ESTIMATING TECHNICAL PROGRESS IN CENTRAL AND EASTERN EUROPE. WHAT ROLE FOR FDI?

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Technical progress is a key factor in economic growth, mainly due to its productivity enhancement. It is a fact that most innovation and new technologies are created in developed countries. International trade and FDI are the main channels for technology transfer. Our objective is to determine the role of FDI in technical progress. In this paper, we start with two questions: is there evidence of significant contribution of technical progress to economic growth? And if there is, what is the role of FDI in technical progress? Using a production function approach, we estimate the TFP and we regress it on the stock of FDI, in a panel framework. We find evidence of positive correlation.

Key words: technical progress, Solow residual, FDI
JEL: O33, O47, F23

1. Introduction

The turmoil in the world economy during the last two years has reinforced research on economic growth and its determinants. This subject is all the more important in Central and Eastern Europe (CEE), since these countries had experienced high rates of economic growth in the years before the crisis. Trying to explain the long run economic growth, scholars have brought into attention the role of technical progress as the key for long term growth.

It as a fact that most innovation and new technology are created in developed countries. Therefore, the chance for developing countries is to import that technology. Unlike Western countries, CEEC are relatively far away from the production possibilities' frontier. That is the reason why they are more concerned with technology transfer and could benefit more from the productivity enhancement effect of technical progress. Furthermore, these countries have a real research-development potential, inherited from the communism, which allows for local adaptations and second rang innovation.

International trade and foreign direct investment (FDI) seem to be the most important channels of technology transfer. FDI is considered to be a crucial factor in economic growth and catching-up process in this region. There are even opinions suggesting that technology transfer through FDI is more important than the capital inflow itself (Hunya, 2000). Blomstrom and Kokko (1996) argue that FDI is also the cheapest channel for technology transfer. Unlike other channels, it simultaneously allows the transfer of tangible and intangible assets, being therefore one of the most effective international technology channels (Kinoshita, 2000).

The ***objective*** of our paper is to estimate the contribution of technical progress in economic growth in CEE and to evaluate which might be the role of FDI in technological change. We adopt a tow step procedure. First, we use the growth accounting approach in order to estimate the Solow residual. Second, we run a panel analysis on 8 countries in CEE, trying to explain the sources of technical progress, more precisely the role of FDI. We find a positive correlation between the stock of FDI and total factor productivity.

We proceed with the paper as follows: section 2 presents the theoretical framework of estimating technical progress, using the Solow growth accounting approach. Section 3 presents the 2 step methodology we have used, section 4 discusses the data and results obtained and section 5 concludes.

2. Theoretical framework

Measuring the stock and the technology transfer is a difficult task, given the fact that technology appears as a latent variable, which is not directly observable at plant level. Especially when dealing with know-how, several proxy variables are being used in order to estimate the technological level. Such variables are: research-development expenses, registered patents, share of high skill workers etc. What is of interest for economic research is not necessarily the technical level itself, but the change in technical level, more specifically technical progress.

The literature retains four main approaches in estimating technical progress: the production function approach, the index number approach, the econometric approach and the distance function approach. The vast majority of the literature uses the production function approach, namely calculating Total Factor Productivity (TFP). For reasons of comparability of results, but also of data availability, we will proceed in our research with this approach.

The production function is a microeconomic concept, indicating the mathematical expression of combing a set of inputs in order to obtain the maximum output. Even if every firm has its own production function, the concept is also being used at aggregate level, for explaining economic growth. Solow and Swan (1956) have based their famous growth model on a two input production function. This model explains economic growth mainly by accumulation of physical capital and labour. The share in economic growth not attributed to these two factors is accounted for technical progress. The sources of this progress are not explained by this neoclassical model, that is why it is called exogenous or unexplained technical progress.

Solow decomposes the observed growth of GDP in 3 components: the first two attributed to capital and labour, and the third attributed to a residual factor. This unexplained factor has been called **Solow residual** and accounts for changes in the technology being used.

