ESTIMATING THE PRODUCTION FUNCTION IN THE CASE OF ROMANIA: METODOLOGY AND RESULTS

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Abstract: *The problem of economic growth is a headline concern among economists, mathematicians and politicians. This is because of the major impact of economic growth on the entire population of a country, which has made achieving or maintaining a sustained growth rate the major objective of macroeconomic policy of any country. Thus, in order to identify present sources of economic growth for Romania in our study we used the Cobb-Douglas type production function. The basic variables of this model are represented by work factors, capital stock and the part of economic growth determined by the technical progress, the Solow residue or total productivity of production factors. To estimate this production function in the case of Romania, we used the quarter statistical data from the period between 2000 – first quarter and 2014 – fourth quarter; the source of the data was Eurostat. The Cobb-Douglas production function with the variables work and capital is valid in Romania's case because it has the parameters of the exogenous variables significantly different from zero. This model became valid after we eliminated the autocorrelation of errors. Removing the autocorrelation of errors does not alter the structure of the production function. The adjusted R^2 determination coefficient, as well as the α and β coefficients have values close to those from the first estimated equation. The regression of the GDP is characterized by marginal decreasing efficiency of the capital stock (α > 1) and decreasing efficiency of work (β < 1). In our case the sum of the α and β coefficients is below 1 (it is 0.75) as well as in the case of the second model (0.89), which corresponds to the decreasing efficiency of the production function. Concerning the working population of Romania, it registered a growing trend, starting with 2000 until 2005, a period that coincided with a sustained economic growth.*

Keywords: *economic growth, production function*, *econometric model, convergence*.

JEL classification: O47, Q56, B23.

Introduction

Until the 60 models that have dominated the literature in the theory of economic growth, exogenous growth models were developed originally in the Solow-Swan neoclassical model and these associated exogenous sources of long-term growth. They support the realization of a process of real economic convergence between countries, based on assumptions, such as, capital is subject to decreasing returns; states that have the same characteristics in terms of population growth, the rate of technical and investment income will record that converge to the value of the most developed state; perfect mobility of factors of production is a factor determining the reduction of regional disparities, and to stimulate the process of convergence; constant returns of scale; technical progress is exogenous. The Solow-Swan model base is found in the aggregate production function (Y - output) with two inputs (physical capital K and labor L) (Solow, 1956: 66). Without diminishing return technology law makes it impossible to sustain growth for an extended period of time, even by accumulating a quantity of capital per capita that is growing. From this, it is considered necessary to introduce a new factor of production, namely, that of technical progress (Mecu, 2013: 240). Analysis of the effect of stimulating long-term economic growth by technical progress, with the sense of an intensive use of the labor force, is based on the Cobb-Douglas production function. In order to identify present growth sources in the economy of Romania, we have used a Cobb-Douglas type production function.

1. Methodological aspect

The explanatory variables of the model are represented by work factors and capital stock. In order to estimate the production function, we have used the statistical quarterly data, the period we studied being the first quarter of 2000 (Q1) until the 4th quarter of 2014 (Q4), for which there is available data. The source of this data is Eurostat, while there are 60 observations for each variable. The work factor refers to the active population (between the age of 15 and 64). The productive capital stock is estimated for the initial capital level, adjusted with the modifications in the net forming of the fixed capital with the level of depreciation, such as:

$$K_1 = K_0 + I_{net} = K_0 + (I_{gross} - \text{Depreciation}) \tag{1}$$

where:

K_1 – stock of capital at t moment in time
K_0 – initial stock of capital
I_{net} – net investment
I_{gross} – gross investment

The quarterly information provided by Eurostat regarding the gross forming of the fixed capital and the variations of stock have helped us determine the gross investment as being the sum of the two. We assumed a constant capital depreciation rate of 6% (as in Marinaș, 2008: 229), a value close to that taken into account by the Convergence Program of Romania for 2013-2016 (where it is 5%). In order to determine the initial stock of capital, we assumed that it represents 66% of the GDP from the first trimester of 2000 (this value reflects the contribution of the capital factor in obtaining the internal production of final goods). The capital stock is expressed in millions of euros, at the price levels of 1999. The bouth data series have been deseasonalized and turned into logarithms.

2. The Cobb-Douglas production function with work and capital variables

The production function with the working population and the stock of capital as variables is presented as:

$$GDP = A \times K^{\alpha} \times L^{\beta} \tag{2}$$

where:
A – the part of economic growth determined by the technical progress, the Solow residue or total productivity of production factors;
K – capital stock
L – working population
α, β – the contribution of capital and of work in obtaining the potential GDP;

By applying a logarithm to the production function, we get::

$$LogGDP = LogA + \alpha \times LogK + \beta \times LogL \tag{3}$$

The α, β coefficients represent the elasticity of the potential GDP compared with the K and L factors. Based on the data provided by Eurostat and using the Eviews software, we have obtained the following results:

Table 1: The estimation of regression equation
Dependent Variable: LogGDP
Method: Least Squares
Sample: 2000:1 2014:4
Included observations: 60
LogGDP=C(1)+C(2)*LogK+C(3)*LogL

