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Some insights about determinants of economic growth in Romania. An empirical exercise

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Abstract. *This paper seeks to identify some determinants of the economic growth in Romania using a Cobb-Douglas production function. We introduce in the standard Cobb-Douglas production function innovation and education. Besides classical factors, such as labor and capital, we add R&D output and human capital variables. We depict significance in the case of classical factors, labor and capital. Patents are found to be negative and significant while human capital is insignificant. These results mean that there is a need to correct for some deficiencies in obtaining patents and to stimulate the development of new own technology and high quality of human capital formation.*

Keywords: Cobb Douglas, regression, economic growth, innovation, education.

JEL Classification: E00, E23, E25.
REL Classification: 8E.

1. Introduction

Nations consider economic growth as an important economic and political objective, being the most important factor for their economic success in the long run (Samuelson and Nordhaus 2001, p. 632). Although every country has this objective, in the world there are many disparities in terms of prosperity. In this context, an important question is raised regarding the factors that enhance the economic growth. The identification of these factors would permit the improvement of the welfare in different countries. Having this in mind, we will focus in this paper on analyzing the impact of some determinants of economic growth, using a Cobb-Douglas production function. We are aware of the criticism that the Cobb-Douglas production function has received due to aggregation of the data when macroeconomic level is considered. However, this function is often used in macroeconomics studies.

In the literature, we find that, when referring to Solow (1956) growth model, some authors express the fact that the functional relation between production, capital and labor is an empirical law since it can be "empirically refuted" (Wan, 1971). Following this idea, we proceed to an empirical exercise to estimate the elasticities of output with respect to capital and labor. Our analysis is important due to the importance of attaining a sustainable economic growth in our country. Over time, to these factors, there were added other factors that count for economic growth. Neoclassical theory became insufficient as it explained economic growth through factors' accumulation and exogenous technical change, without focusing upon the causes (Wennekers and Thurik 1999, p. 27). The new theory of economic growth (endogenous growth theory) added new factors for explaining economic growth such as human capital and innovation. The promoters of this new theory implied that the neoclassical model with the production function, with the logic of rational choice and perfect information, do not allow for an active entrepreneur. But innovations and entrepreneurship represents the heart of the national competitiveness (Porter 1990, p. 125 apud Wennekers and Thurik 1999, p. 43). The technical progress left as a residual in the Solow (1956) model of economic growth is explained through the endogenous growth theory. Increasing returns to scale, research and development activity and imperfect competition, human capital and governmental policies are intended to explain the technical progress (Havrylyshyn et al., 1999, p. 2). The endogenous theory implies that the increase of productivity from the developed countries is due to the intellectual achievements and new flows of ideas (Lucas, 2008, p. 1). In his work, Lucas (2008) raises the question if economic growth is generated by the work of genius, scientists which create patents or it can result from other sources too? Thus the new endogenous growth theory comes into place, the explanation being valid: each person earns due to the knowledge of people around him while his idea also stimulates other people too (Jones, 2005 apud Lucas 2008, p. 2). Thus a positive externality is produced.

Levin, Klevorick, Nelson and Winter (1987) state that a patent offers monopoly of an invention for a limited period as a price for a public recognition that patent assures. When the patent expires, it offers a high diffusion of the benefits. The authors state that, often, the right offered by a patent is broken through competition, by creative methods under the law and thus, the diffusion of the benefits is not always visible. The authors consider that the policy of the patents is efficient in some industries (such as pharmaceutical) but inefficient in other industries. In another study, Hu and Png (2012) mention that, although the objective of the property rights is that of stimulating innovation and economic growth, this is not always attained in practice. One of the reasons suggested by these authors is that because of the restriction imposed of the legislation in order to protect innovation, diffusion is not produced anymore and implicitly economic growth is not generated.

