# THE ANALYSIS OF THE CORRELATION BETWEEN GDP, PRIVATE AND PUBLIC CONSUMPTION THROUGH MULTIPLE REGRESSION

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#### Abstract

The analysis of the correlation between indicators, through multiple regression, completes the information and conclusions drawn through the application of some simple regression models. Supplementary elements achieved by using multiple regression form an additional informational support for decision makers and analysts. This paper describes a correlation between the GDP, private and public consumption, through a multiple regression model. The model explains the influence of the two types of consumption on the evolution of the GDP and allows the make of forecasts.

**Key words:** *GDP, private consumption, public consumption, regression, factor* 

The information obtained through the utilization of the simple linear regression model are not always sufficient enough in order to characterize the evolution of an economic phenomenon and, mainly, to identify the possible subsequent evolution of this one. A significant argument in this respect may be considered as being the possible value high enough of the free term (as image of the factors not included into the model), which occurs in each of the simple linear regressions.

In order to eliminate these difficulties, the simple linear regression method may be extended from couples of two variables to more variables through the method of the multiple regression, in which case we have a dependent variable and several factorial variables.

The multiple linear regression model may be utilized also at the level of the economy of Romania, as it is completing the analysis performed with the support of certain simple linear models. In this respect, we shall consider as resulting variable the value of the Gross Domestic Product while the factorial variables should be considered the private and public consumption in our country during the period 1990

- 2014. The values of these macroeconomic indicators have been deflated using in this sense the consumption prices index (utilized by the National Institute for Statistics for calculating the inflation rate in our country), which shows the evolution of the final prices for goods and the tariffs for services acquired by the population during the current year as against the year 1990, selected as reference period.

The three indicators can be submitted synthetically as follows:

|      | -  |   | Table  |  |
|------|--|---|--|--|
| Year | Gross Domestic Product<br>(comparable prices)<br>million lei | Private consumption<br>(comparable prices)<br>million lei | Public consumption<br>(comparable prices)<br>million lei |  |
| 1990 | 85,8   | 55,8  | 12,2   |  |
| 1991 | 81,6   | 49,0  | 12,9   |  |
| 1992 | 71,9   | 44,7  | 10,6   |  |
| 1993 | 67,1   | 42,4  | 8,6  |  |
| 1994 | 70,4   | 44,5  | 9,9  |  |
| 1995 | 77,1   | 51,9  | 10,8   |  |
| 1996 | 83,9   | 58,0  | 11,3   |  |
| 1997 | 76,5   | 56,3  | 9,8  |  |
| 1998 | 71,0   | 59,1  | 5,0  |  |
| 1999 | 71,1   | 59,1  | 4,0  |  |
| 2000 | 71,9   | 56,8  | 5,2  |  |
| 2001 | 77,7   | 61,0  | 5,2  |  |
| 2002 | 82,5   | 63,5  | 5,6  |  |
| 2003 | 93,0   | 70,4  | 9,1  |  |
| 2004 | 104,2  | 80,6  | 8,2  |  |
| 2005 | 111,6  | 87,6  | 9,3  |  |
| 2006 | 124,9  | 97,3  | 9,6  |  |
| 2007 | 143,8  | 107,4   | 10,9   |  |
| 2008 | 168,1  | 121,7   | 12,5   |  |
| 2009 | 155,0  | 109,8   | 13,1   |  |
| 2010 | 152,8  | 110,5   | 10,7   |  |
| 2011 | 152,9  | 109,3   | 9,5  |  |
| 2012 | 156,2  | 112,0   | 9,8  |  |
| 2013 | 160,5  | 110,9   | 11,4   |  |
| 2014 | 166,1  | 115,0   | 13,2   |  |

The evolution of the Gross Domestic Product, private and public consumption in Romania, during the period 1990 – 2014

Source: Annual Statistical Book of Romania - Gross Domestic Product, By categories of utilization, I.N.S., Bucharest, 2008, 2009, 2010, 2011, 2014

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Based on these information, we shall analyse the existence of an eventual connection of dependence between the value of the Gross Domestic Product (the resulting variable y), on the one side and the level of the private consumption (the causal variable  $x_1$ ) and that of the public consumption (the causal variable  $x_2$ ), on the other side (Anghelache et al. 2015).

