ANALYSIS OF THE BASIC CORRELATIONS OF ECONOMIC GROWTH USING THE MULTIPLE REGRESSION MODELS

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Abstract

The evolution of the national economy is achieved in some parameters, which have crystallized over time and which indicate certain correlations that must exist between a numbers of factors, which have an effect on how macroeconomic stability is achieved. Thus, we can discuss the correlation between the GDP growth rate and the evolution of labour productivity, a qualitative element that gives the possibility to increase macroeconomic results.

On the other hand, we can discuss the evolution of the change in the Gross Domestic Product correlated with the total number of employees in the national economy, this being a quantitative factor. This quantitative factor in the conditions of pandemic and economic-financial crisis implies another element, namely that of the influence of unemployment, because by increasing the unemployed population in the national economy we happen to have a negative influence due to rising unemployment. This is mainly reflected in the use of the Gross Domestic Product in the sense that the national unemployment fund will increase other requirements imposed by the impossibility of employment and so on will increase.

Also, another basic correlation of the Gross Domestic Product growth is that between the level and the effect that each branch has as a source of the Gross Domestic Product, this changing particularly in the current conditions of the pandemic crisis and economic and financial.

This article presents a number of elements, which are theoretically presented with the necessary explanations in this direction. A multiple linear regression model is then used taking the Gross Domestic Product as the resultant variable, and the number of employees and labour productivity considered as factorial variables. The resulting data are sufficiently edifying

leading to the obtaining of parameters, on the basis of which to estimate the future evolution.
Keywords: statistical-econometric models, correlations, factors, variables, economic branches, crises.
JEL classification: C10, E20

Introduction

In this article, starting from the situation imposed by the current health crisis, combined with the financial-economic one, a multifactorial analysis is imposed in order to establish the way in which it evolves in Romania. In a first phase we presented the theoretical aspects starting from the fact that the indicator that characterizes economic growth is the Gross Domestic Product and the Gross Domestic Product per inhabitant and growth is defined as a process determined by the effect of various factors of production.

Of course, qualitative factors, quantitative factors are analysed, trying to establish mathematical relationships between these variables, so that by moving to practical solving using data recorded in the national economy to foreshadow the stage reached by the national economy, how certain factors they have contributed and especially the possibility to establish the trend in a forecast, which is important especially in conditions of economic and financial crisis.

The presented relations induce the fact that both the quantitative and qualitative factors act on the Gross Domestic Product, a situation in which we presented the statistical-mathematical relations, which also result on the basis of which analyses and interpretations can be made.

Using the theoretical aspects we referred to, in the second part of the article we applied a multiple linear regression considering the Gross Domestic Product as the resultant variable, and the number of employees and labour productivity as quantitative / qualitative factors, which can influence. Of course, this is just an example simply understanding that it can be extended to other cases where the same statistical-econometric relationship of multiple regression applies, each time determining the influence of quantitative / qualitative factors taken into account.

In this model of multiple linear regressions we considered to add a residual variable in the sense that it is absolutely necessary when analysing the evolution of the Gross Domestic Product based on two or three factors. It is obvious that other factors influence the Gross Domestic Product, but which at the time of applying this model we consider either as a constant influence or have no influence, but in reality this influence is also manifested and therefore the residual variable (residue) encompasses the influence of all other factors not considered.

The established data ensure the possibility of extending the analysis resulting in the influence that each factor has, and through calculated parameters ensuring the possibility of extension in the next period.

Literature review

Anghelache, Anghel and Burea (2017) conducted a study on labour costs in the EU. Anghelache, Avram, Burea and Olteanu (Petre) (2018), as well as Anghel, Anghelache, Avram, Burea and Marinescu (2018) studied the causes and effects of the natural movement of the population. The field of human resources entered the field of research of Backes-Gellner (2004) and Badal (2010), while Bils, Yongsung and Sun-Bin (2009) focused on the impact of unemployment on the economy. Kazantsev (2008) analysed the role of regional economic potential in terms of competitiveness. Klein, Wolfe and Woife (2003) showed the importance of using modelling in the analysis of economic situations. Trade issues are addressed to Reinsdorf (2010). Wakita (2006) studied the main features of the Japanese labour market.

Methodology, data, results and discussions

The indicator that characterizes economic growth is total GDP or per capita. Economic growth is defined as a process of growth due to the influence of factors of production.

The size of GDP depends on the labour force used, measured by the employed population $(\sum T)^3$, as well as through the social productivity of labour $(\overline{W})$.