Therefore, innovation is an essential factor of economic growth, which helps producers to satisfy diversified demands of consumers in a context with high competition. This helps the companies to maintain their competitive advantage (Prodan, 2005, p. 5). Same author found a positive relation between the research and development expenditures (independent variable) and patents (dependent variable). His result is in line with the theory that patents are results of precedent investments in research and development (Grossman and Helpman 1990, p. 3). Felix (2008) also finds a positive relation between number of patents and personnel in the field of research and development. The author does an analysis for European Union countries in the period 2000-2005. The same study draws the attention upon the fact that not all the inventions lead to applications for patents. There exist also other modalities to protect the intellectual property for authors' rights, brands. Wennekers and Thurik (1999) which estimate an unrestricted VAR model for the countries of G7 find a long-run relationship between the growth rate of patents and the growth rate of the economy. In the short run there is obtained a negative coefficient for patents. A negative coefficient is also found in a study realised in Malaysia by Gee, Ida and Alavi, published by the International Organisation of Intellectual Property rights. Although the trends of GDP per capita and the trend for applications in obtaining patents are similar, the relation depicted is a negative one. More, Saini and Jain (2011) find a negative correlation between the number of applications for patents and the rate of growth for GDP in China, Indonesia and Malaysia during 2000-2009. Their conclusion is that the impact of the patents over the economic growth is lower in economies which are poorer or in those in which industries that are dependent of patents (such as pharmaceutical industry) have a low share. In the same study, it is mentioned that the developing countries can choose imitation or transfer while they avoid involving in activities that generate innovations. The negative coefficient means that it is necessary to build an efficient institutional environment so as the property rights could function.

An essential role is accorded to human capital as well, considering that if its level is too low, it is possible that growth will not be produced (Romer 1990, p. 73). Romer highlights the fact that the rate of increase of human capital does not necessarily depend on the labor force or population. In his model, human capital is seen as formal education or instruction at the workplace. According to his model, as long as less human capital is allocated towards research, the growth rate will be smaller. Yamarik (2011, p. 195) explains the importance of human capital through the fact that formal education increases the productivity of workers. More, an educated labor force is more capable to create, implement and adopt new technologies, generating thus economic growth (Benhabib and Spiegel 1994, p. 144). As for the level of education, they are different proxies such as: university enrolment (Yamarik, 2011) or highschool level (Mankiw, Romer and Weil, 1992; Holtz-Eakin, 1992). More, the Asian miracle which refers to the increase of productivity is associated more with investments in primary and secondary education rather than in tertiary education (Aghion et al., 2009, p. 3). Barro and Lee (2000, p. 17) also consider that during the secondary cycle of studies there can be acquired important aptitudes. In the literature there are some debates in what concerns the number of schooling as a proxy for human capital. This is due to the fact that the years of schooling do not represent a measure of the abilities of that person, but the time period allocated in order to obtain the aptitudes (Khan 2009, p. 13). It has been reached the conclusion that a quantitative analysis is not sufficient and that this analysis should be completed with a qualitative analysis based on the existing resources in the school's level and the results of tests (Caselli 2004, p. 3). The main problem of a quantitative measure is that it measures input and not output of the schooling years. Same author insists upon the fact that in rich countries, employees spent more years learning and not accumulating practical experience. In the same line, Klenow and Rodriguez-Clare (1997) reach the conclusion that experience is higher in the poorer countries. However, in these countries experience does not generate economic growth because it is orientated upon unproductive sectors.

In our study, we also choose as a proxy for human capital secondary school graduates, due to lack of data on qualitative measures of human capital.

Even if the theoretical literature is obvious in terms of the positive impact that human capital has upon economic growth, some researchers (see Pritchett, 1996) find in their studies a negative and significant coefficient for the human capital.

The explanation lies in the existence of some deficiencies in the education system and also in the allocation of human capital towards unproductive activities. Other studies find negative and insignificant coefficient for human capital (Benhabib and Spiegel, 1994; Temple, 1999 apud Engelbrecht 2001, p. 3).

More recent studies on the determinants of economic growth include in estimations the role of entrepreneurship for economic growth. In a study made for Iran during the period 1968-2009, Rabiei (2011) finds positive the coefficient for entrepreneurs' production and higher than the coefficients for labor, human capital (proxied by the number of students in tertiary education) and for research and development expenditures.

