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EDUCATION AND ECONOMIC GROWTH: AN EMPIRICAL ANALYSIS OF INTERDEPENDENCIES AND IMPACTS BASED ON PANEL DATA

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The paper focuses particularly on proving that education can lead to economic growth within five groups of EU Member States. Our study reviews the human capital from its quantitative (years of study) and qualitative (education quality) dimensions, the empirical panel data analysis being based on three double-log models developed and processed through random and fixed effects. The main explanatory variables comprise the GDP per capita, the physical capital, the average number of years of schooling (for all three levels, especially tertiary education), the quality of education measured through scores on skill tests, the degree of international openness, life expectancy and inflation rate. Our results highlight that education is extremely important in positively influencing economic growth. Within this framework, the results emphasize that within the European Union there is a strong positive influence of education on economic growth, expressed mainly through an increase in GDP per capita growth rate, especially when the human capital is expressed by qualitative variables, while the quantitative variable’s importance is being greatly reduced.

Keywords: Human capital; Economic growth; Education; Schooling; Knowledge.

JEL Classification: J24; F43; O47.

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1. Introduction

The key role played by competencies and knowledge is largely known in stimulating economic growth and has been the main research topic for economists, especially due to the fact that there are several studies which point out and prove the positive connection between economic growth and human capital (education). The results of the models developed by Mankiw, Romer and Weil (1992) have proved a significant and certain positive influence of the investment in education over the economic growth process. However, other studies have interfered and revealed an ambiguous relation between the two variables (the model of Islam, 1995), the results of these models being quite the opposite of previous models, which were in favour of investments in education in order to gain economic growth. Therefore it had turned rather difficult to allege an absolute correlation between the GDP per capita and the various levels of human capital (regarded from the education’s point of view), but, one thing had become obvious, the fact that the measurement of the human capital continues to be a difficult and delicate issue, that can easily cause serious problems and an insignificant relation, as a result of poor usage of quantitative and partial scientific measures, or as a result of research limits caused by the lack of comparable data or the low quality of indicators that have been used in the research.

The analysis of interdependencies between human capital and economic growth found in the empirical literature includes the quality dimension of education (human capital known by its educational component), which have better shown the influence that the education has on development and growth. Hanushek and Kimbo (2000), Barro (2000), Hanushek and Wößmann (2007), Altinok (2007), Atherton, Appleton and Bleaney (2009), have all pointed out the fact that the average results of international knowledge and competencies tests that the student have could represent a better estimator for the human capital, having strong effects on economic growth. Benhabib and Spiegel (1994) also suggested as a human capital estimator, the average years of schooling, on three educational levels, based on a study performed on a group of 122 countries during the period 1965-1985.

The contradictory results of the studies have brought up the difficulty of building up or finding the most realistic indicators for the human capital factor, regarding education. This is one of the reasons why starting from 2000, several authors have started to measure the human capital not only by its quantitative dimension, the number of years of schooling, but also by its qualitative dimension, the education quality. This complex dimension has proved even harder to measure, due to the lack of unique criteria which could assess the relationship within the educational system, between students and teachers. The quality of education is reflected in the results registered by the students and their achievements. Things are not very well demarcated to this respect, therefore there are different opinions on the matter, some of which affirm that the quality of education resides in the inputs (such as the number of teachers), others refer to the processes (the amount of time dedicated to teaching, the extension of the active learning) or the outputs, such as test results. In other words, the quality of education could involve
attaining the objectives, fulfilling the purposes and attaining some indicators. As regarded from the point of view of the educational offer, the quality in education also refers to the amount of influence the school has on knowing its pupils or students, on their behavioural changes and on the prolonging of the learning process (Adams, 2002, p. 2). In approaching the two dimensions of the education, Dumont (1999) refers to the population and the labour force as quantitative measures of variables that influence production and personal characteristics (level of education, health) which affect the productive powers of individuals, as a qualitative approach.