The econometric description of the connection between the three variables can be made with the support of four models:

- A unifactorial model explaining the variation of the Gross Domestic Product on the ground of the modification of the level of the private consumption recorded in our country:
- $y_i = f(x_{1i}) + \varepsilon_{1i}$
- A unifactorial model explaining the variation of the Gross Domestic Product on the ground of the modification of the level of the public consumption recorded in our country:
- $y_i = f(x_{1i}) + \varepsilon_{1i}$
- A unifactorial model explaining the variation of the Gross Domestic Product on the ground of the level of the final consumption, considered as a total of its two components, the private and public consumption:
- $y_i = f(x_{3i}) + \varepsilon_{3i}$
- A multifactorial model explaining the variation of the Gross Domestic Product on the ground of the simultaneous influence of the two indicators previously mentioned.

 $y_i = f(x_{1i}, x_{2i}) + \varepsilon_i$ 

As far as the first three above models are concerned, the relations between the indicators can be reflected with the support of certain unifactorial linear regression models.

In this context, it becomes of the utmost significance to specify and analyse the relationship existing between the three macroeconomic indicators with the support of a multifactorial regression model. From a mathematical point of view, this one can be transcribed as follows:

 $y_i = b_0 + b_1 \cdot x_{1i} + b_2 \cdot x_{2i} + \varepsilon_i$ The multifactorial linear model identified above can be written in a matrix form as follows:

 $\mathbf{Y} = \mathbf{X} \cdot \mathbf{B} + \boldsymbol{\varepsilon}$ 

$$\begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix} = \begin{pmatrix} 1 & X_{11} \cdots & X_{1k} \\ 1 & X_{21} \cdots & X_{2k} \\ \vdots & \vdots & \vdots \\ 1 & X_{n1} \cdots & X_{nk} \end{pmatrix} * \begin{pmatrix} b_0 \\ b_1 \\ \vdots \\ b_k \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{pmatrix}$$

where:

 $n = 25 \rightarrow$  the number of the available observations

 $k = 2 \rightarrow$  the number of the exogenous variables .

The regression function corresponding to the considered model, written as a matrix, is:

 $Y = \mathbf{X} \cdot \mathbf{B} \ .$ 

For estimating the parameters, we shall utilize the least squares method (MCMMP – least squares). For the multifactorial linear model, applying this method implies the minimization of the function:

$$\mathbf{F} \stackrel{\circ}{(B)} = \min^{t=1} = \min^{t=1} (\mathbf{Y} - \mathbf{X} \stackrel{\circ}{B})^{2}$$
$$= \min^{\circ} (\mathbf{Y}^{\mathrm{T}}\mathbf{Y} - 2\stackrel{\circ}{B}^{\mathrm{T}}(\mathbf{X}^{\mathrm{T}}\mathbf{Y}) + \stackrel{\circ}{B}^{\mathrm{T}}(\mathbf{X}^{\mathrm{T}}\mathbf{X}) \stackrel{\circ}{B})$$

which implies the setting up of the function differential in connection with the estimator  $\hat{B}$  and its cancelation:

$$(\mathbf{X}^{\mathrm{T}} \mathbf{X}) \stackrel{\circ}{B} = \mathbf{X}^{\mathrm{T}} \mathbf{Y}$$

In order to facilitate the estimation of the multiple regression model we used the informatics program Eviews, in which frame we defined the equation having as resulting variable the Gross Domestic Product (GDP), and as factorial variables, the value of the private consumption (PC) and public consumption (PLC). Meantime, we considered the fact that this regression model will contain the free term C, meant to reflect the influence of the terms not considered by the time of the model construction. The estimating method defined in the program frame is the least squares method.

The outcomes obtained through the program Eviews are the following:

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# The outcomes of the estimation for the parameters of the regression model

Fig. 1

Dependent Variable: PIB Method: Least Squares Date: 07/16/15 Time: 13:18 Sample: 1990 2014 Included observations: 25

| Variable           | Coefficient | Std. Error            | t-Statistic | Prob.    |
|--------------------|-------------|-----------------------|-------------|----------|
| С                  | -12.95039   | 3.480306              | -3.721048   | 0.0012   |
| CP                 | 1.250675    | 0.034558              | 36.19085    | 0.0000   |
| CPL                | 2.440453    | 0.352096              | 6.931223    | 0.0000   |
| R-squared          | 0.988164    | Mean dependent var    |             | 107.1040 |
| Adjusted R-squared | 0.987088    | S.D. dependent var    |             | 37.53240 |
| S.E. of regression | 4.264808    | Akaike info criterion |             | 5.850838 |
| Sum squared resid  | 400.1489    | Schwarz criterion     |             | 5.997103 |
| Log likelihood     | -70.13547   | Hannan-Quinn criter.  |             | 5.891406 |
| F-statistic        | 918.3837    | Durbin-Watso          | on stat     | 0.481706 |
| Prob(F-statistic)  | 0.000000    |                       |             |          |