$GDP = \overline{W \cdot \sum T}$ - at the macroeconomic level (1)

The relationship can be analysed in the light of the same indicators at the level of each branch.

$VAB = W \cdot T$ - at the level of branches, (2)

where: *VAB* represents the gross added value.

The first relationship, if transferred to dynamics, becomes:

$$IPIB = \overline{IW} \cdot I \sum T \quad (3)$$

or

$$RPIB + 1^* = (R\overline{W} + 1) \cdot (R \sum T + 1) \quad (4)$$

where: *I* represents the growth index of each indicator;

R represents the growth rate of each indicator.

Through development, the last relationship can be rewritten in the form of a correlation between growth rates:

$$RPIB = \underbrace{R\overline{W}}_{\text{influence factor intensive}} + \underbrace{R\sum T}_{\text{influence factor extensive}} + \underbrace{\overline{RW \cdot R\sum T}}_{\text{influence common}} \quad (5)$$

This relationship applies depending on the treatment of the common influence: the common influence can be disregarded, when at least one of the growth rates registers a significant level and the common influence is attributed to one of the factors.

$$RPIB = R\overline{W} + R\overline{W} \cdot R\sum T + R\sum T = R\overline{W}(1 + R\sum T) + R\sum T =$$
$$= R\overline{W} \cdot I\sum T + R\sum T \quad (6)$$

or

$$RPIB = R\overline{W} + R\sum T + R\overline{W} \cdot R\sum T = R\overline{W} + R\sum T\left(1 + R\overline{W}\right) =$$
$$= R\overline{W} \cdot R\sum T + I\overline{W} \quad (7)$$

We can distribute the common influence to each factor, equally or proportionally.

The size of GDP is analysed according to fixed funds ($\sum F$) and their average efficiency ($\overline{E}$).

$PIB = \overline{E} \cdot \sum F$ - at the macroeconomic level

$VAB = E \cdot F$ - at the branch level

The correlation between GDP growth rates and those of influencing factors is as follows:

$$RPIB = \underbrace{R\overline{E}}_{\text{influence factor intensive}} + \underbrace{R\sum F}_{\text{influence factor extensive}} + \underbrace{R\overline{E} \cdot R\sum F}_{\text{influence common}} \quad (8)$$

Also, the size of GDP depends on the value of circulating materials consumed $(\sum C)^4$ and average efficiency of their use ($\overline{M}$).

$PIB = \overline{M} \cdot \sum C$ - at the macroeconomic level

$VAB = M \cdot C$ - at the branch level

The correlation between growth rates is as follows:

$$RPIB = \underset{\substack{\text{influence}\\ \text{factor}\\ \text{intensive}}}{R\overline{M}} + \underset{\substack{\text{influence}\\ \text{factor}\\ \text{extensive}}}{R\sum C} + \underset{\substack{\text{influence}\\ \text{common}}}{R\overline{M}\cdot R\sum C} \quad (9)$$

Correlations refer to a factor of production, labor, fixed capital or consumption of materials. The change in GDP results from relations:

$$RPIB = R\sum T + R\overline{W}\cdot I\sum T \quad (10)$$

$$RPIB = R\sum F + R\overline{E}\cdot I\sum F$$

$$RPIB = \underset{\substack{\text{influence}\\ \text{factor}\\ \text{intensive}}}{R\sum C} + \underset{\substack{\text{influence}\\ \text{factor}\\ \text{extensive}}}{R\overline{M}\cdot I\sum C}$$

The three correlations can be summarized in the following relationships:

$$PIB = \sum W\cdot T \quad (11)$$

$$PIB = \sum E\cdot F \quad (12)$$

$$PIB = \sum M\cdot C \quad (13)$$

The established relationships can also be analysed through factorial systems that involve the influence of changes in the branch structure of each resource:

$$PIB = \overline{W}\cdot\sum T = \sum(W\cdot YT)\cdot\sum T \quad (14)$$

$$PIB = \overline{E}\cdot\sum F = \sum(E\cdot YF)\cdot\sum F \quad (15)$$

$$PIB = \overline{M}\cdot\sum C = \sum(M\cdot YM)\cdot\sum C \quad (16)$$

The influencing factors highlighted are:

• qualitative at branch level (*W*,*E*,*M*);

• structural (*YT*, *YF*, *YM*);

• quantitative (extensive) at the macroeconomic level ($\sum T, \sum F, \sum C$).