The measurement indicators for the human capital are addressed to as flow and stock, though in time a large portfolio of indicators measuring human capital has been formed and is now used in growth models. The usage of various educational variables within the empirical models as approximations (measurements) for the human capital has led to different approaches and results. Therefore some of the authors who have used in their research models the flow variables are Lucas (1988), Mankiw, Romer and Weil (1992), Benhabib and Spiegel (1994), Barro and Sala-i-Martin (1995). Stock variables in absolute terms are widely found in the empirical literature, influencing the results obtained in models made by Nelson-Phelps (1966), Islam (1995), Barro and Lee (1994), Benhabib and Spiegel (1994).

However, there is unanimity regarding potential deviations from proper evaluation of the human capital, especially the physical ones, directly measuring certain dimensions of education, as a proxy for human capital. For example, one of the usual indicators is the average length of schooling of the working age population, by age and sex; to this have been brought many criticisms: that this does not take into account differences in skills between individuals with the same level of education; it ignores what people learn outside of the school, on the labour market or informal learning through various programs, or by accessing various information available; the quantity of time and money resources devoted to learning by practicing characteristics acquired through work experience, are neglected.

Given the heterogeneity of the content and quality of formal education, human capital measurement using the score results on international assessments of student learning is considered to be a much more appropriate alternative. These tests are carried out on the basis of questionnaires to measure the actual knowledge acquired by students in certain areas like: literature, mathematics and science. Among such investigations are the PISA tests - Programme for International Student Assessment, which are organized under the auspices of OECD. This is a survey conducted every 3 years to assess pupils aged 15 on their ability to mobilize and apply their knowledge in common situations. Other examples are the IALS tests - International Adult Literacy Survey; TIMSS - Trends in International Mathematics and Science Study, in the USA, or the SACMEQ - Southern and East African Consortium for Monitoring Educational Quality, for Africa. They are carried out on groups of students from different countries, with the advantage that scores as measures of actual knowledge acquired by students include information about the contents and quality of the educational system and the students’ knowledge accumulation factors. This result indicator provides a basis for international comparability, but has the
disadvantage of being limited to students of a certain age, only particular aspects of skills and knowledge are evaluated, and includes certain groups of countries (some only relatively recent).

All these indicators are included in the econometric models which analyze the economic growth process, though there are many studies which do not reach a unanimous agreement on the influence of education on growth, even if this role is widely accepted. Such indicators are found in reference works like the model of Mankiw, Romer and Weil (1992), the model of Barro (1991), the model of Islam (1995), the model of Nelson and Phelps (1966).

Since a number of these models will be the purpose of a literature analysis on the issue of human capital (education) contribution to economic growth, we will briefly explain the model of Hanushek and Kimko (2000) which measures human capital scores on international assessments in following investigation of knowledge in mathematics and science in 31 countries, conducted by IAP (International Assessment of Educational Progress) and IEA (International Association of Education Achievement). In building this model we focused on the assumptions of the human capital theory, namely the human capital stock and the variations of the human capital which influence economic growth. Using the Cobb-Douglas production function, Hanushek and Kimko (2000) introduced in their models several independent variables such as the national income, the average population growth, the number of years of schooling (as a measure for the human capital), measures of test scores, and by this combination they are seeking to explain the GDP growth rate. The conclusion reached by the authors on education is different from other models (Mankiw, Romer & Weil, 1992), meaning that the approximation of the human capital by international student test scores, leads to an improvement on the model’s results, increasing their ability to explain the economic growth and demonstrating better specificity of the model.

Altinok (2007) has also a different approach to the measurement of education, by quantifying the qualitative dimension of it by an index constructed on the basis of the scores obtained at various international assessment tests, knowledge and skills acquired by students in three areas: writing and reading, mathematics and science. Altinok was processing the performance results of countries participating simultaneously in several surveys (at least two for comparability between surveys, on six groups of investigation - IEA (International Association of the Evaluation of Educational Achievement), PISA (Programme for International Student Assessment) SACMEQ (Southern and East African Consortium for Monitoring Educational Quality), PASEC (Programme d'Analyse des Systemes educatifs) LLCE (Laboratorio Latinoamericano de la Calidad Evaluación from Educación), MLA (Monitoring Learning Achievement), by building qualitative indicators of the human capital QIHC - Qualitative Indicators of Human Capital, on three basic areas. The resulting database contains qualitative indicators for 105 countries, revealing wide disparities between countries, indicators that were then included in the econometric models of the impact of education on economic growth (Altinok, 2007). At the same time, other educational databases were built that are frequently cited in terms of model results, which are considered reference models suitable for analysis. Some of the databases used to evaluate human capital are constructed by Barro and Lee.
(2011) and Heston, Summers and Aten (updated in July 2012). The database developed by Robert J. Barro and Lee (2001) covers 100 countries with different economic development levels over the period 1965-1995. In his model, based on years of secondary education (high-school level), as human capital measure, Barro (1991) concludes on its relevant role on economic growth.

