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Abstract

In the present research we have used the Cobb-Douglas production function in its classical form for analyzing Romania's and Moldova's economic growth in relation to the intensity of using the capital and labour, as determinants of the production and GDP level and structure.

Key words: production function, capital, labour, sustainable development

Our research is based on one of the most famous production functions, the Cobb-Douglas function, formulated in 1928 by the American economist Paul Douglas and the mathematician Charles W. Cobb. In our opinion, the theoretic-methodological and practical significance of the utilization of the Cobb-Douglas production function on the macroeconomic level consists in the opportunity to analyse the economic growth in relation to the capital intensity and labour intensity as determinants of the production and GDP level and structure.

Initially, we based our analysis on the classical form of the Cobb-Douglas production function:

$$Y = AK^{\alpha}L^{\beta}, \quad \alpha, \beta > 0 \tag{1}$$

where: Y - output;
K - capital production factor;
L - labour production factor;
A, α, β - function parameters (constant)

The α and β parameters measure the amount of the output generated by the capital and the labour, respectively. In a way, the two constant parameters may be assimilated to some *sui generis* elasticity coefficients. If α + β = 1, the production function is called homotetic and implies the constant return to scale; for example, by doubling the consumption of either factor, the production doubles itself as well. The A constant expresses the integral efficiency of the production factors.

The application of the Cobb-Douglas model to Romania's and the Republic of Moldova's economy pursues both the determination of the capital and labour contribution to the GDP in both countries and the time and country comparison of the size of the production function parameters.

The available statistics about Romania's and Moldova's economy allow to set the corresponding territorial statistical series for analyses based on the Cobb-Douglas production function, in accordance with the cross-section analysis. We advance the working hypothesis that each territorial unit (district) has a relatively autonomous economy whose main aggregates of the production factors, labour and capital, form a compound quite representative for the whole economy, even if there are territorial differences within a certain range, higher as absolute values and lower as relative values. To estimate the parameters of the Cobb-

Douglas production function for Romania's and Moldova's economy we considered the follwing primary data:

1. The **turnover** of the non-agricultural sectors (industry, constructions, trade and other services), as an expression of the output achieved by the statistically recorded territorial units (Romania's and Moldova's districts).
2. The **amount of the gross investments** in the non-agricultural sectors, by district, as approximation of the capital production function factor, K, in relation to both the results of the fixed assets in function and their multiplying effect in the future. We are aware that this indicator reflects partially the capital factor. At present, the official statistics do not provide data on the tangible assets by districts in Romania, while in Moldova data on the value of the fixed assets by district are available.
3. The **number of personnel employed** in the non-agricultural sectors represents the labour factor, L.

The statistical data on the model indicators (explained and explanatory variables) concerning Romania's districts and Bucharest and Moldova's districts and Kishinev are referred to the years 2002, 2003 and 2004. The statistical analysis of the three variables (turnover, investments/fixed assets and personnel) over the three years reveals a relatively homogenous distribution of the values of the statistical series terms, as proved by the moderate values of the variation coefficients. The homogeneity of the statistical distribution could be higher for each data series if Bucharest, in the case of Romania, and Kishinev in the case of Moldova, were excluded from the analysis, as they imply values much beyond the national average of all indicators, which might distort the structural regularity of the territorial statistical distribution. Another comment on the descriptive statistical analysis is that the number of the employed personnel is the variable showing the most uniform distribution throughout the country.

The estimation of the Cobb-Douglas production function, based on the primary data concerning the turnover, gross investments/fixed assets and number of employees was made by means of the STATISTICA software and the Simplex and Quasi-Newton method, preferred for its higher accuracy [Ştefănescu, 2004]. Table 1 shows the values of the Cobb-Douglas production function parameters in 2002, 2003 and 2004.

Table 1. Parameters calculated for Romania and Moldova

Parameter	2002*		2003		2004	
	Romania	Moldova	Romania	Moldova*	Romania	Moldova
α	0.626	0.662	0.621	0.666	0.558	0.665
β	0.374	0.338	0.511	0.334	0.538	0.453
A	3.22	44.60	0.710	52.69	1.020	13.45

* The homotetic form of the production function ($\alpha + \beta=1$) is considered.