The analysis can be deepened taking into account the correlation that exists between labor productivity and fixed capital efficiency:

$\overline{W} = \overline{E} \cdot \overline{Z}$ - at the macroeconomic level; (17)

$W = E \cdot Z$ - at the branch level, (18)

where: Z represents the endowment of work with fixed funds.

Under these conditions, the size of GDP is determined using formulas:

$$PIB = \sum W \cdot T = OE \cdot Z \cdot T \quad (19)$$

$$PIB = \overline{W} \cdot \sum T = \overline{E} \cdot \overline{Z} \cdot \sum T = \sum (E \cdot YF) \cdot \sum (YT \cdot Z) \cdot \sum T \quad (20)$$

In this sense, in the following I will use the method of multiple linear regression to highlight the dependence that exists between the variables considered independent (number of employees and labour productivity) and the economic results obtained by Romania in the period 2005-2020, through the most complex indicator of results, namely the Gross Domestic Product. Thus, the data on the evolution of the three macroeconomic indicators are structured in the following table.

Gross Domestic Product, number of employees and labour productivity

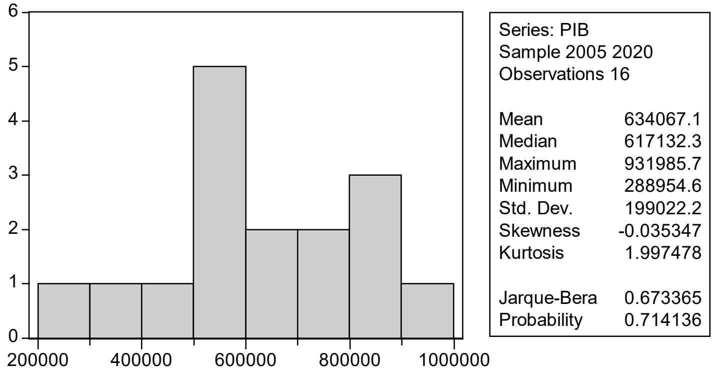
Table 1

Year	GDP (mil. RON)	Number of employees (thousands)	Work productivity
2005	288954.60	9267	86.2
2006	344650.60	9330	90.1
2007	416006.80	9364	96.3
2008	524388.70	9365	106.4
2009	510522.80	8952	102,8
2010	533881.10	8713	100.0
2011	565097.20	8528	100.1
2012	596681.50	8605	110.6
2013	637583.10	8549	115.9
2014	668590.10	8614	118.2
2015	712587.80	8535	124.3
2016	765135.40	8449	131.8
2017	856726.60	8671	134.7
2018	895279.30	8896	142.7
2019	931985.70	6465	143.2
2020	897002.60	4950	137.6

The histogram of the evolution of the Gross Domestic Product in the period 2005-2020 is presented in the following graph:

Histogram of GDP evolution in the period 2005-2020

Graph 1

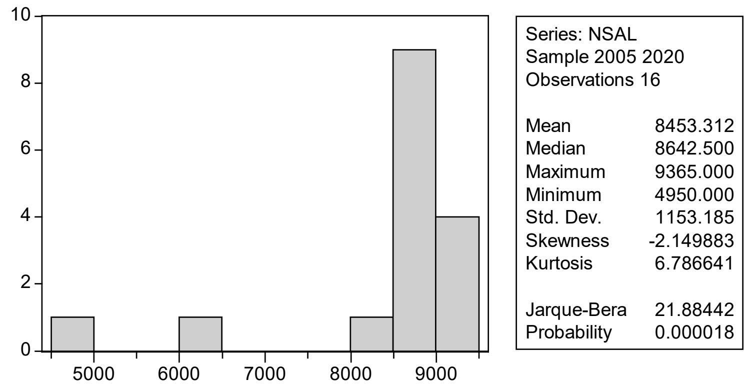


The data contained in graph number 1 suggest that the Gross Domestic Product distribution is not perfectly symmetrical confirmed by the value of the Skewness test and is also slightly slower than normal due to the Kurtosis test, which recorded a value of 1.99 less than 3.

Next we will present the histograms of the evolution of the other two indicators, which are presented in graphs 2 and 3.