There are indicators, such as individual income on levels of education which can be considered as human capital measures in micro- and macroeconomic models, but that are only available for a specific number of countries, in certain periods, or cannot capture the importance of collective knowledge in organizations or groups of people. Perhaps the most difficult to find in educational indicators is the aspect of knowledge and skills communication dimension (tacit, heterogeneous) or the education’s externality effects.

All these measures limit the human capital dimension, requiring attention and caution in estimating stocks and flows, especially when they serve some international comparisons. Among human capital indicators that are monitored to attain the targets on education in the European development strategy objectives are included: literacy levels, performance in reading, investing in education.

According to the latest PISA test results (2009), the situation is worse in the European Union in this regard, about 20% of young people barely read (have real difficulties in reading), compared to 18% in US, 14% in Japan, 10% in Canada and 6% in South Korea (OECD, 2010). Also, according to PISA, in 2009, on average 19.6% of the students were performing poorly assessed in there are recorded large differences in reading performance, so that in Finland only 8.1% of students have a low level of performance in reading, but in other four countries (Estonia, Netherlands, Poland, Czech Republic) up to 15% of students fall into this category.

The proportion of pupils aged 15 who have only level 1 (out of five) based on PISA reading tests in 2009 are shown in Figure 1. In most states, this percentage varies around the European average, while Bulgaria and Romania are characterized by a large number of low-performing students in reading and writing, with more than 40%.

Within the EU, there are large discrepancies in the number of people able to complete only the least complex tasks of reading (like the location of only one aspect identifying the main theme of a text). In the EU countries there are currently few recent studies on the literacy rate. Thus, the analysis performed in Germany, France, United Kingdom have indicated that one adult out of five has low or just basic knowledge, which would mean over 75 million people in the EU, for whom there is a real risk of being excluded from all education forms and therefore not being able to integrate into the labour market or to meet everyday demands of life.
The object which the European Commission proposed for 2020, in this regard, is limiting the number of children of 15 years, who have only basic knowledge (or none) to less than 15%, taking into account the need to update skills of reading and writing, especially for a population in a clear process of aging, as the European one.

The need to correct this problem is highly stressed at the European level. The report of the expert group regarding the European crisis on levels of reading and writing skills, shows that good reading and writing skills are essential to improve the lives of citizens and also for promoting knowledge, innovation and economic growth, showing that just as „smart” means knowledge and innovation, investing in skills of reading is a prerequisite to achieve such growth (European Commission, 2012).

2. Models developed based on the human capital qualitative dimension

2.1 The importance of international test scores in order to evaluate the student performance impacts on economic growth

The model specification and variables

The model based on which we will examine the role played by education quality in influencing the economic growth process, starts with a general one and together with the variable of interest - the quality in education - we have introduced a number of control variables in order to capture as completely as possible what influences the GDP per capita growth. The analysis includes a group of countries in the European Union during the period 1960-2010 with data at every five years.
The specification of the first (Model 1) and second (Model 2) models that also include a quantitative variable of the human capital is expressed as:

$$ln(g_{it}) = \beta_0 + \beta_1 ln(k_{it}) + \beta_2 ln(schooling_{it}) + \beta_3 ln(qualityhc_{it}) + \beta_4 ln(openk_{it}) +$$

$$\beta_5 ln(lifeexpect_{it}) + \beta_6 ln(inflation_{it}) + \epsilon_{it}$$

where: $ln(g_{it})$ is the logarithmic value of GDP per capita for the country $i$ within the analyzed panel, at year $t$;

$ln(k_{it})$ is the physical capital;

in Model 1: $ln(schooling)$ is the average number of years of education (for all three levels);

in Model 2: $ln(schter)$ represents the average number of years of schooling to tertiary level;

$ln(qualityhc)$ is the quality of education, measured by scores on skill tests;

$ln(openk)$ represents the degree of international openness;

$ln(lifeexpect)$ is the life expectancy rate;

$ln(inflation)$ is the inflation rate.