	Coefficient	Std. Error	t-Statistic	Prob.
A	2.619141	1.261353	2.076452	0.0407
α	1.769408	0.064726	27.33679	0.0000
β	-1.018079	0.338723	-3.005639	0.0039
R-squared	0.945696	Mean dependent var		10.01701
Adjusted R-squared	0.943791	S.D. dependent var		0.470707
S.E. of regression	0.111597	Akaike info criterion		-1.499133
Sum squared resid	0.709875	Schwarz criterion		-1.394416
Log likelihood	47.97400	Durbin-Watson stat		1.272745

Source: the author's calculus based on the data provided by Eurostat

Thus, the production function is:

$$GDP = 2,61 \times K^{1,76} \times L^{-1,01} \tag{4}$$

Or in a linear form:

$$LogGDP = 0.41 + 1,76 \times LogK - 1,01 \times LogL \tag{5}$$

The potential GDP's elasticity compared to the initial stock capital is 1.76, while compared to the working population is of 1.01. Thus, the results are validated, from other previous empiric studies which have underlined the negative contribution of the work factor in obtaining internal production. According to the table above, it can be observed that the α and β factors are significantly different from zero, at the sample level, as well as for the entire population. The probability that the null hypothesis is true is smaller than 5% (p=0.0000 for α and p=0.0039 for β), so it can be stated that the null hypothesis is rejected and the only accepted true hypothesis is the alternative H_1 ($\alpha \neq 0$, and $\beta \neq 0$).
As to what the R^2 adjusted determination coefficient is concerned, this is equal to 0.94 at sample level, which suggests a strong link between the model variables. In order to study the size of R^2 adjusted for the entire population, we used the Fisher test.
Because $F_{calc} = 496.32 > F_{tab} = 3,15$ the results prove that the null hypothesis is rejected, so the influence of exogenous variables is significant. If the difference between F_{calc} and F_{tab} increases, the link between the two variables is stronger at the level of the entire population.
In order to find out the autocorrelation of errors, we have used the Durbin-Watson test (Andrei et al, 2008: 126). Working with a significance level of α= 0.05, the number of exogenous variables is *k*=2, and the number of observations is T=60, from the Durbin-Watson distribution table we find the following values: $d_1 = 1.51$ and $d_2 = 1.65$. Because $0 < DW_{calc} = 1.27275 < d_1 = 1.51$, the errors are auto correlated in a positive manner, the H_0 hypothesis is rejected, so the independence hypothesis of errors is not verified.
In order to eliminate the autocorrelation phenomenon, we used the Cochrane-Orcutt method, which states that estimating the ρ coefficient and making a regression through quasi-difference in a model that has the form:

$$Y_t = c(1) + c(2) X_{1t} + c(2)X_{2t} + \varepsilon_t \quad (6)$$

$$Y_{t-1} = c(1) + c(2) X_{1t-1} + c(2)X_{2t-1} + \varepsilon_{t-1} \quad (7)$$

The ρ coefficient is determined through direct regression of the residue on the delayed (t-1) value of it. Thus the quasi-differential value is written as:

$$Y_t – \rho Y_{t-1} = c(1)(1- \rho) + c(2)(X_{1t} - \rho X_{1t-1}) + c(3)(X_{2t} - \rho X_{2t-1}) + u_t \quad (8)$$

Starting from the regression model that presents the production function of the capital stock and of the working population, we re-estimated the value of the ρ parameter and the previous regression, until the stability of the c(1), c(2), c(3) parameters. The ρ parameter is estimated using the smallest squares method, observing the hypothesis that the residues follow a self-regressive first order process: $\varepsilon_t = \rho\varepsilon_{t-1} + u_t$, where u_t is a white noise and $\rho \in R$. After the calculus, we have obtained the value of ρ as being equal to 0.363627.
Thus, based on the previous regression and the 8 base relation, corresponding to the ρ parameter estimated above, we have equation:

$$LogGDP_t – \rho LogGDP_{t-1} = LogA(1- \rho) + \alpha(LogK_t - \rho LogK_{t-1}) + \beta(LogL_t - \rho LogL_{t-1}) + u_t \quad (9)$$

We check the qualities of the new model, repeating the same stages as for the previous model. In order to estimate its parameters, we used the method of the smallest squares and we obtained the following results:

Table 2: Estimating the parameters of the new regression model

*Dependent Variable: LogGDP-(0.36*LogGDP(-1))* *Method: Least Squares* *Included observation: 59 after adjustments* LogGDP-(0.3636*LogGDP(-1))=C(1)*(1-0.3636)+C(2)*(LogK-0.3636*LogK(-1))+C(3)* (LogL)-0.3636*LogL(-1))		
Testing the significance of the parameters (Student Test)	LogA α (K) β (L)	1.380273 (Prob=0.0469) 1.674699 (Prob=0.0000) -0.778305 (Prob=0.0170)
Adjusted R-squared		0.898793
Independence of errors (Durbin Watson Test)	DW_{calc}	1.705635*
Homoscedasticity of errors (White Test)	F_{calc}	0.631610 (Prob=0.6764)
Normality of errors (Jarque Bera Test)	JB_{calc}	1.942936 (Prob=0.378527)

