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CAUSALITY BETWEEN SCHOOL EDUCATION AND ECONOMIC GROWTH IN ROMANIA[1]

This study investigates the causal relation between school education and economic growth in Romania, using annual time series data from 1985 to 2009. The econometric approach of this paper is based on the bivariate Vector Autoregression (VAR) model, Granger causality test and unit root test. The empirical results show evidence of unidirectional causality between school education and economic growth in Romania.

Keywords: school education, economic growth, granger causality, cointegration

1. INTRODUCTION

The interrelationship between education and economic growth has been the subject of public debates, enjoying a wide interest since the era of Plato. Over time, economists have offered a variety of theories and models for analyzing causality between education and growth. Solow (1956, 1957) pointed out that economic growth cannot be explained just in terms of capital, labour and technical progress. Denison (1967) was one of the first economists who emphasized the importance of investing in education, which was thought to have an impact on economic growth. Lucas (1988) further developed an endogenous growth model by considering human capital as one of the inputs and education as an expression of human capital accumulation. This approach assumes that education positively affects labour productivity, leading to better economic performance at the macroeconomic level. Romer (1990), Rebelo (1991), Grossman and Helpman (1991) focused their attention on the relationship between human capital and economic growth. Using a sample of 98 countries, Barro (1991) demonstrated that economic growth has been positively influenced by the initial level of human capital measured by schooling rates, and negatively by

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the initial level of gross national product per capita, in between 1960 and 1985. Using an extended Solow model by introducing the accumulation of human capital measured by education levels, Mankiw et al (1992) have demonstrated that the contribution of human capital on economic growth is significant. Barro and Lee (1993) have analyzed the causality between education (rate of schooling for adult population, by level of education, primary education, secondary education, higher education), and economic growth for 129 countries, from 1960 to 1985, and demonstrated that the education had a significant impact on economic growth. In contrast, Benhabib and Spigel (1994) showed in their study that the growth rate of human capital does not significantly explain the economic growth rate. Bils and Klenow (2000) argued that a significant positive correlation between education and economic growth does not necessarily imply that education influences economic growth. According to them, both education and economic growth can be influenced by a third omitted variable, such as total factor productivity. Pritchett (2001) also demonstrated that changes of the schooling rates play a minor role in explaining cross-country variation in growth rate. In contrast, using an endogenous growth model for 87 countries Gylfason and Zoega (2003) demonstrated that gross-secondary-school enrolment, public expenditure on education relative to national income and expected years of schooling for girls, vary directly with economic growth, and concluded that education has a significant impact on the economic growth rate.

Agiomirgianakis, Asteriou and Monastiriotis (2001) investigated the relationship between human capital (analyzed by rates in primary, secondary, and higher education) and economic growth in Greece, and found out that causality runs through educational variables to economic growth, with the exception of higher education where reverse causality exists. Podrecca and Carmeci (2002) analyzed the causality between education and economic growth using Granger causality, for a set of 86 countries over the period 1960-1990. Their results show that both education investment and the educational stock had an impact on growth rates, both individually and jointly with physical capital investment. There is also a reverse causality that runs from growth to investment in education. Jaoul (2004) analyzed causality between higher education and economic growth in France and Germany in the period before the Second World War. The obtained results demonstrate that higher education has an influence on gross domestic product just for the case of France. For Germany, education does not appear as a cause of growth. Kui Liu (2006) analyzed the causality and cointegration between education and gross domestic product, showing that economic development is the cause of higher education and the result of primary education in China, for the period of 1978-2004. T. S. Islam, Wadud and Q.B.T. Islam (2007), using the multivariate causality analysis, analyzed the relationship between education and growth in Bangladesh, in between 1976 and 2003 period. The authors included in his analysis also capital and labour. The obtained results show evidence of bidirectional causality between education and growth in Bangladesh, for the mentioned period of time. Huang, Jin, and Sun (2009) analyzed the causality between scale evolution of higher education and economic growth in China, in between 1972 and 2007. The empirical results show that there is a long-term steady relationship between variables of enrolment in higher education and gross domestic product per capita. For the analyzed period, with the growth of the economy, the scale of higher education exhibits an ascending trend. Pradhan (2009), using error correction modeling shows that there is a unidirectional causality between education and economic growth in the Indian economy (there is no reverse causality), in the period 1951-2002. Bo-nai and Xiong-Xiang (2006) show that there is an evident bi-directional causality relationship between education investments and China's economic growth during the period 1952-2003. Chaudhary, Iqbal and Gillani (2009), using the Johansen co-integration and Tod & Yamamoto causality approach in VAR framework analyzed the role of higher education in economic growth for Pakistan between 1972 and 2005. Their results show that there is a unidirectional causality running from economic growth to higher education and no other causality running from higher education to economic growth. Using an endogenous growth model developed by Lucas (1988), Gutema and Mekonnen (2004) demonstrated that education has a significant positive influence on the economic growth of Sub-Saharian Africa. Loening (2004) investigated the impact of education on economic growth in Guatemala during the period 1951-2002. Using an error-correction model, the author pointed out that a better-educated labour force has a positive and significant impact on economic growth, explaining 50 percent of its output. Katircioglu (2009) demonstrates that long-run equilibrium relationship exists between higher education growth and economic growth of North Cyprus. His results suggest a unidirectional causality that runs from higher education to economic growth in Northern Cyprus.