Regarding the quality of education, this is reflected by the test scores on three competencies areas and the data is extracted from Altinok (2007) database. This variable is introduced within two growth models developed based on panel data, which differ according to the considered educational level, namely, Model 1 - education on three educational levels and Model 2 - tertiary education. In this estimation, the quality of education, or scores on performance tests, varies largely between countries, but is constant over time. This type of estimate is very close to that used by Barro (2000), except that we use estimates in a random effects model (RE) on groups of EU countries, Barro containing information for 43 countries and Altinok for 120 countries on the model with fixed effects (FE).

The variable representing education comprised in the model is expressed in two ways, namely, first, as an average of the years of study (the three educational levels) and then including the tertiary cycle, aiming thereby we conclude on a higher impact on economic growth of rising levels of education (higher education), together with the qualitative dimension of education.

Testing the assumptions and parameters

The homoscedasticity restriction was confirmed by the fact that the p values obtained for the Breusch-Pagan Lagrangian Multiplier test are different from zero. For testing the first order autocorrelation we applied the Wooldridge test, and the correlation matrix was generated in order to verify the absence of multicollinearity across exogenous variables.

The Wald test indicates statistically significant values for all models, and the $t$ test, with the associated $p$ values indicates the relevance attached to the individual explanatory variables.
Parameter estimation and interpretation of results

In the case of Model 1 and Model 2 the dependent variable is GDP per capita and the explanatory variables are: human capital, which is expressed both through qualitative variables and through a quantitative one (the average years of schooling for the three levels – Model 1; the average years of schooling for tertiary education – the Model 2), the physical capital, the international openness level, life expectancy and inflation. The results were relevant only for five groups of EU countries (EU27, EU17, EU15, EU10 and EU8).