* Working with a significance level of α= 0.05, the number of exogenous variables is k=2, and the number of observations is T=60, from the Durbin-Watson distribution table we find the following values: d1 = 1.51 and d2 = 1.65.
Source: the authors' calculus

The three parameters of the new model are significantly different from zero, at the sample level, but also at the level of the entire population, a fact that is confirmed by the probability that the null hypothesis is correct, a probability that is smaller than 5% in the case of the three parameters.
In order to measure the intensity of the endogenous variable's dependency to regression factors, the determination coefficient is used. At a sample level, there is a strong intensity link between the variables, because R^2 adjusted = 0.898793. At the level of the entire

population, we have used the Fisher test. Because F_{calc} = 248.6619 > F_{tab} = 3,153, the result is that the null hypothesis is rejected.
As to what the testing of the fundamental hypothesis referring to the random u_t variable is concerned for the new model, we have reached the following conclusions:
-*the independence hypothesis* of the values of the residual variable u_t is confirmed this time, because the Durbin-Watson statistic is equal to 1.705635, so that d_2 = 1.65 < DW_{calc} = 1.730679 < 4-d_2 = 2.35, meaning the errors of the model are independent;
-*the homoscedasticity hypothesis* of the residual variable u_t is confirmed, because, as the data from table 2 shows, the probability related to the Fisher statistic is higher than 5%, which determines the acceptance of the H_0 hypothesis as being true.
-*the normality hypothesis* of the random variable u_t is confirmed. One way of checking the normality of errors hypothesis is the Jarque-Berra test, which is an asymptotic test, usable in the case of a large volume sample, which follows a chi-squared distribution with two degrees of freedom (Meşter, 2012: p.150). Because the related probability of accepting the null hypothesis as being true (Prob=0.378527) is larger than 5%, we can state that the normality of errors hypothesis cannot be rejected for the level of the entire population, the errors being normally distributed.
Also, it could be observed that the procedure for eliminating the autocorrelation of errors does not alter the structure of the production function. The R^2 adjusted determination coefficient, as well as the α and β coefficients have values close to those from the first estimated equation.
The regression of the GDP is characterized by marginal decreasing efficiency of the capital stock (α > 1) and decreasing efficiency of work (β < 1). Concerning the working population of Romania, as in Figure. 1, it registered a growing trend, starting with 2000 and until 2005, a period that coincided with a sustained economic growth.

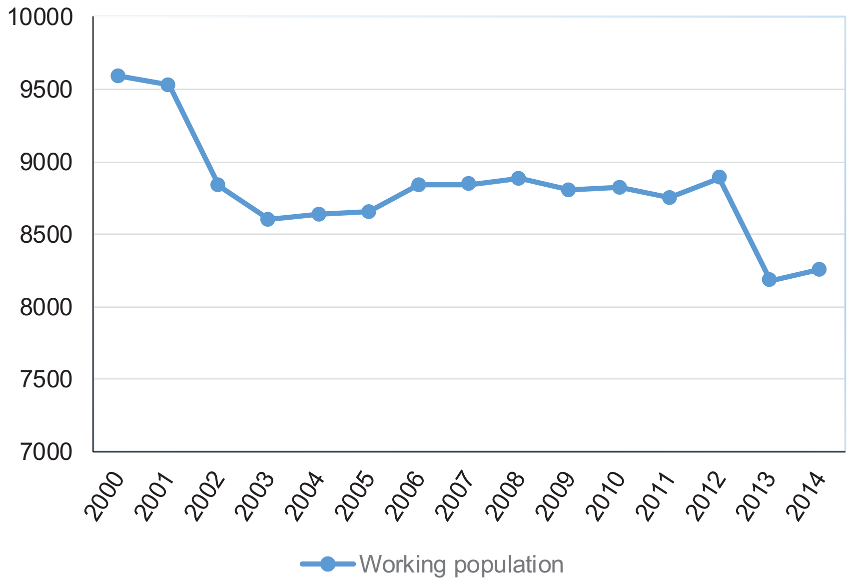

Figure 1: The evolution of the working population in Romania during 2000-2014
Source: made by the author based on data from Eurostat

Given the conditions that the working population in the rural areas is producing mostly for themselves, the variation of this number will influence the growth rate in a less important manner (Marinaș 2008, p. 283).

Conclusions

According to the results we have obtained based on this production function elaborated in this study, we can conclude that the economic growth process in Romania has been influenced in a positive manner by the stock of capital while the work factor has influenced economic growth in a negative manner. According to data from the National Statistics Institute, starting with 2000, the percentage of the working population in agriculture in the total working population started to decrease, from 46.27% in 2000, to 31.36 in 2010 (TEMPO-Online databases, A.4). This shows a tendency of decreasing the percentage of the working population in agriculture and reorientation to the service sector. In time this will generate an elasticity of the potential GDP compared to the working population. The sum of the α and β coefficients is below 1 (it is 0.75) as well as in the case of the second model (0.89), which corresponds to decreasing efficiency of the production function.

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