The aim of this article is to analyze the causality between school education and economic growth for Romania, in between 1985 and 2009. In general, most of the studies that analyze the causality between education and economic growth use the following variables to describe education: *school enrolment rates* used by Barro (1991), Barro and Lee (1993), Barro and Sala-i-Martin (1995), Bils and Klenow (2000), Pritchett (2001), Asteriou and Agiomirgianakis (2001), Huang, Jin and Sun (2009), Guatema and Mekonnem (2004), Loening (2004), *school enrolment* used by Gylfason and Zoega (2003), Boldin, Morote and Mc. Mullen (1996), Kui Liu (2006), *average years of schooling*, used by Benhabib and Spigel (1994), *public expenditure in education as a percent of gross domestic product*, utilized by Gylfason and Zoega (2003), Kui Liu (2006), Pradhan (2009), Chaudhary, Iqbal and Gillani (2009), or *investments in education* used by Podrecca and Carmeci (2002), Bo-nai and Xiong-Xiang (2006), Katircioglu (2009). As variables describing the economic growth, most studies completed until now use different measures of gross domestic product, gross domestic product per capita, national income or gross national income. The variables used in this study are school enrolment ratio and gross domestic product per capita. Unfortunately, there is no data for Romania regarding the public expenditure on education as a percent of gross domestic product for all the analyzed period. There are no studies about causality between school education and economic growth for Romania, except for one paper of Andrei (2010) which analyzes, among other aspects, cointegration between public expenditure on higher education as a percent of gross domestic product and growth in the period 1990-2008. Therefore, this paper seeks to fill a gap in the empirical literature. The chosen period of study is not random; as a consequence of the economic crisis of the 1980s, the volume of financial resources allocated to the Romanian educational system has decreased, leading to a difficult functionality of it. The rest of the paper is organized as follows: a description of used variables and data sources is given in section 2; section 3 describes the methodological approach of the VAR model and presents the empirical results; conclusions of the study are presented in section 4.

2. VARIABLE DESCRIPTION AND DATA SOURCES

The aim of this paper is to analyze the cointegration between school education and economic growth in Romania, using dynamic causality analytical methods. In my analysis I used annual time series data of gross domestic product and school education, for the period 1985-2009. As a measure of school education I used school enrolment ratio, called *edu* in my analysis. School education enrolment ratio is obtained dividing total school enrolments by the population of that age group (5-24 years). This proxy has been used by Barro (1991), Barro and Lee (1993), Barro and Sala-i-Martin (1995), Bils and Klenow (2000), Pritchett (2001), Asteriou and Agiomirgianakis (2001), Huang, Jin and Sun (2009), Guatema and Mekonnem (2004) and Loening (2004). However, due to the lack of data or uncertain data for school population enrolled in pre-school education and in primary and secondary education for the analyzed period, I included in my analysis just the school population enrolled in secondary educational level (high-school, vocational and complementary or apprentice schools, post-high-school, technical vocational school), and higher educational level. The school population enrolled in pre-school education and in primary and secondary education has constantly decreased from 1986 on, due to the demographical changes of the Romanian population. In contrast, higher education showed a major increase since 1990, and this increase was maintained until 2007. This situation is due to the profound changes occurred in the higher education system in Romania after the 1989 revolution, the emergence of many state universities in almost all counties, the emergence of private universities and the substantial increase in the number of students enrolled in higher education institutions. While before the revolution of 1989, access to the universities was limited and the number of enrolled students was small, after 1990 the Romanian higher education became a mass education. According to the statistics of the Romanian Ministry of Education, at the moment there are 56 state universities in Romania and 28 recognized private universities. The impact of this substantial growth in the number of students on economic growth has neither been estimated until now, nor has the issue been tackled whether the economic growth of Romania has influenced higher education growth.