The Solow standard model uses a neoclassical production function and tries to establish the share in economic growth due to capital, labour and technical progress. In order to better estimate the share in output growth due to technical progress, taking into account FDI, we have **extended the standard model** by including a third factor, which is intermediate inputs. The theoretical model we use is as follows:

$$Y_t = A_t F(K_t, L_t, II_t) \qquad (1)$$

where Y is gross output, K capital, L labour, II intermediate inputs and t time. A_t is a variable that measures the technical level in the economy, on which we will base our technical progress estimates. In order to obtain a linear model, we took logarithms on both sides of equation (1), and then derived with respect to time, and we obtained equation (2):

$$\frac{\partial \ln Y/\partial t}{\ln Y} = \frac{\partial \ln A/\partial t}{\ln A} + \frac{A\frac{\partial F}{\partial K}K}{Y} * \frac{\partial \ln F/\partial K}{\ln K} + \frac{A\frac{\partial F}{\partial L}L}{Y} * \frac{\partial \ln F/\partial L}{\ln L} + \frac{A\frac{\partial F}{\partial II}II}{Y} * \frac{\partial \ln F/\partial II}{\ln II} \qquad (2)$$

In order to empirically fit the model to the data, we need to re-estimate it in a discrete form:

$$\Delta Y = \Delta A + \alpha \Delta K + \beta \Delta L + \gamma \Delta II \qquad (3)$$

ΔY, ΔK, ΔL, ΔII represent the growth rate of output, capital, labour and intermediate inputs. α, β, γ represent the factor remuneration shares in total output. For this reason, $\alpha + \beta + \gamma = 1$.

The variation in the A parameter is called ***Solow residual***, or Total Factor Productivity (TFP), and is the expression of technical progress. A represents the percentage in the annual increase in output which is not accounted for an increase of labour or capital.
From equation (3), we can see that the growth rate of output is decomposed in the growth rate of TFP, given by the A parameter, and the weighted growth rates of capital, labour and intermediate inputs. All the rates are known, except for the variation in the A parameter. This variation is estimated as a residual, by subtraction, where the name of Solow residual.
From a theoretical point of view, the ***TFP contains all the changes in output which are not accounted for by an increase in the quantities of K, L and II being used***. Therefore, besides the efficiency of using the production factors, TFP also accounts for changes in the quality of these factors. But from a practical point of view, TFP comprises much more than that. In empirical estimations, it acts as a residual that "collects" all the factors having generated economic growth, besides the quantities of *K, L* and *II*, which are not observable or have been excluded from the model (Neuhaus, 2005). For example, technical progress can be embedded in capital goods. The qualitative change in factors is therefore contained in the TFP, overestimating it, even though it should be included in the "qualitative growth" of inputs.
Estimations of the Solow residual, especially in the early literature, have been affected by several errors[147]. The parameter also residually contains errors of measuring inputs, imperfect competition effects, scale economies etc. Fortunately, several adjustments have been proposed in the literature, so that the Solow residual still remains the best way of estimating technical progress
A drawback of the production function approach is the hypothesis that firms act on the production possibility frontier, which implicitly assumes that the production function describes the maximum output that can be obtained with a given set of inputs. This might be close to reality in the long run, but in the short run there are real distances given by market conditions, labour training and employment, financing the necessary investment etc. More, this is in fact a microeconomic approach that can loose it accuracy by aggregation at a macroeconomic level. For these reasons, whenever possible, production functions should be estimated differently at sector and even plant level.

3. Methodology

Our methodology in estimating the technology transfer through FDI is a **two step procedure**. First, we need to confirm the **presence of technical progress**. Second, we are trying to establish the sources of that technical progress. To put it differently, **is FDI a source of technical progress?** Even if one might find evidence of technical progress, it doesn't necessarily mean that it is the consequence of foreign firms' activity in the national economy.