### Table 1
Model estimation results based on the qualitative measure of human capital and other control variables

<table>
<thead>
<tr>
<th>Parameter</th>
<th>EU 27 Model 1 b/se</th>
<th>EU 27 Model 2 b/se</th>
<th>EU 17 Model 1 b/se</th>
<th>EU 17 Model 2 b/se</th>
<th>EU 15 Model 1 b/se</th>
<th>EU 15 Model 2 b/se</th>
<th>EU 10 Model 1 b/se</th>
<th>EU 10 Model 2 b/se</th>
<th>EU 8 Model 1 b/se</th>
</tr>
</thead>
<tbody>
<tr>
<td>logki</td>
<td>0.103 (0.07)</td>
<td>0.161* (0.06)</td>
<td>0.029 (0.08)</td>
<td>0.087 (0.07)</td>
<td>0.140* (0.07)</td>
<td>0.166* (0.07)</td>
<td>0.253* (0.11)</td>
<td>0.256** (0.10)</td>
<td>0.176 (0.20)</td>
</tr>
<tr>
<td>logschooling</td>
<td>0.128* (0.10)</td>
<td>0.160* (0.11)</td>
<td>0.149*** (0.03)</td>
<td>0.088 (0.03)</td>
<td>0.091** (0.03)</td>
<td>0.549*** (0.16)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>logschter</td>
<td>0.160*** (0.03)</td>
<td></td>
<td>0.149*** (0.03)</td>
<td>0.088 (0.03)</td>
<td>0.091** (0.03)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>logqualityhc</td>
<td>4.103*** (2.05)</td>
<td>3.893*** (1.19)</td>
<td>3.614*** (1.30)</td>
<td>3.630*** (1.29)</td>
<td>1.315** (1.14)</td>
<td>1.390** (1.13)</td>
<td>4.162* (2.25)</td>
<td>4.043* (2.50)</td>
<td>3.291 (2.35)</td>
</tr>
<tr>
<td>logopenk</td>
<td>0.120** (0.05)</td>
<td>0.054 (0.06)</td>
<td>0.287*** (0.06)</td>
<td>0.216*** (0.06)</td>
<td>0.344*** (0.05)</td>
<td>0.305*** (0.05)</td>
<td>0.041 (0.07)</td>
<td>0.166 (0.09)</td>
<td>0.059 (0.08)</td>
</tr>
<tr>
<td>loglifeexpect</td>
<td>6.534*** (0.47)</td>
<td>5.734*** (0.44)</td>
<td>5.160*** (0.57)</td>
<td>4.629*** (0.50)</td>
<td>5.381*** (0.48)</td>
<td>4.670*** (0.46)</td>
<td>5.092*** (1.23)</td>
<td>5.697*** (1.17)</td>
<td>4.234*** (1.16)</td>
</tr>
<tr>
<td>loginflation</td>
<td>0.041*** (0.01)</td>
<td>0.029** (0.01)</td>
<td>0.067*** (0.01)</td>
<td>0.054*** (0.01)</td>
<td>0.077*** (0.01)</td>
<td>0.066*** (0.01)</td>
<td>0.008 (0.02)</td>
<td>0.012 (0.02)</td>
<td>0.012 (0.04)</td>
</tr>
<tr>
<td>Constant</td>
<td>-35.886*** (5.36)</td>
<td>-31.067*** (5.38)</td>
<td>28.448*** (5.94)</td>
<td>-25.602*** (5.78)</td>
<td>-20.342*** (5.22)</td>
<td>-17.347*** (5.10)</td>
<td>32.581** (11.25)</td>
<td>-30.657*** (12.14)</td>
<td>22.844*** (10.80)</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.6560</td>
<td>0.5784</td>
<td>0.6017</td>
<td>0.5420</td>
<td>0.7512</td>
<td>0.7339</td>
<td>0.6521</td>
<td>0.5598</td>
<td>0.9040</td>
</tr>
<tr>
<td>Wald</td>
<td>1241.51</td>
<td>1431.13</td>
<td>1328.92</td>
<td>1513.05</td>
<td>1776.33</td>
<td>912.96</td>
<td>113.82</td>
<td>130.01</td>
<td>45.81</td>
</tr>
<tr>
<td>N observations</td>
<td>199</td>
<td>199</td>
<td>155</td>
<td>158</td>
<td>150</td>
<td>150</td>
<td>41</td>
<td>41</td>
<td>23</td>
</tr>
</tbody>
</table>

GLS Regression

Note: * p<0.05, ** p<0.01, *** p<0.001; standard errors are presented in brackets

Source: Authors' estimations.

The human capital coefficients (for the qualitative and quantitative variables) as well as that of the physical capital and life expectancy are positive for all groups of countries, in both models. The quality variable of the human capital (international test scores) has the relevant statistical significance level of 0.1% for the EU27 and EU17 and it decreases for the rest of the groups. The qualitative variable coefficients which values human capital are high, so a 1% increase in GDP growth per capita leads to a 4.1% increase in the human capital for EU27 in Model 1, respectively, 3.9% for EU27 in Model 2, 3.6% for both models in the case of EU17 and 1.3%,
respectively, 1.4% for EU15. These results highlight the role of human capital, measured by a qualitative variable in influencing the GDP per capita growth, unlike human capital results expressed as the average years of schooling (both for all three levels and only tertiary), where coefficient values indicate a significantly lower influence on the growth of GDP per capita. Specifically, for a 1% increase in the average years of schooling, the GDP per capita will increase by only 0.03% for the EU15, which is the minimum value and a maximum impact of 1.26% for the group of EU10 countries. Average years of schooling to tertiary influence the GDP per capita growth in a range between 0.09% (EU15) and 0.55% (EU10).

Therefore, the quantitative human capital variables have little influence on GDP per capita growth for EU15, but a high influence on the EU10, the group of developing countries having an average on years of schooling lower than developed countries in the EU15.

The physical capital variable coefficients in both models and for all groups of countries have positive values, thus reflecting that it leads to an increase in GDP per capita, but lower than in the case of human capital (the human capital coefficients, expressed by various qualitative and quantitative dimensions, are higher).