The number of enrolled persons in secondary educational level (high-school, vocational and complementary or apprentice school, post-high-school and foremen school), exhibited an oscillating trend during the analyzed period, with increases between 1985 and 1990, declines after the revolution and again small increases for the 2002-2009 period. Statistical data that describe the variable school education (*edu*) were gathered from various issues of the Statistical Year Book of Romania (1994, 1995, 2004, 2008), and from the National Statistical Institute of Romania, Tempo-Online Database. To capture the economic growth in Romania during the analyzed period, I used the gross domestic product per capita variable (named *gdp* in my econometric analysis). In order to avoid possible errors caused by the fact that during the analyzed period Romania underwent a currency reform from the old ROL to a new RON, I used statistical data provided by the International Monetary Fund, World Economic Outlook Database, October 2009, representing gross domestic product based on purchasing-power-parity (PPP) per capita. Again, the population variable is included in the analysis by a gross domestic product per capita. Most studies cited in section 1 of my paper used gross domestic product per capita as a proxy for economic growth. Regarding the dynamics of gross domestic product per capita in the analyzed period, there was an ascending trend in the periods 1985-1988 and 1999-2008, and a descending trend in the periods 1988-1992 and 1997-1998.

3. METHODS AND EMPIRICAL RESULTS

The econometric approach of this paper is based on the autoregressive vector VAR. The chosen methodology is justified by the nature of the analysis performed in this study. The macroeconomic phenomena are complex, with feedback and bilateral causality. Therefore, only a system analysis with simultaneous equations may embrace the interconnections between economic variables. An important particularity of the VAR model is that it captures the dynamic structure of several variables simultaneously, and the impulse response functions capture the shock propagation of a dependent variable on the system.

Granger (1969) developed a test to check the causality between variables. Granger causality examines to what extent a change from past values of a variable affect the subsequent changes of the other variable. We can say that there is Granger causality between two variables x_t and y_t if a forecast y_t taken from a set of information that includes the past variability of x_t is better than a forecast that ignores the past variability x_t, with the assumption that other variables stay unchanged.

The Granger causality test involves estimating the following pair of regressions:

$$y_t = \sum_{i=1}^{n} \alpha_i x_{t-i} + \sum_{j=1}^{n} \beta_j y_{t-j} + \varepsilon_{1t} \tag{1}$$

$$x_t = \sum_{i=1}^{n} \lambda_i x_{t-i} + \sum_{j=1}^{n} \delta_j y_{t-j} + \varepsilon_{2t} \tag{2}$$

with the assumption that the disturbances ε_{1t} and ε_{2t} are uncorrelated.

We distinguish four cases:

- unidirectional causality from x_t to y_t is indicated if the estimated coefficients on the lagged x_t in (1) are statistically different from zero as a group ($\sum_{i=1}^{n} \alpha_i \neq 0$) and the set of estimated coefficients on the lagged y_t in (2) is not statistically different from zero ($\sum_{j=1}^{n} \delta_j = 0$).
- unidirectional causality from y_t to x_t is indicated if the estimated coefficients on the lagged y_t in (2) are statistically different from zero as a group ($\sum_{j=1}^{n} \delta_j \neq 0$) and the set of estimated coefficients on the lagged x_t in (1) is not statistically different from zero ($\sum_{i=1}^{n} \alpha_i = 0$).
- feedback (bilateral causality) is indicated when the set of x_t and y_t coefficients are statistically different from zero in both regression equations (1) and (2).
- independence occurs when the set of x_t and y_t coefficients are not statistically significant in both regression equations (1) and (2).

In all four cases it is assumed that the two variables x_t and y_t are stationary. In a stochastic process stationarity means that statistical characteristics of the process do not change in time. As Granger and Newbold (1974) and Cheng (1996) point out, Granger causality on non-stationary time data may lead to spurious causal relation. The stationarity of a non-stable time series can be obtained with the help of certain mathematic procedure, such as differentiation of variables (Gujarati 2004).

In my analysis the variables are transformed through the use of natural logarithm to ease interpretation of the coefficients. Using log function the regression coefficients are interpreted as elasticities, i.e., a percentage change in the dependent variable in response to a 1% change in the independent variable.