Step I. Estimating technical progress based on the production function approach

For calculating the growth rates we have computed the logarithmic variations between the 2 time periods *t* and *t+1*. For the factor weights, we have two possibilities. The first one, suggested by Thornquist (1936) is to calculate the average for the shares in *t* and *t+1*. Therefore, equation (3) becomes:

$$\frac{Y_{t+1}-Y_t}{Y_t}=\frac{A_{t+1}-A_t}{A_t}+\frac{\alpha_{t+1}+\alpha_t}{2}*\frac{K_{t+1}-K_t}{K_t}+\frac{\beta_{t+1}+\beta_t}{2}*\frac{L_{t+1}-L_t}{L_t}+\frac{\lambda_{t+1}+\lambda_t}{2}*\frac{CI_{t+1}-CI_t}{CI_t} \quad (4)$$

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147 Initially, Solow (1957) had estimated for the USA that only 12,5% from the GDP growth was explained by factor accumulation, the rest of 87,5% being explained by technical progress. Griliches and Jorgensen (1967) have proved these estimations to be wrong, the Solow residual being overestimated due to omitted or unobserved variables.

The second approach, introduced by Nordahaus (2005), consists of using as weights in *t+1* the exact shares in *t+1*, the argument being the use of “end of period” data. Considering that our data are not end of period, but average for the period taken into consideration, we have decided to use the first approach in calculating the weights. We can therefore see that the weights of K, L and II are not constant, but variant over time. On real data, and especially for aggregated functions, it is expected for the weights not to be constant.

Our objective is the estimation of the A parameter from the growth accounting equation. More precisely, the equation we used for estimation has the following form:

$$\Delta A = \Delta Y - \frac{\alpha_t + \alpha_{t+1}}{2}\Delta K - \frac{\beta_t + \beta_{t+1}}{2}\Delta L - \frac{\gamma_t + \gamma_{t+1}}{2}\Delta II \qquad (5)$$

α, β and γ are the weights of capital, labour and intermediate inputs in gross output.

In elaborating our methodology, we identified two ***estimation problems***. The first one refers to the reported values of output (being gross output or value added), which are nominal values. An increase in nominal value could mean a decrease in real terms, so in order to correctly estimate the Solow residual we need the real values. Another correction is needed for the weights, as we calculated them not as a quantity ratio, but as a value ratio.

In the case of estimating the Solow residual in the presence of FDI, there is always the risk that the productivity growth due to technology transfer could be compensated by losses due to the crowding-out effect (Blalock and Gertler, 2004). Since both of them come from the entry of multinational firms on the local market, we consider relevant for our research the net outcome.

Step II. Searching for the sources of technical progress

Inn the first step, using an aggregated production function, we try to establish if there is indeed technical progress and to what extend. For this stage, even if we find evidence of technical progress, we don’t know yet which are the sources of such a progress. Once we have established the presence of technical progress, in a second stage, we will try to decompose this residual factor in order to identify the sources of technical change. One of these ***potential sources is technological transfer through FDI.*** There is an important body of literature who tries to identify correlations between FDI and changes in total productivity.

In searching of the sources of technical progress, there are two main factors that influence the technical level: the quality of inputs, and second, the way these inputs are being used in order to obtain the maximum output. Therefore, explaining the sources of technical progress has been the starting point in *endogenous growth models*. Romer (1986) was the first to argue the endogenous character of technical progress, building a growth model based on technology diffusion and learning by doing. He eliminated the problem of decreasing returns of capital from the Solow model, by assuming that every capital unit invested brigs gain not only to the firm itself, but to the rest of the economy also. Technology diffusion, as a result from investment, was considered the source of long term economic growth.

This idea of technology diffusion as a consequence of investment has been extended by other authors also, in order to explain the role of FDI in economic growth. FDI is directly liked to capital stock accumulation, in both quantity and quality.

Numerous studies who applied growth decomposition have come to the conclusion that technical progress and capital accumulation were the main factors that drove economic growth in transition countries. As FDI proved to be an important channel in technology transfer and fixed capital formation in Central and Eastern Europe, we can argue that FDI has played a major role in economic growth in this region.