By entering control variables of a different nature into the model, aimed at highlighting the role and influence of other factors on growth, given that they reflect the possibilities of introducing new technologies to attract foreign direct investment, we were able to highlight the adjustment of macroeconomic imbalances and the impact on economic growth. Not all these indicators have supported growth, so the situation is again different across the analyzed groups of countries. Thus, the positive coefficient of this variable indicates statistical significance at the level of 0.1% for EU developed countries (EU15) and at 5% level for all Member States. This indicator is not statistically significant for the EU10 group, and the share of exports to these countries in their GDP is much lower compared to the first states. If we withdraw Romania and Bulgaria from the group of the ten former communist countries, the influence of international trade openness could be regarded as positive, but not statistically significant. The positive sign of the variable coefficients for EU8 compared to the EU10 negative sign indicates that for Romania and Bulgaria this indicator is another factor influencing the specified configuration.

Inflation is a potential determinant of economic growth for developed EU countries, the positive sign and the statistical significance level of 0.1%, highlighting the importance of price stability for economic growth. Given that in the former communist countries, the period immediately after the 1990s was characterized by extreme inflation increases, the maintaining of high rates in some countries for almost the entire analyzed period shows a negative cumulative effect without statistical significance for the EU-10.

Unlike the two previous indicators (openness and inflation), but similar to the human capital approximated by qualitative variables, life expectancy has a positive sign for all the
analysed groups of countries, and a high statistical significance level of 0.1%, both for the specification Model 1 (quantitative dimension of human capital expressed as the average years of education at all three educational levels) and the Model 2 (quantitative dimension of human capital expressed as average years of higher education), the values of the coefficients have been very high. The beneficial influence of life expectancy on economic growth, highlights the fact that it is quite high, so the potentially important effect is greater.

The $R^2$ values are above 0.50 for all developed models and show that the variation in GDP per capita could be explained by up to 90% through the variation explanatory variables, respectively the human capital, physical capital, international openness, life expectancy and inflation.

The results obtained converge to those found in other studies (Hanushek & Kimbo, 2000) showing that scores on international tests can be considered as highly significant and perform better than other measures of education expressed in quantitative terms. However, the results of various studies are not uniform on the amplitude effects of education quality, some authors explaining these variations by different methods of estimating test scores, the number of tests considered or the number of countries included in such tests.

### 2.2 Quality variables of the human capital in dynamic models with time delay (lag)

**The model specification and variables**

Economic growth involves the increasing of economic results for a national economy reflected by the GDP per capita (or national income). The interest in the long-term growth and development of international databases including multiple indicators for a growing number of countries and for longer periods has become obvious through the numerous dynamic models of panel data analysis. The discovery and use of dynamic models for estimating economic processes are due to Frisch and Tinbergen, this becoming a widely used tool in empirical economic growth literature.

Some reference models regarding the causal relationship between human capital – economic growth, have used such econometric tools: Mankiw, Romer, and Weil (1992), Fischer (1993), Levine and Renelt (1992). Without the static analysis of the relationship between determinants and researched phenomenon to mean that it is static, but only that this trial is conducted at a time, the dynamic analysis is studying a changing economic process, based on the factors that led to such changes.

In the previous model, the results of the parameters indicated the influence of the level of education on growth. We can appreciate which is the influence of the variation of the education level on growth, by using a dynamic model with a delayed variable. The motivation of running such a model lies precisely in the time dependence of the explained variable, the dynamic model involving the fact that the delayed variable or the differences over time in the explanatory variables are part of the model (Albu, 2007).
The general form of the model is:

\[ Y_{it} = \beta_1 Y_{i,t-1} + \beta_2 K_{it} + \beta_3 X_{it} + \beta_4 Q_{it} + \epsilon_{it} \]  

(2)

where: \( Y_{it} \) is the GDP per capita and \( Y_{i,t-1} \) is the delayed value;
\( K_{it} \) is the matrix of the physical capital;
\( X_{it} \) is the matrix of control variables on demographic, economic, social, political components (such as openness, foreign direct flow component as a percentage of GDP, government spending, property rights);
\( Q_{it} \) is the matrix variable of education (quantitative or qualitative dimensions).