The aim of econometric analysis is to determine which of the following relations are valid for the mentioned variables:

- whether school education affects the growth of gross domestic product per capita;
- whether the growth of gross domestic product per capita affects school education;

- whether there is a bilateral causality between school education and gross domestic product per capita;
- whether the variables are independent of each other.

3.1. Unit root tests

The first step of my analysis was to examine the stationarity of the variables. As Enders (1995) points out, stationarity means that the mean and variance of a series are constant through time and the auto-covariance of the series is not time varying. If all the variables are stationary I(0), then there is no problem to estimate the coefficients using the variables with initial specification. However, most of the main macroeconomic variables are non-stationary, integrated of order higher than zero.

Most commonly used tests for the integration order of variables are Dickey-Fuller (DF) test, Augmented Dickey-Fuller test (ADF, 1979), Philips-Peron test (PP, 1988) and Kwiatkowski test (KPSS, 1992).

Dickey Fuller (DF) test and Augmented Dickey-Fuller (ADF) test are described by the following equations:

(DF) $$\Delta x_t = a + bx_{t-1} + \varepsilon_t \quad (3)$$

where Δ is the difference operator and *a* and *b* are parameters to be estimated.

(ADF) $$\Delta x_t = a + bx_{t-1} + \sum_{i=1}^{\gamma} c\Delta x_{t-1} + \varepsilon_t \quad (4)$$

where *a*, *b*, *c* are parameters to be estimated.

Both of these tests are based on the null hypothesis $H_0 :$ x_t is not *I(0)*. If the obtained DF and ADF statistics are less than their critical values from Fuller's table, then we can reject the null hypothesis H_0 and we conclude that the series are stationary or integrated.

I used the Dickey-Fuller test (DF) and augmented Dickey-Fuller test (ADF) to test the existence of unit roots and to determine the order of integration of the variables. The tests were done with and without a time trend. As can be seen from Table 1, the results of both tests show that the variables *edu* and *gdp* are non-stationary, at the 5% significance level. However, as it can be noticed from Table 1, the non-stationary problem vanished after second difference.

Table 1

Results of ADF unit root test

Variable	Difference order	Without a time trend		With a time trend	
		ADF statistics	Critical values	ADF statistics	Critical values
lngdp	0	-1.064309	-2.998064	-2.569708	-3.622033
	1	-2.033584	-2.998064	-2.015268	-3.622033
	2	-3.190392*	-3.004861	-3.054312	-3.632896
lnedu	0	-0.533408	-2.998064	-1.018768	-3.612199
	1	-2.608534	-2.998064	-2.912948	-3.622033
	2	-5.756256*	-3.004861	-5.565783	-3.632896

*indicates that the null hypothesis is rejected at the 5% significant level. Critical values are from MacKinnon (1996)

Source: author's computations. The analysis was performed with the Eviews 4.0 package.

3.2. Optimal lag length and co-integration tests

Choosing the optimal lag length is based on the results of several methods such as Akaike Information Criteria (AIC), Schwartz Bayesian Criteria (SC), Hannan-Quinn information criteria (HQ), final prediction error (FPE) and likelihood ratio test (LR). As Enders (1995) suggested, the optimal lag is selected based on the lowest values of AIC, SC, HQ criteria, and rejecting the null hypothesis in LR test that parameter values at lag *k* are equal to zero. Due to the fact that I used annual data in my analysis, I chose six lags to be included. In Table 2 the results of the lag selection are presented. As can be noticed from Table 2, most of the tests (FPE, AIC and HQ) suggest that the optimal lag length is one.

Table 2

VAR lag selection for ($\Delta^2 \ln edu$, $\Delta^2 \ln gdp$)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	87.62351	NA	1.45e-07	-10.07335	-9.975329	-10.06361
1	94.14838	10.74685*	1.08e-07*	-10.37040*	-10.07632*	-10.34117*
2	94.91487	1.082107	1.63e-07	-9.989985	-9.499860	-9.941266
3	96.65349	2.045436	2.28e-07	-9.723940	-9.037765	-9.655733
4	99.58924	2.763051	2.95e-07	-9.598734	-8.716508	-9.511039
5	100.2839	0.490351	5.61e-07	-9.209870	-8.131594	-9.102688
6	106.4785	2.915122	7.00e-07	-9.468063	-8.193737	-9.341392

*indicates the optimal lag selection

Source: author's computations. The analysis was performed with the Eviews 4.0 package.