Out of the previous discussion, the multiple regression model previously set up, describing the relation between the macroeconomic indicators subject of this study can be transcribed in the form of an equation, as follows:

GDP = -12.95039 + 1.250675 · PC + 2.440453 · PLC

As it may be noticed, the utilization of the multiple regression model is confirming the conclusions drawn out of the analyses that can be performed with the support of the simple linear model, namely the fact that the values of the private and public consumption are significant factors of influence for the evolution of the variation of the Gross Domestic Product in our country.

It can be observed that, in this case, the increase of the GDP, generated by the increase with one million lei of the private consumption, counts for about 1.250675 million lei, in the conditions of maintaining the other variables as constant. In the case of the public consumption, the difference is by far more significant, if considering that in Romania, each million lei spent in a public regime brings in an increase of 2.440453 million lei at the level of the Gross Domestic Product, the other included factors remaining constant. Hence, there is a direct dependence between the GDP and the private consumption, respectively, public consumption in Romania during the period 1990 - 2014.

However, we have to emphasize the fact that, in the frame of the considered model, the influence of the free term, as image of the factors not being included in the model, is a significant one. Thus, if the two factorial variables, PC and PLC have the value 0, the average value of the GDP is estimated at about -12.95039 million lei. We can allege the fact that the factors being not considered at the moment of the econometric model construction are generating a significant diminishing of the Gross Domestic Product value. Although the value of the free term is still high enough, we can state out the fact that it can be different comparatively with the analysis based on the unifactorial model between the GDP and the public consumption, which allows us to allege the fact that the utilization of the multifactorial regression models is recommendable for all the macroeconomic analyses.

From the point of view of the statistical tests meant to verify the correctness of the considered econometric model, we can notice the fact that the values relating to the tests  $R^2$  and, respectively,  $R^2$  – adjusted, are very close to the maximum ( $R^2 = 98.82\%$ , while  $R^2$  adjusted = 98.71\%), which allows us to allege the fact that the model subject of the analysis is a correct one bearing a minimum degree of risk in the case of an economic analysis. Meanwhile, we can notice the fact that by including in the model frame several factorial variables, led to the increase of its degree of probability as comparatively with the simple linear regression models.

The determination coefficient shows that 98.82%, of the variation of the dependent variable is explained by the simultaneous variation of the private and public consumption in Romania during the period 1990 - 2014, meaning that there is a strong connection between the endogenous variable and the two exogenous variables, a fact which is confirmed as well by the adjusted determination coefficient (Adjusted R -squared = 0.9871), which takes into consideration both the number of observations and the number of exogenous variables. The correlation ratio (R = 0.9882) tending to 1 is proving that the estimated regression model is approximating very well the observation data, bearing a high credibility.

All the parameters bi are statistically significant at the significance threshold of 5% (i=0,1,2), so that the model is valid. This fact is strengthened also by the very small values of the Prob. for each parameter of the model.

We can also state out the fact that the value of the test F-statistic is superior to the tableted values of reference, which implies that the considered econometric model is a correct one, which may be subsequently utilized in the macroeconomic analyses and the forecast of the level of the Gross Domestic Product.

At last but not the least, the value of the test Prob (F-statistic) is zero, confirming thus the previous allegations according to which an econometric

regression model utilizing as resulting variable the Gross Domestic Product and as factorial variables the private and public consumption is a correct one and may be utilized for the forecast of the economic development of our country.

### Conclusions

On the basis of all the observations formulated as a result of the analysis of the Gross Domestic Product of Romania by means of the regression models, we can conclude the fact that the value of this indicator is significantly influenced by the variations of the private and public consumption.

From a methodological point of view, we can notice the fact that the utilization of a multifactorial regression model allows more conclusive outcomes to be obtained within the macroeconomic analyses however, without meaning that the unifactorial regression model does not allow that pertinent researches on the evolution of the national economy are performed as well.

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