Zaman, Goschin, Partachi and Herteliu (2007) estimate the classical production function for Romania and Moldavia. Their analysis is a cross-section analysis upon a period of 3 years, during 2002-2004. The capital coefficient for Romania is 0.56 and 0.63 while in Moldavia it has a value of 0.66.Labor in Romania lies between 0.3 and 0.5 and in Moldavia it lies between 0.3 and 0.4. Zaman and Goschin (2010) also find positive coefficients for labor and capital for the period 1990-2007 (0.337 for labor and 0.4098 for capital). In their paper, the authors focus on the technological development of the country.

As we could see in this section, main impact factors on economic growth are labor and capital. However, the science evolved in time and there are identified new determinants of economic growth, such as innovation and education. These factors can be considered as economic growth itself (North and Thomas, 1973 apud Wennerkers and Thurik 1999, p. 36). Our intention is to see, based on an empirical exercise, using the Cobb-Douglas production function, if these factors count for the economic growth in Romania alongside the classical ones, i.e. labor and capital. Identifying if these factors enhance or not economic growth helps us to offer some policy recommendations to attain a sustainable economic growth rate.

The paper is organized as it follows: in section 2 we present the methodology and the data, in section 3 we present the results while section 4 concludes.

2. Methodology and data

Our study is based upon Cobb-Douglas model. The model in its preliminary version represents one of the estimating methods of the production function and identification of its determinants, capital and labor. This model is preferred due to the simplicity of the function which is linear in a logarithmic form of the variables and due to the small number of parameters involved (see Tintner et al., 1977). The American senator Paul Douglas noticed the fact that the national income distribution between capital and labor remained constant for a long period of time (Mankiw, 2002, p. 71). Starting from this observation, he asked for help from the mathematician Charles Cobb so as to identify the production function which respects this rule. Thus, the assumptions of such a production function were as below:

$$\text{Capital income} = MPK \text{ x } K = \alpha \text{ x } Y \quad (1)$$

$$\text{Labour income} = MPL \text{ x } L = (1-\alpha) \text{x Y} \quad (2)$$

where,
K – capital;
L – labor;
MPK – marginal productivity of capital;
α – constant which measures the capital income share in total income, with values between 0 and 1;
MPL – marginal productivity of L.

Thus, the production function has the following form:

$$Y = F(K, L) = A \text{ x } K^{\alpha} \text{ x } L^{\beta} \quad (3)$$

where,
Y – total output;
A – parameter which measures technology productivity;
K – capital;
L – labor;
β – constant which measures the labor income share in total income.

In the neoclassical theory, we have the assumption of constant returns to scale (thus $\beta = (1-\alpha)$). This hypothesis is frequent in most of the studies (Abraham-Frois 1998, p. 126). The assumption of constant returns to scale means:

$$\text{z x } F(K, L) = (zK)^{\alpha} \text{ x } (zL)^{\beta} = z^{\alpha+\beta} \text{ x } K^{\alpha} \text{ x } L^{\beta}, \text{ where } \alpha + \beta = 1 \quad (4)$$

In our paper, we use an augmented Cobb Douglas production function, in which we add new variables such as patents and human capital. The general form of the function when more factors are included is as it follows:

$$F(x_1, x_2, ..., x_n) = x_1^{\alpha_1} * x_2^{\alpha_2} * ... * x_n^{\alpha_n} \quad (5)$$

where,

$x_1, x_2, ..., x_n$ – independent variables (determinants of economic growth);

$\alpha_1, \alpha_2, ..., \alpha_n$ – elasticity coefficients of output with respect to each variable.

Our data are collected from National Databases (INSSE) over the period 1990-2010. Our variables are: gross domestic product (Y), gross fixed capital formation (FBCF), number of employees (L), number of patents (patents) and number of secondary education graduates (HC). Gross fixed capital formation is used in accordance with Zaman and Goschin (2010).It represents the value of durable goods (tangible and intangible), dedicated to other purposes than military, bought by producing units in the scope of using them at least one year in the production process, and also the value of services found in fixed capital goods. We deflated the data for gross domestic product and gross fixed capital formation using constant prices expressed in the year 1990. Some of the data for some years (i.e. patents, number of secondary graduation educates) were collected manually from the Statistical Yearbooks of Romania due to difficulty in finding them electronically reported. The rough data proved us a decrease in terms of labor force, a decrease in terms of patents while gross fixed capital formation flows generally increased. In what the number of secondary education graduates is concerned, we noticed small variations in the data.