Starting from the general form of a dynamic model and by customizing the specification of the relationship growth - qualitative dimension of education, we obtain the following relation:

\[ \Delta Y_{it} = \beta_1 \Delta Y_{i,t-1} + \beta_2 \Delta K_{it} + \beta_3 \Delta X_{it} + \beta_4 \Delta Q_{it} + \Delta \epsilon_{it} \]  

(3)

By transforming the regressors through first order differences, the fixed effects are eliminated, because they do not vary over time (Mileva, 2008) and by introducing into the model the same variables as in the previous model, the equation becomes:

Model 3

\[ \Delta g_{it} = \alpha + \beta_1 \Delta g_{it-1} + \beta_2 \varphi \Delta Q_{IHC_{it}} + \beta_3 \Delta schooling_{it} + \beta_4 \Delta ki_{it} + \beta_5 \Delta openk_{it} + \beta_6 \Delta lifeexpect_{it} + \beta_7 \Delta inflation_{it} + \Delta \epsilon_{it} \]  

(4)

We are regressing the natural logarithm of GDP / capita at the end of each period of 5 years (\( g_{it} \)) with its deferred value (\( g_{i,t-1} \)), \( Q_{IHC} \) is the quality of education, \( schooling \) is the average number of years of education, \( ki \) is the physical capital, while the others are control variables: international trade openness (openk), life expectancy (lifeexpect), inflation rate (inflation).

The database is built using the same data sources as in previous models. Dynamic modelling results show the evolution of the growth process in time, the model formulation differences which means that the regression shows how variations in the quality of education affects economic growth.

**Testing the assumptions and the parameters**

The model was validated in terms of the homoscedasticity restriction through the Breusch-Pagan Lagrangian Multiplier test. At the same time, in order to test the first order autocorrelation we applied the Wooldridge test and to verify the absence of multicollinearity of the exogenous variables the correlation matrix was generated.
Results and discussions

Table 2 includes the results of MLE and GLS estimators on a panel model with variable effects. The relatively small number of countries in the panel, compared with the large number of explanatory variables can lead to over identifying variables, which implies a p value > 0.05 so the strict exogeneity is not rejected.

Table 2
Analysis of the interdependencies between the log GDP per capita and the physical capital dimension, the quality and quantity of education, openness, life expectancy, inflation

<table>
<thead>
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<th>GLS b/se</th>
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<tr>
<td>laglog_g</td>
<td>0.807***</td>
<td>0.828***</td>
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<td>0.786***</td>
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<td></td>
<td>(0.04)</td>
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<td>logQIHC</td>
<td>1.155***</td>
<td>1.036**</td>
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<td>0.469*</td>
<td>0.479*</td>
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<td>(0.38)</td>
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<td>-0.073</td>
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<td>0.188***</td>
<td>0.166***</td>
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<td>0.171***</td>
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<td>(0.04)</td>
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<td>0.052*</td>
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<td>loglifeexpect</td>
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<td>0.700</td>
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<td>(0.38)</td>
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<td>(0.42)</td>
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<td>(0.01)</td>
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<td>(2.42)</td>
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<td>(2.27)</td>
<td>(2.68)</td>
<td>(2.06)</td>
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R-squared 0.9772 0.9801 0.9790
Wald 3140.40 531.10 2914.71 531.10 4175.27 482.46
N observations 186 186 146 146 138 138

Note: * p<0.05, ** p<0.01, *** p<0.001; standard errors are presented in brackets
Source: Authors’ estimations.

It should be noted that when introducing this variable and its expected value (quality), the number of observations drops significantly.

Given the technical limitations imposed by the construction of dynamic models with time delay, we obtained robust results only for groups composed of a larger number of countries, so the model cannot be estimated in a relevant manner for samples consisting of fewer countries.

Dynamic models with time delayed variable could be applied only for three of the five groups of countries (EU27, EU17, EU15), but in order to see the effect of education on GDP per capita growth, we have estimated the coefficients of the regression both through
Generalised Least Squares Method (GLS) and Maximum Likelihood Estimator (MLE). We used two different estimation methods in order to increase the accuracy of estimated coefficients, thus allowing pertinent and correct interpretation of data and valid conclusions.

For the three groups of countries (by both methods) offset variable sign coefficients GDP per capita, human capital (measured in terms of qualitative dimension of education), physical capital per worker, the degree of international openness and life expectancy show an increasing positive effect on GDP per capita. For the human capital expressed through the quantitative variable, the coefficients show a negative impact, but statistically insignificant.