4. Data and results for Central and Eastern Europe

For estimating the Solow residual, we use data for 8 countries in Central and Eastern Europe, drawn from the **EU KLEMS database.** EU KLEMS Growth and Productivity Account is a database created by the European Commission, for the analysis of productivity at industry level in the European Union. Data is available for 27 countries (25 EU members, Japan and the USA). This is the only database at European level to contain series at industry level, constructed on the growth accounting methodology. To our knowledge, this is the first study made by Romanian authors to use this database. For FDI and gross fixed capital formation, we used EUROSTAT.
Concerning the aggregation level of the data, the production function approach is more adapted for a microeconomic perspective. From a policy maker point of view, a sector or industry level would be more appropriate. The recent work in this field uses plant level data, where problems of quantifying technical changes and economic performance are less important and easier to correct. Being constrained by data availability, we will run our analysis on macroeconomic data. Aggregation problems at industry level are corrected by EU KLEMS by calibrating the variables, so that the contribution of each NACE Rev. 2 sector is taken into account.
In order to apply the decomposition of growth, we used the following ***variables***:

- ***Y*** - Output, expressed as gross output in current prices;
- ***L*** – Labour, expressed as labour services, based on the hours worked and not on the number of employees;
- ***K*** - Capital. EU KLEMS uses a special method in calculating the capital input. It is computed not as capital stock, but as capital services, weighted by types of assets.
- ***II*** – Intermediate inputs, given by the value of materials, energy and services, also expressed in current prices.

The availability of intermediate inputs series has allowed us to estimate TFP based on the gross output. Another way of estimating the TFP would have been by value added. We have chosen using the gross output for 2 reasons. The first one is the fact that technical progress can be already embedded in the intermediate inputs used in production. An important part of FDI contribution to technical progress, besides capital accumulation, is the use of intermediate goods. Since our objective is estimating the contribution of FDI to technical progress, we can not ignore this potential channel for technology transfer. The second one, regressing output on labour, capital and materials, avoids the assumption of additive separability of material inputs, and therefore allows a certain generality (Arnold, 2005).
We used data for Hungary, Poland, Slovakia, Slovenia, Czech Republic, Estonia, Latvia and Lithuania, for the period 1995-2007. Our initial intention was to include Romania and Bulgaria also, but data is not available for these countries.
Each of the variables was expressed in national currency, in current prices. We first proceeded in deflating all the nominal series on the base of the appropriate price indexes, in order to obtain the real values. We therefore obtained the real evolution of quantities, inflation excluded.
Starting from the growth rates of real gross output for the period 1995-2007, we tried to estimate what percentage in growth was due to other factors than labour, capital and intermediate inputs. The residual factor that remains after subtracting all these evolutions is the expression of technical progress.
On the basis of equation (5), we computed the contribution of each factor in growth, for each country and every year. The mean values of these contributions are presented in Table 1. We present the data under the form of a mean aggregated production function, expressed in first order differences (growth rates).

Table 1. Aggregated production function estimates

Countries	**Production function estimates on the basis of mean parameters**
Hungary	$\Delta Y = 0.64 + 0.16\Delta K + 0.25\Delta L + 0.58\Delta CI$
Poland	$\Delta Y = 0.63 + 0.14\Delta K + 0.32\Delta L + 0.55\Delta CI$

Slovakia	*ΔY = 0.90 + 0.19ΔK + 0.19ΔL + 0.62ΔCI*
Slovenia	*ΔY = 0.71 + 0.11ΔK + 0.33ΔL + 0.56ΔCI*
Czech Republic	*ΔY = 0.76 + 0.15ΔK + 0.22ΔL + 0.63ΔCI*
Estonia	*ΔY =0.84 + 0.18ΔK + 0.23ΔL + 0.59ΔCI*
Latvia	*ΔY = 0.76 + 0.22ΔK + 0.24ΔL + 0.54ΔCI*
Lithuania	*ΔY = 0.87 + 0.24ΔK+ 0.27ΔL + 0.49ΔCI*

Source: Authors calculus, on the base of EU KLEMS data. The coefficients are computed as mean values for the yearly coefficients, 1995-2007.