We are aware that the results are affected by the length of the data series and also by the fact that the analyzed period includes also the years in which the financial crisis took part. Our period of analysis starts with the year 1990 because this is the year when Romania started a transition period to the market economy. Thus, our series contains 21 observations. As for the second disadvantage, if we did not include the years of crisis, our time series would have been reduced, fact that is not desirable.

We run our estimations in Eviews 7.0.

Our econometrical model is given below:

$$\ln(GDP) = \beta_1 \ln(fbcf) + \beta_2 \ln(L) + \beta_3 \ln(patents) + \beta_4 \ln(HC) + \varepsilon \qquad (6)$$

where,
GDP – gross domestic product;
fbcf – gross fixed capital formation;
L – number of employees;
patents – number of patents that were given;
HC – number of secondary education graduates;
β_1, β_2, β_3, β_4 – elasticity coefficients;
ε – error variable.

Looking at the graphs for each series, our observation is that they are not stationary. To verify the non-stationarity hypothesis we applied Augmented Dickey Fuller test (ADF) to find out the number of unit roots at a level of significance of 5%. Results are reported below:

Table 1. *ADF unit root test, 5% significance level*

Variable	Trend/intercepts	Critical values	t-Statistic	Probability
ln_GDP	Trend and Intercept	-3.673616	-2.658121	0.2619
ln_fbcf	Trend and Intercept	-3.875302	-0.530305	0.9623
ln_L	Intercept	-3.029970	-1.623913	0.4516
ln_patents	Trend and Intercept	-3.759743	-3.204105	0.1207
ln_HC	Trend and Intercept	-3.658446	-2.464484	0.3396

In the case of each variable, the value of t-statistics is higher than the critical value for a 5% level of significance. Also, the probability is higher than 5% in every case. Results indicate that the series are non-stationary, having unit roots. We have to differentiate them before proceeding further in estimating the regression. We took the first order differences, we applied the ADF over them and we conclude that our series do not have unit roots. The values for t- statistic are less than the critical level for 5% level of significance, while the probability is under 0.05. This confirms the stationarity of the series, which can be used further in estimating our Cobb-Douglas production function.

Table 2. *ADF unit root test, 5% significance level, differentiated series*

Variable	Trend/intercept	Critical value	t-Statistic	Probability
d_ln_GDP	None	-1.960171	-2.301598	0.0242
d_ln_fbcf	None	-1.960171	-3.738841	0.0008
d_ln_L	Intercept	-3.175352	-43.20934	0.0001
d_ln_patents	None	-1.960171	-5.700563	0.0000
d_ln_HC	None	-1.960171	-5.122419	0.0000

In the next section, we describe the results we obtain when testing the Cobb-Douglas production function on the differentiated series.

3. Results

Our econometrical model based on differentiated series is:

$$dlnGDP = \beta_1 dlnfbcf + \beta_2 dlnL + \beta_3 dlnpatents + \beta_4 lnHC \qquad (7)$$

The recommended lag number for patents is one or two years, based on the fact that the positive results generated by an innovation appear in time, after the new idea is implemented in practice (see Prodan, 2005; Josheski and Koteski, 2011). The lag tests indicated as optimum a two-year lag in the case of patents and labor (number of employees) and a five-year lag in the case of graduates, in line with other studies in which same lag numbers are used. For labor, the lag length tests also indicated that a two-year lag should be used in order to obtain significant result for labor itself. In the case of capital, there were no indications that lags should be used in running the estimation.

In what follows, we give the regression results for the differentiated series in Table 3.

Table 3. *Estimation results*

Variable	Coefficient	Probability
C	0.018744	0.0343
dlnfbcf	0.493856	0.0000
dlnL(-2)	0.516556	0.0136
dlnpatents(-2)	-0.089525	0.0148
dlnHC(-5)	-0.064636	0.3349
R-squared	0.939920	
Adjusted R-squared	0.915888	
Durbin-Watson	2.025761	
F-statistic	39.11108	
Probability F-stat	0.00	

In Table 3 we present the detailed results of the regression. As we can see, probabilities are under 5% for gross fixed capital formation, number of employees and number of patents. The only insignificant coefficient is the coefficient for human capital. The value for R^2 is 0.93 which says that the dependent variable is explained in a proportion of 93.99% by the explicative variables. Durbin Watson statistic is also close to 2 (2.02) which means that the errors are not correlated.