The quality variable of the human capital has a relevant statistical significance level of 0.1% for the EU27 by using the GLS method and for the rest of the group it drops to 1% (EU17) and 5% (EU15), which can be explained by decreasing the number of countries in the group.

The qualitative variable’s coefficient values of the human capital are high, so at its 1% growth the increase of the GDP per capita is 1.15% for the EU27 (GLS method) and, respectively, 1.04% (MLE), for EU17 is 0.63%, respectively 0.47% and for the EU15 is 0.48% and 0.48%. Comparing these values with those obtained in models without offset variables, they are smaller, but you must keep in mind that we had no data available to show the evolution of international test scores education, which are considered constant throughout the analyzed period, 1960-2010. The results are robust and emphasize the role of human capital in influencing economic growth when it is measured by a qualitative variable, the quantitative variable’s importance being greatly reduced. This fact is confirmed by many authors (Pritchett, 1996; Hanusek & Kimko, 2000; Bose et al., 2007; Hanusek & Wößmann, 2007), who capture the important effects of international test scores at the expense of the average of the years of schooling for all three levels of education.

Relevant is the fact that the same great influence on GDP growth is also the merit of the physical capital, which has a maximum statistical significance level of 0.1% for all three groups of countries and by any method, the obtained values of its coefficients are positive and large, but smaller than the values obtained for human capital expressed through qualitative variable. This comparison between the two types of capital highlights the major influence they have on economic growth.

The control variables entered into the model also have a positive role in influencing the growth of GDP / capita. Thus, the estimated coefficients of international trade openness have positive values in all models, indicating the beneficial role of participation in international flows of goods and service on GDP per capita (even if the coefficient values do not show a large determination, being of the order increased from 0.04 to 0.06% of GDP / capita to an increase of 1% in opening trade (calculated as the sum of exports and imports of a country relative to its GDP). Life expectancy is relevant on influencing the long term
economic growth, the coefficients having very high positive values even if less statistically significant (only 1% for the EU27), but this is due to the limited number of countries included in the model. The GDP per capita offset variable value is in the range [0,1], therefore the dependent variable, GDP per capita, can be estimated both on the current period and in other periods, the requirement of stability of the model being followed. The $R^2$ values were of 0.98 for all models, indicating that the variations in GDP per capita could be explained by up to 98% by the variations in human capital, physical capital, international openness, life expectancy and the level of inflation. This model emphasizes the significant positive influence of the human capital on economic growth when expressed through qualitative variables. The results are generally similar to those of the models developed by Barro (2000) or Altinok (2007), thus confirming the importance of human capital in influencing economic growth.

3. Concluding Remarks

The debate on economic growth and education is extremely intense and it reveals the importance of theoretical and empirical analyses of the interdependencies and impacts between human capital, expressed through qualitative and quantitative dimensions, and economic growth, respectively long term economic development and national welfare.

Within this framework, our results emphasize that within the European Union there is a strong positive influence of education on economic growth, expressed mainly through an increase in GDP per capita growth rate, especially when the human capital is expressed by qualitative variables, while the quantitative variable’s importance is being greatly reduced. At the same time, the results obtained converge to those found in the literature, showing that the scores on international tests can be considered as highly significant and perform better than other measures of education expressed in quantitative terms. The quantitative human capital variables have little influence on GDP per capita growth for EU15 countries, but a higher influence on the EU10, the group of developing countries having the average years of schooling lower than the EU15 developed countries. Moreover, the results point out several future research guidelines for the empirical analysis of economic growth, mainly by taking into consideration a larger sample of countries and indicators, both from quantitative and qualitative perspectives, and by including the potential positive impact of international labour migration on education and economic growth.

The results highlight an extremely important influence of human capital on economic growth, thus confirming the causality relationship on education-economic growth. This general appreciation results from the potential impact of tertiary education pointed out by our developed models, this type of investment increasing the GDP per capita both through its quantitative and qualitative dimensions. Nevertheless, the qualitative measures perform much better than the quantitative ones, especially when we use specifications of endogenous growth, where the human capital is an extremely relevant, dynamic and robust influential factor.
References