In order to test the co-integration of the analyzed variables, I used the maximum likelihood estimation method of Johansen and Juselius (1990, 1995). Both eigenvalue and trace tests, without a trend, led to the same results; there are two co-integration equations at the 5% level of significance between school education and gross domestic product per capita (Table 3). The fact that the analyzed variables are co-integrated is very important for the validity of the Granger causality test results. According to Sims et al (1990), if the times series are non-stationarity and not co-integrated, then the obtained *F* statistics used to detected Granger causality are not valid.

Table 3

Trace Test and Maximum Eigenvalue test for co-integration without a trend

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.500755	21.21869	15.49471	0.0061
At most 1 *	0.270762	6.630863	3.841466	0.0100
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.500755	14.58783	14.26460	0.0444
At most 1 *	0.270762	6.630863	3.841466	0.0100

*indicates that the null hypothesis is rejected at the 5% significance level. Critical values are from MacKinnon (1996).

Source: author's computations. The empirical analysis was performed with the Eviews 4.0 package.

3.3. Granger causality test

The four hypotheses introduced at the beginning of section 3 that school education affects economic growth, economic growth affects school education and bilateral causality or independence were tested using Granger causality method. According to Enders (1995), this method is best suited to determine whether the lags of one variable enter into the equation for the other variable.

Customizing equations (1) and (2) with the analyzed variables we have:

$$\Delta^2 gdp_t = \sum_{i=1}^{n} \alpha_i \Delta^2 edu_{t-i} + \sum_{j=1}^{n} \beta_j \Delta^2 gdp_{t-j} + \varepsilon_{1t} \qquad (4)$$

$$\Delta^2 edu_t = \sum_{i=1}^{n} \lambda_i \Delta^2 edu_{t-i} + \sum_{j=1}^{n} \delta_j \Delta^2 gdp_{t-j} + \varepsilon_{2t} \qquad (5)$$

In order to determine if there is a Granger causality between school education and gross domestic product per capita, I used an *F*-statistics to test $H_0 : \sum_{i=1}^{n} \alpha_i = 0$. Likewise, I applied the *F*-statistics for testing the hypothesis of Granger causality between gross domestic product per capita and school education, $H_0 : \sum_{j=1}^{n} \delta_j = 0$. The obtained results are presented in Table 4.

Table 4

Granger causality test

Null Hypothesis		Obs	F-statistics	Probability
Lag 1	Δ^2 lngdp does not Granger cause Δ^2 lnedu	22	0.17718	0.67853
	Δ^2 lnedu does not Granger cause Δ^2 lngdp	22	4.91813	0.01832
Lag 2	Δ^2 lngdp does not Granger cause Δ^2 lnedu	21	0.37985	0.68997
	Δ^2 lnedu does not Granger cause Δ^2 lngdp	21	4.41277	0.04925
Lag 3	Δ^2 lngdp does not Granger cause Δ^2 lnedu	20	0.27830	0.84007
	Δ^2 lnedu does not Granger cause Δ^2 lngdp	20	3.09774	0.06404

Source: author's computations using Granger causality test, performed with Eviews 4.0 package.

Analyzing the results presented in table 4 we can conclude that the variable school education is Granger cause of economic growth with a 5% significance level. Regarding the variable gross domestic product per capita, the results of the Granger test show a lack of statistical significance for causality between *gdp* and school education.

As Pindyck and Rubinfeld (1991), Shan and Sun (1997) emphasized, it is very important to perform the Granger test for different lag selections and the results should not be sensitive to the different lag structures. I performed the Granger test with different lag selections, and the obtained results, as can be noticed from table 4, are almost the same (for three lags, school education is Granger cause of economic growth with a 10% significant level).

Based on the obtained results of the VAR model evaluation, the equation of the influence of gross domestic product change on the education (second system equation) can be written as follows:

$$\Delta^2 \ln gdp_t = \text{-}0.000393\text{-}0.060912\Delta^2 \ln gdp_{t-1} + 0.197234\Delta^2 \ln edu_{t-1} \quad (6)$$

As can be noticed in equation (6), the results suggest that 1% change of the variable *edu* in the period *t*-1 would result in a 0.197% change of annual gross domestic product per capita in the period *t*. VAR model is stationary if all roots have absolute value less than one and lie inside the unit circle. As we can see from figure 1, in our model all the roots lie inside the unit circle, so this suggests that our model is stable.