In order to check for the validity of the estimated regression, there were tested the 3 criteria that need to be satisfied: the lack of correlation of the residuals, the normality of residuals, homoskedasticity of residuals (constant variance). To check for the correlation of residuals we applied Correlogram – Q-statistics. Results are given in Table 4. To verify the lack or the presence of cointegration we have calculated the interval for no significance [$-1,96/T^{1/2}$; $1,96/T^{1/2}$], where T represents the number of observations. All the coefficients of the autocorrelation and partial autocorrelation function are included in the interval: [-0.506; 0.506], which corresponds to the lack of correlation of the errors. Also, the probability of Q-statistics is higher than 5% in most of the cases.

Table 4. *Testing correlation of residuals*

AC	PAC	Q-Stat	Prob
-0.023	-0.023	0.0098	0.921
-0.338	-0.339	2.2532	0.324
-0.247	-0.300	3.5495	0.314
0.005	-0.189	3.5500	0.470
0.464	0.320	9.0415	0.107
-0.297	-0.458	11.538	0.073
-0.198	-0.016	12.782	0.078
0.051	-0.026	12.876	0.116
0.046	-0.188	12.964	0.164
0.131	-0.216	13.833	0.181
-0.127	0.173	14.863	0.189
0.003	-0.165	14.864	0.249

For testing the variance we used the test ARCH LM which has a null hypothesis homoskedasticity. The probability of the test is 81.55% which leads to the acceptance of the null hypothesis of homoskedasticity. Another aspect we were concerned of is to test normality based on the histogram. In our case, the value of skewness equal with 0.021 which is higher than zero which reflects the existence of a right asymmetry. Also, the value of the kurtosis is 2,911 < 3, which reflects a platikurtic distribution. The coefficients record very close values of those for normal distribution, which is zero for skewness and three for the kurtosis. The value of the Jarque-Bera statistic is 1.02 with a probability higher than 5%, which confirms that the errors are normally distributed(1).

Based on the previous tests, we can say that our regression is correct, so as we can proceed in interpreting our results. If we look at the coefficients, their sum is not 1 as assumed in the standard Cobb-Douglas production function. In our case, the sum is 0.856 which means that in the case of Romania we obtained decreasing returns to scale with respect to both inputs. Our results are similar to studies such as: Knut and Jungmittag (2008); Zaman and Goschin (2010); Rabiei (2011). At an 1% increase of gross fixed capital formation, gross domestic product increases with 0.493% while at an increase with 1% of labor, gross domestic product increases with 0.516% (in a two-year period). Unlike for these two variables, we obtained an inverse relation for the case of the other two variables, patents and the number of secondary education graduates. More, in the case of patents we obtained a negative relation even when lags were considered. Thus, an increase with 1% of the number of patents is associated with a decrease of 0.089% of the gross domestic product.

We try to explain the puzzling result that we have obtained for the Romanian case. In Romania, the institution which records and analyzes the demands from the industrial property field is State Office for Inventions and Brands (Romanian abbreviation OSIM). This has the role to free some protection titles for property in Romania, which offers the proprietors some exclusive rights in this space. If the market that is designated to commercialize products is reduced, a lot of products which present this potential are patented in other countries. In Romania, as a developing country, often technology is imitated from abroad instead of own innovations and new own technologies. Moreover, in recent analysis (see Andronic 2011), it was observed the fact that Romania is avoided as a space for patents because there is not a sufficient developed country for trading the patented products. Thus, even if there are companies which conduct research and development activities, they often patent their products abroad where they intend to sell their product. The efficiency of patenting differs from one country to another. Some Romanian specialists in the field of intellectual property (as Andronic, 2011) show the main problems on the Romanian market: the long period of time that is necessary to obtain a patent at OSIM, the high costs of the process and a very low developed market for trading the patented product. Thus, even if there are companies, including foreign ones which have research activities in Romania and obtain products that are likely to be patented, they opt often to patent their product on the markets where they intend to trade them. This fact can influence the result of the research, being imposed a high attention regarding the significance of the patent variable in our study.