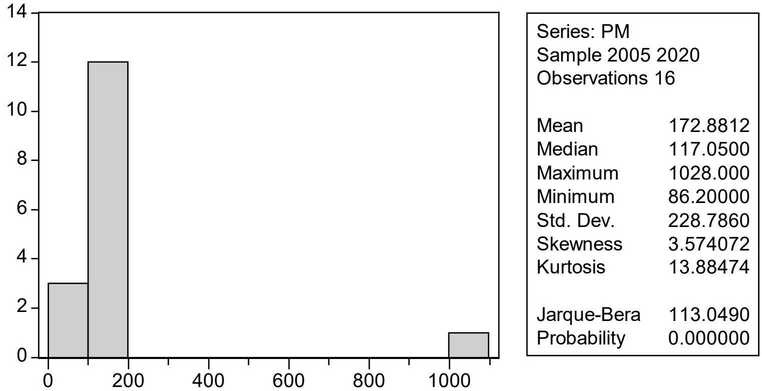
Histogram of the evolution of the number of employees in the period 2005-2020

Graph 2



Histogram of the evolution of labour productivity in the period 2005-2020

Graph 3



Both the distribution of the number of employees and the labour productivity are not perfectly symmetrical due to the value of the Skewness tests, but at the same time normal, an aspect indicated by the Kurtosis test values higher than the reference one.

Next I will continue the statistical-econometric analysis of this economic phenomenon by indicating the multiple linear regression equation that I will use and which has the following form:

$$PIB = a + b \cdot NSAL + c \cdot PM + \varepsilon \quad (21)$$

where: PIB is the dependent variable (Gross Domestic Product);

$NSAL$ is an independent variable (Number of employees);

PM is an independent variable (Labour productivity);

a, b and c are the regression parameters;

ε represents the residual variable.

Both for estimating the parameters *a*, *b* and *c*, as well as for testing the significance of the model, I will use the EViews statistical-econometric analysis program, and the results are presented in the following table:

Dependence of GDP on the evolution of the number of employees and on labour productivity

Table 2

Dependent Variable: PIB
Method: Least Squares
Sample: 2005 2020
Included observations: 16

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1598018.	306637.7	5.211420	0.0002
NSAL	-113.2708	36.01689	-3.144935	0.0077
PM	-37.23680	181.5413	-0.205115	0.8407

R-squared	0.436308	Mean dependent var	634067.1
Adjusted R-squared	0.349587	S.D. dependent var	199022.2
S.E. of regression	160507.8	Akaike info criterion	26.97743
Sum squared resid	3.35E+11	Schwarz criterion	27.12229
Log likelihood	-212.8195	F-statistic	5.031129
Durbin-Watson stat	0.444055	Prob(F-statistic)	0.024086

Interpreting the results obtained and presented in table number 2, we can consider the model a good one, and can be used in macroeconomic forecasts. Both the significantly different values of zero recorded by the estimated parameters and the statistical tests F-statistic and t-Statistic whose values are higher than those tabulated, confirm those mentioned above. Thus, we can estimate the theoretical values of the resultant characteristic, according to the relation:

$$\widehat{PIB} = 1598018 - 113.2708 \cdot \widehat{NSAL} - 37.23680 \cdot \widehat{PM} + \varepsilon \qquad (22)$$

Due to the value of the correlation ratio (R-squared = 0.436308) we are confirmed that there are other factors that influence the evolution of the complex indicator of results, namely the Gross Domestic Product.

Conclusions

The study carried out and presented in this article shows that there is the possibility of a rigorous and thorough analysis of the evolution of the Gross Domestic Product growth rate using econometric models, in particular in this article of multiple linear regression. Multiple linear regressions ensure the calculation of some parameters, which indicate the quantitative effect that each factor has on the modification of the Gross Domestic Product.

The study shows that it is limited to this, but can be extended to other variables, that the multiple linear regression models offers the possibility of a careful analysis of the stage in which the level of Gross Domestic Product was achieved, but especially of the possibility to establish the trend and future evolution.

The practical model applied in this article is not limiting, it is just an example of the use of variables and correlations that are established between them, presented in the theoretical part of this approach. Of course, we must pay attention to the fact that evolution must always be interpreted in the sense in which it is achieved. For example, sometimes in this case it was clear, the reduction of the number of employees in terms of quantity determines a reduction of the Gross Domestic Product. An increase in labour productivity is interpreted as a positive element.

Finally, we can appreciate that this exposition of possibilities regarding the use of statistical-econometric methods in the analysis of the growth rate of the Gross Domestic Product can be made starting from the basic correlations of economic growth in the context in which they are maintained and the factorial variables have a positive effect economic growth.

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