The quality of the model is checked by statistical methods for each year. The explained variation ranges between 95% and 99.5%.

What concerns us to a great extent are the results produced by the model and the economic policy conclusions after the analysis of the production function coefficients. Therefore, the parameters estimated by means of the model may help to determine the contribution of the capital (K) and labour (L) production factors to the output, Y (Table 2).

Table 2. The capital and labour contribution to the output

Factor contribution to the output (%)	2002		2003		2004	
	Romania	Moldova	Romania	Moldova	Romania	Moldova
K	62.6	66.2	54.7	66.6	50.9	59.5

L	37.4	33.8	45.3	33.4	49.1	40.5

The conclusions drawn after the application of the Cobb-Douglas production function with two factors – labour and capital – to Romania and Moldova in 2002, 2003 and 2004 refer mainly to the significantly lower contribution (but increasing year by year) of the labour factor to the total results (turnover) and the relatively high contribution of the investments/fixed assets to the economic growth of the two countries at the present development stage. The contribution of the labour factor to the economic growth is higher and increase faster in Romania as against Moldova, but the discrepancy between the two countries is moderate.

The lower contribution of the labour factor in Moldova may also be explained by the fact that the workforce, in general, and the "brain", in special, played a major role in the capital contribution growth, of course, in relative terms, which did not necessarily imply an exceptional qualitative component. As for Romania, affected by the same brain drain, the existing labour potential – higher than that of Moldova – was influenced by the phenomenon to a lower extent, although the unfavorable effects could be serious on long term.

As regards the strategy for the sustainable economic development, the size of the above parameters provides elements for making decisions in support of a high rate of formation of the fixed capital, provided that it has a high utilization efficiency.

The empiric studies came to conclusions similar to ours, using either time series or territorial series. For example, Karagianis, Palivos and Papageorgiou (2004), using data on 82 countries over 28 years, estimated by means of a VES production function the contribution of the production factors to the GDP. The results showed that the contribution of the capital factor accounted for 66.7%, that of the labour factor was 32.05% and the non-included technical progress reached 1.17%. The above results were very close to the previous ones concerning Romania's and Moldova's economy.

Another more specific form of the classical Cobb-Douglas production function includes, besides the labour and capital factors, the residual factor, λ, that expresses the influence of the included or non-included technical progress. While the non-included technical progress acts uniformly and undistinctly by means of the production factor, components, the included technical progress acts distinctly by means of the different components of the two production factors: labour and capital. The action of the included technical progress is stronger in relation to the new generation of production factors. The economic-mathematical models include frequently production functions with included technical progress of a neutral type: Hicks - type functions implying that the technical progress acts by means of the two production factors, the Harrod-type functions implying that the influence of the technical progress is exerted through labour, and the Sollow-type functions implying that the influence of the technical progress is exerted through the capital.

The Cobb-Douglas production function with Hicks-type technical progress is the following:

$$Y = K^{\alpha} L^{\beta} e^{-\lambda t}, \tag{2}$$

where α, β, λ > 0, the λ parameter is the expression of the technical progress and *t* is the time variation.

Trying to be as close to reality as possible, the production function model was refined by several changes with a view to the following:

1. Increasing the number of factors by including in the analysis the technological progress, intermediate consumption (material expenditure), etc. as well as dividing the classical production factors into components, such as unskilled/skilled labour or tangible/intangible assets. An example is the following model:

$$Y = A \cdot K^{\alpha} \cdot L^{\beta} \sum_{j=1}^{N} (X_j)^{1-\alpha-\beta} \quad (3)$$

where $\alpha + \beta < 1$, $\alpha, \beta > 0$ and X_j represent the material consumption in the production.

2. Multi-output production functions.
3. Complementary factor production functions.
4. The replacement of the constant elasticity of substitution (CES) hypothesis with the variable elasticity of substitution (VES) hypothesis.

The CES production functions, introduced by the American economists K. Arrow, H. Chenery and R. Sollow are homogenous linear ones, characterized by constant elasticity of substitution. Their general form is expressed by the relation:

$$Y = A[\alpha K^{-\rho} + (1-\alpha)L^{-\rho}]^{-1/\rho}, \ \rho > -1, \ 0 < \alpha < 1, \ A > 1 \quad (4)$$

where:
A – constant, it expresses the integral efficiency of the production factors;
ρ – substitution parameter;
α – constant, it measures the capital contribution to the output.

