungary, Poland, Moldova, Czech Republic and Slovak Republic, for the period 1993-2009. The empirical analysis reveals that FDI impacts on economic growth for the countries and periods included in the sample. We began by performing the Im, Pesaran, Shin unit root test in order to see whether the series were stationary or not and thus if there was any possibility of cointegration between the variables considered. We found out that all of the series were stationary while the first difference was used. Fixed and random effects OLS and GMM estimations for first difference series have been performed, the results obtained being in compliance with the economic theory, revealing FDI impact in the short-run on GDP. Once we have obtained all series I(1), we have also resorted to the Pedroni cointegration test so as to check the long-run relationship between the variables of interest. For Pedroni panel pp-stat and group pp-stat, respectively adf-stat and group adf-stat, the most significant analyses for panel data not exceeding 100 time periods, a cointegration relationship was revealed, therefore indicating a long-run relationship between FDI, DI, TG, INF, EDU and GDP. Finally the Granger causality test revealed a bi-directional causal relationship between gross domestic product and foreign direct investments, strengthening the importance of FDI in sustaining economic growth which, at its turn attracts, by the raising the infrastructure and educational level, more foreign investments, a permanent source of technology diffusion, and diminishes the technological gap, converging to the status of more developed countries.

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