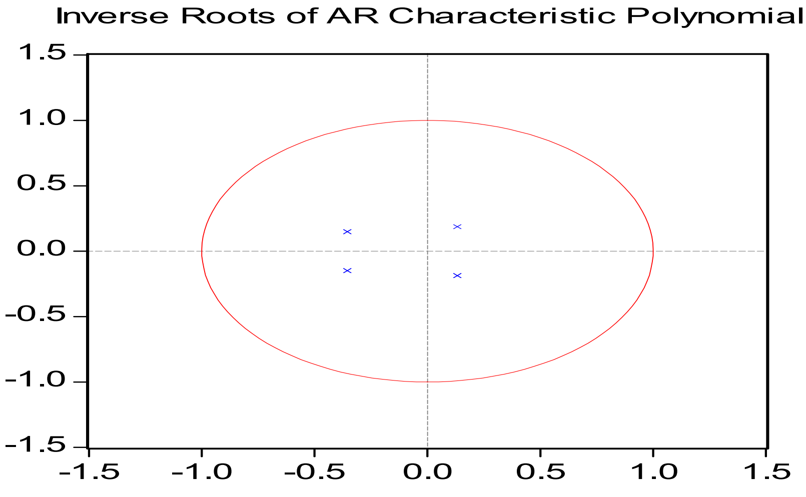

Figure 1. Inverse roots of VAR

Source: author's computations using Eviews 4.0 package

4. CONCLUSIONS

The aim of this article was to analyze the causality between school education and economic growth for Romania, between 1985 and 2009. Unfortunately, there have been no studies regarding a potential causality between school education and economic growth for Romania until now. Therefore, this paper seeks to fill a gap in the empirical literature. School enrolment ratio was used as a proxy for education, and gross domestic product per capita as a proxy for economic growth in Romania.

Using data gathered from various issues of the Statistical Year Book of Romania (1994, 1995, 2004, 2008), from the National Statistical Institute of Romania, Tempo-Online Database and the VAR methodology, I found that there is empirical evidence of a long-run relationship between school education and gross domestic product per capita in Romania, during the analyzed period. Granger test showed a unidirectional causality running from school education to gross domestic product per capita. Moreover, the results of VAR model evaluation show that a 1% change of the variable school education in the period t-1 would result in a 0.197% change of annual gross domestic product per capita in the period t. The results are similar to those obtained by Barro (1991), Barro and Lee (1993), Sala-i-Martin (1997), Barro and Xavier Sala-i-Martin (1998), Asteriou and Agiomirgianakis (2001), Podrecca and Carmeci (2002), Gutema and Mekonnen (2004), Benhabile and Spigel (2004), Pradhan (2009).

The results of the empirical analysis show that human capital has a significant and positive impact on the long-run growth in Romania, during the analyzed period. Unfortunately, as a consequence of the economic crisis of the 1980s, the volume of financial resources allocated to the Romanian educational system has decreased, leading to its disturbed functioning. During the period of 1985-2002, Romania allocated to education spending one of the lowest percentages of gross domestic product compared with other EU member states. Although we have made progress in terms of gross domestic product percentage spent on education, the statistics still are below the average of EU 27. For example, in 2006, Romania spent 4.3% of the gross domestic product to education, while in Denmark the share was 8%, 6.9% in Sweden, 5.7% in Slovenia and 4.2% in Bulgaria (Eurostat Database). According to the same source, in 2007 Romania allocated 4.25% of the gross domestic product to education, below the EU 27 average.

Also, after the revolution of 1989, the Romanian educational system has been in a continuous process of reorganization and reforms are rapidly progressing, amplifying the disfunctionalities and leading to disturbances of the educational activities. Amid the financial crisis faced by Romania, cuts in wages of educators and teachers have led to a significant migration flow of people working in the educational system to developed countries of the EU, making the crisis faced by the Romanian educational system even worse. A long term consequence of this situation will be a negative externality that will lead to a lower quality of the learning process in Romania.

The results of this study emphasize the importance of school education for economic development of Romania and the importance of developing viable educational policies that support sustainable development of this priority sector. In the future, I want to extend my study and analyze the causality between quality of school education and economic development of

Romania, and also the impact of higher education on economic growth in Romania. Most investment in the educational field between 2000 and 2010 have been directed to higher education, the number of students exploded just after the revolution, the number of universities has increased, all this raised the question: did the development of the higher education system lead to economic growth in Romania?

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