It is a first degree homogenous function: the modification in some proportion of the capital, K, and labour, L, the output, Y, varies in the same proportion.

The form of the VES production function is:

$$Y = AK^{\alpha\nu}[L + \alpha\beta K]^{(1-\alpha)\nu}, \quad (5)$$

where A, α, β, ν are constant; ν stands for the variation in the elasticity of substitution.

Thus, if $\nu = 1$, the function (5) presents a constant elasticity of substitution, and if additionally $\beta = 0$, we get the Cobb-Douglas production function.

Another trend in the development of the production function model is the research on the integration in forms quite suitable for the contemporary growth of the natural capital and natural resources whose present assessment and prospective estimation are an area of scientific debate and creativeness. The human capital is part of the national wealth, which sheds a new light of the complementarity of the resource advantage theory, competition theory and sustainability theory which is clearly and directly connected with the self-sustained growth theory, steady-state growth models and infinit horizon growth (Ramsey) models.

Another development of the production function models is related to the contribution of the workforce migration on national and international scales, which, as experts say, will increase in the future due to the favoring action of several factors: low transport cost, quick communication and information means, governmental and regional policies for the immigrants' integration, increasing number of agreements between countries concerning the temporary workforce migration, etc. In our opinion, a factor of major scientific and practical interest in this category of models is the brain drain and its variants, such as brain gain, brain loss and brain circulation, clearly connected with the new paradigm of the human capital contribution to the global economic growth, to reviewing the means for filling the economic, technological and scientific gap among the countries and leap-frogging of the development stages.

Conclusions

To our knowledge, it is the first time in Romania and Moldova that the Cobb-Douglas model calculation at the macroeconomic level in the cross-section variant provides such positive results that comply with all usual statistical tests.

The most relevant conclusion concerns the importance of the capital (the technological level of the machinery, equipment and tools) for the economic growth, which ensures the proper endowment of the workforce whose training, retraining and productivity should increase for the effective utilization of the new technologies that imply more employed workforce involved in the lifelong learning.

As the investment increases, the upgrading requires a higher training level dependent on the information technology and, implicitly, on the increasing workforce contribution to the GDP. The R&D and intellectual capital are turned to good account by the labour factor, as revealed by the increasing share of the intangible assets (sometimes, up to 80%) in all assets of the companies. It is one of the facts showing the transition to the knowledge-based economy, on the one hand, and, along with the development of the endogenous economic growth models by Romer (1986) and Lucas (1989), the rejection of the idea that the capital/labour ratio is an essential endogenous variable, on the other hand.

The formulation of the contemporary economic growth theory is aimed at separating and particularizing the influences of the entire set of internal factors related to the innovation, institutional effectiveness, education, spillover and spinoff, as these factors are included in the intangible assets of the economy and, of course, show the contribution of the intellectual (human) capital, which is a new perspective regarding the fundamental and applied economic research.

The estimation of the parameters of the Cobb-Douglas production function reveals, according to our analysis, that the classical form of the production functions is the first step in analyzing the multitude of quantitative and qualitative production factors specific, on the one hand, to a certain level of economic-social development and, on the other hand, to the common denominator of the information economy and society based on knowledge, of the globalization and necessity to ensure the sustainability of the economic-social development.

The Cobb-Douglas production function could be a very useful tool for the decision-making on different levels of the economic aggregation, by combining the static analysis and dynamic analysis of the influence factors, based on the hypothesis of the CES and VES production function; according to our research, the main role in the substitution is played by the capital, in its broad sense, supported by high-skilled workforce, which changes substantially the ratio of physical work to the scientific creation work, the simple work to the complex one, as well as of the routine work to the innovative one, by adding new management and organization schemes, as required by the expanding business networks, the market globalization and the economic development sustainability.

The outcome of our research suggests to carry on the investigation by distinguishing between the contribution of the stage-based factor and the economic-social development of the countries, and the economic-social convergence and non-convergence of the countries. As the capital contribution is higher in the developed countries than in Romania and Moldova is, of course, a challenge and, at the same time, a benchmark not only in the theoretical-methodological field, but also in the policy and decision making on short, medium and long terms.

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