For all the 8 countries included in the sample, the Solow residual has similar values, between 0.63 and 0.90. We can interpret these values as percentage points in output growth due to technical progress. This means that technical progress contributes to a little less that 1% point to the growth rates of output in the new EU member states. These are the absolute values.

We can see that the sample is quite homogenous in terms of absolute contribution of technical progress. Concerning the production factors, capital has a contribution between 14 and 24% to output growth, the highest values being for Latvia and Lithuania. For the two countries, the result seems to have 3 explanations. First, the decrease in labour supply (because of demographic and emigration issues) has led to a decrease in the contribution of labour. Labour has practically been replaced by capital. Second, the period taken into account was that of gross privatization, which has led to technological restructuring and increase in gross fixed capital formation. Last, once EU member states, important investment inflows have taken place, which reinforced capital accumulation. A small contribution of capital we find for Slovenia, compensated by a high contribution of labour. This is explained by labour intensive industries, also suggested by the sector distribution of output.

Since our objective was to determine the correlation between technical progress and FDI, we have proceeded with the analysis of the Solow residual, on the basis of an 8 country panel, for the period 1996-2007. The advantage of such a method comparing to classical regression is that it takes into account the unobserved country specific effects. As value for FDI, we have used the FDI stock, in stead of inflows, because we considered that accumulated FDI, rather than inflow, is responsible for an increase in technology stock and contribution to output growth. As we previously discussed, a part of the technology is incorporated in capital goods. For this theoretical reason we have decided to also include fixed capital formation as a variable in the panel regression. The equation we estimated using STATA 10.0 was the following:

$$A_{it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 GFCF_{it} + u_{it} \qquad (6)$$

The Haussman test indicated that a fixed effect model would be more suitable than a random effect model. This means that the error term u_{it} has in fact the form $u_{it} = \mu_i + v_{it}$. The first term has no time index, referring to the country-specific, time-invariant effects.

The results we have obtained are the following:

$$A_{it} = 0.31 + 0.12 FDI_{it} + 0.52 GFCF_{it} + u_{it} \qquad (7)$$

(0.041**) (0.088*) (0.423)

The preliminary results show a positive coefficient for FDI, even if it is significantly different from zero only at a 10% significance level (In brackets we have presented the p values associated with each coefficient). This means that for a billion euros increase in FDI stock, the residual parameter, more precisely TFP, increases by 0.12 percentage points. The coefficient associated with gross fixed capital formation it is not statistically significant. We are aware that the two exogenous variables are not independent, but could be in fact correlated (a part from FDI will result in GFCF). We consider these as preliminary results, in order to have a general idea about the relationship between FDI and TFP. We are planning to improve our empirical part by correcting the model (6) with an interaction term between the exogenous variables FDI*GFCF.

5. Conclusion

As a general conclusion regarding CEEC, they are in a convergence process towards the western productivity levels. After the collapse of the socialist regime, these countries have known important transformations, like: decrease in the contribution of labour to output, substitution of labour with capital and therefore increase in the contribution of capital. FDI has played an important role both in fixed capital accumulation and technology stock.

Using the new EUKLEMS database, we have shown that technical progress has generated between 13%-19% of output growth in the region and that the 8 countries are similar in this concern. In evaluating the role of FDI, we are cautious in interpreting the coefficients of the panel regression model. The only thing we can say is that ***technology and the stock of FDI are positively correlated***. This correlation does not imply causality. It only means that an increase in the FDI stock is accompanied by an increase in the technical level. These two variables can be linked either directly or indirectly, through other variables such as fixed capital formation, research expenses etc. We consider this to be a first step in analysing the implications of FDI on the stock of technology. A further, more detailed, analysis is needed in order to evaluate the possible sources of technical progress. When analyzing FDI as a determinant of TFP growth, we consider useful taking the analysis at industry level, to better correlate it with the foreign presence in the sector.

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