Our result is in line with results obtained also by other others, such as (Iwaisako and Futagami, 2011). They explain the negative sign of the patents as a result of the protection offered by them. This protection decreases severely the demand for capital, thus the accumulation for capital is discouraged and they have a negative impact on output, which generates a trap for the economic growth of the country. The authors also state that to this result contributes also the open economy, which permits the technology transfer and diminish the capital accumulation due to the high protection measures. These effects are seen also at the level of output.

In what concerns the negative but not significant coefficient for the secondary education graduates, this lead to the conclusion that in the Romanian case, this variable does not influence economic growth. The negative result for human capital is explained by some researchers (Pritchett, 1996), as the consequence of three deficiencies. First refers to the fact that, school does not create human capital. There exists the possibility that school does not contribute to the improvements of aptitudes and implicitly to the increase of productivity. Another explanation offered by Pritchett refers to the fact that marginal productivity of education decreases soon, while the demand for educated labor force stagnate and labor force supply increases. And finally, the third explanation found by the author for justifying the negative sign of the coefficient is that if, human capital is oriented in activities which are not productive, it can even lead to a decrease of economic growth.

Our results suggest that there is a need to improve the actual systems of education and innovation so as these factors can really be used to their true potential and transformed thus into determinants of economic growth. This situation is highlighted in the literature (Olsen apud Havrylyshyn et al., 1999, p. 2), making reference to the fact that many countries are too poor because they do not use their available resources. Also, the same researcher stated that the higher is the waste of resources, the lower developed is the institutional framework and the legal framework of the country in case.

4. Conclusions

In this paper we analyzed the impact of the labor and capital factors, but also of innovation and human capital, on the output of Romania. We obtained positive coefficients for capital and labor in a multiple regression analysis. Being aware of the short number of observations and also of the critics that could be raised due to endogeneity issues, it seemed to us worthwhile to comment upon the results of this simple exercise. The positive effect that these factors have upon economic growth and especially the positive impact of capital is, however, threatened by factors such as patents which come in with a puzzling negative sign. As we could guess from this result, in Romania the intellectual property rights' system has some flaws which impede patents to generate economic growth. One of the most important deficiencies from those mentioned in the literature, is, in our opinion, the reduced market for trading patented products. This fact certainly reduces the positive impact that a patent could have for our national economy. More, bureaucracy in obtaining a patent and high associated costs discourage inventors to patent their discoveries inside the country. These facts discourage the process of inventions in general, which explains the tendency to decrease of obtained patents and also the tendency of the developing economies, in this case Romania to borrow technology from abroad instead of encouraging its own innovations. We come close to the well-known hypothesis from the literature that imitation is preferred when it is cheaper than innovation.

In accordance with other similar studies for other countries, we obtained an insignificant result for the impact of human capital on economic growth, even when a five-year lag was considered. The reasons behind this result are many. One of the most obvious one is the proxy itself for human capital. A qualitative measure for human capital would proxy in a much more consistent way with the theory the role that human capital can play in the economic growth process. Given our proxy based on our data availability, however, we highlight the fact that educational system needs to be improved. The skills that are offered to students after graduating schools (in our case, secondary school) must be correlated with the requirements on both, a superior level of schooling or a job market in case of schools of arts and crafts.

In the end of our study, an interesting question comes up. How long it will take for Romania to attain sustainable economic growth paths, based on other factors than capital and labor? Is Romania prepared to improve significantly the system of innovation and education so they can create value and contribute seriously to the increase of the national income?

As a further direction of study, it would be interesting to include in this very simple framework, the Cobb-Douglas production function, a variable that corresponds to the entrepreneurship. Certainly, if the entrepreneurial activities will increase inside the country, this could be correlated with the impact that innovation and education can have on economic growth.

Note

(1) These diagnosis results as obtained in Eviews 7.0 can be provided upon request.

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