

## **Macroeconomic models used in structural analysis of GDP**

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**Abstract.** *In this paper, the authors present some models useful for the analysis of the Gross Domestic Product. The study capitalizes official data published by the National Institute of Statistics from Romania. As the principal indicator of the macroeconomic results in the national economies, the Gross Domestic Product is influenced by a variety of factors, whose impact can be estimated with the help of appropriate models. After presenting some aspects on the evolution of Romania’s Gross Domestic Product, the authors propose a set of econometric models, based on the simple and multiple regression approach, which are able to measure the impact of final consumption, on one hand, and the turnover of the companies acting in the retail sector, on the other hand, on the main indicator considered in the research. The models are tested against R-squared and Adjusted R-squared parameters, and the results of estimations are further explained.*

**Keywords:** gross domestic product, final consumption, turnover, regression, parameter, public, private.

**JEL Classification:** B22, B23, E21.

## 1. Introduction. Literature review

GDP is calculated by all countries and it represents, under synthesized form, the quantitative and qualitative evolution registered by a country in a given period of time.

If we compare this indicator obtained by our country in recent years with the one realized by the European countries, the situation would be clearly negative, our country being on one of the last places, but an explanation can be found through the gap in the social-economic development. The situation is not any different even if we compare the GDP achieved by Romania with the same indicator achieved by countries in Central and Eastern Europe, who walked the path of transition in the same time with our country. In this context, comparisons are more enlightening because it highlights certain developments that occurred in roughly similar circumstances and the sharp drop of this indicator in our country compels us to seek real causes of such developments.

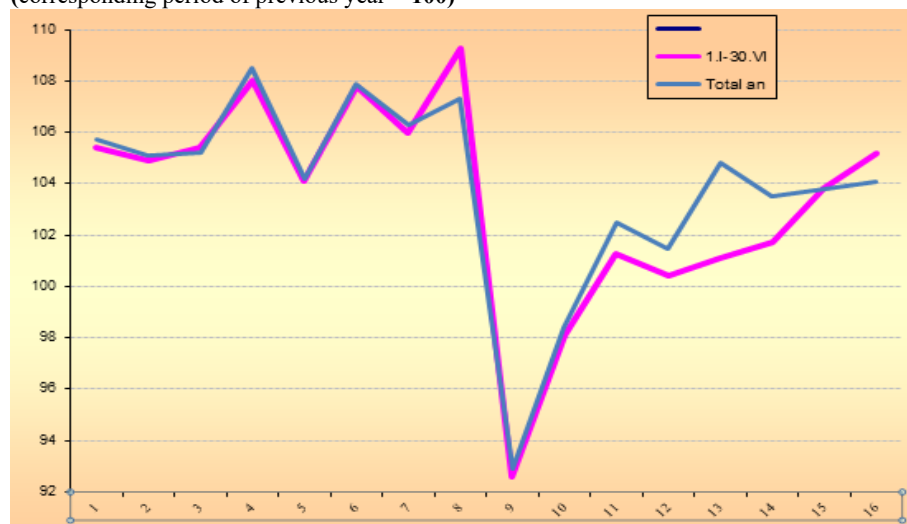
From this point of view, we consider that the most objective is the comparison of GDP index realized by our country with the levels of the indicator registered by Cyprus, Estonia, Latvia, Lithuania, Czech Republic, Poland, Hungary, Slovenia, Slovakia and Bulgaria. We find that, starting with 1990 and until 1995, these indicators have registered differentiated development, in most of them a downward trend being produced, before micro stabilization. From 1995 until the end of 1999, this process of considerably decrease of GDP continued especially in Romania, the country that remained alone from the ones mentioned above in the situation of having a low GDP indicator. After 2000, GDP registered a growth process. It is significant that in 2007 GDP was by 6.0% higher than in 2006, but in absolute numbers is still far from the potential that Romania has. In 2005, GDP was in absolute numbers and current prices of 287.1863 billion lei, meaning over 100 billion dollars at the rate of 2.85 lei/USD on 31.12.2005. In 2006 the GDP, recorded a level of 342.2 billion lei, meaning approximately 142.7 billion dollars at the rate of 2.40 lei/USD, which represents an increase of 7.7% compared to 2005. In 2007, GDP was in absolute numbers and current prices 404,708.8 million lei, that is over 169.4 billion dollars at the rate of 2.4564 lei/USD on 31.12.2007, which represents an increase of 6.1% compared to the previous year. In 2008, GDP reached 514.654 million lei. Compared to 2007, GDP grew by 7.1% in 2008. In 2009, due to a lack of proactive programs, the "election budget" from 2008 and 2009 and under the devastating effect of the crisis, GDP fell to 491,273.7 lei, registering a decrease in deflated data by -7.1%. In 2010 the GDP reached 522,561.1 million lei, and in 2011 was 578,551.9 (recorded minimum wages are not deflated being expressed in current prices of each period). In 2012, the GDP was 587,494.4 million. In 2013, the GDP was 637,583.1 million, with 3.4% higher than in 2012. In 2014, GDP reached 668,143.6 million, recording an increase of 3.1% over 2013. In 2015, GDP registered a value of 712,832.3 million lei. In 2016, in the first semester, GDP reached the value of 325,572.9 million lei, the level which is undoubtedly higher than the one registered in the same period of time in previous years until present day. In Hungary, a country which we can compare with, there was a fluctuating trend of GDP growth from 1.3% in 1996, 4.6% in 1997, 5.1% in 1998, 5.9% in 1999, 7.7% in 2000 and 3.5% in 2002 3.7% in 2003, 2.1% in 2004, 4.1% in 2005, 3.9% in 2006, 3.7% in 2007, 0.5% in 2008, 1.1% in 2009 and - 1.6% in 2010. In 2010, GDP decreased by -1.0%, being 522,561.1 million lei.

Hungary and Poland are countries which, although they also encountered a number of difficulties over time, they switched to an improvement of the activity which allowed them a quantitative increase of the GDP indicator.

In our country, if in 1996 this indicator showed a 3.9% increase compared to 1995, in the next period of 1997 there was a decrease of 6.6%, in 1998, a decrease of 7.3% and in 1999, a decrease of 3.2%. Starting 2000, GDP registered a steady upward trend, increasing by 3% in 2001, with 5.3% with 4.8% in 2002, 4.9% in 2003, 8.4% in 2004, 4.1 in 2005, 7.7% in 2006, 6.0% in 2007 and 7.1 in 2008. The estimation was made compared with the previous year. In 2009 he began the real rebound, registering a decrease of -7.1% compared with the previous year. The decrease percentage of GDP continued in 2010, when GDP was reduced by -1.6% and for 2011 the GDP increased by 2.5%. In 2012 also it was a slight increase (1.1%), and in 2013 was registered a comparable increase of 3.4% in 2014 to 3.1% and 3.8% in 2015.

#### GDP evolution between 2001-2016

(corresponding period of previous year = 100)



\* Temporary data, estimated for 2016.

Source: National Institute of Statistics, Statistical Bulletin no. 7/2016.

Aisen and Veiga (2013) discuss on the political instability's negative effects on the economic development and growth. Alfaro, Chanda, Kalemli-Ozcan Sayek (2004) analyze the role of financial markets at the local level in the development of the foreign component of investments in the national economy and of the economic growth.

Anghelache, Anghel, Manole and Lilea (2016) develop on instruments of modeling, in economy, finance, and information technology. Anghelache, Manole, and Anghel (2015) study the influence of final consumption and gross investments on the Gross Domestic Product, they apply the multiple regression model, another work by the authors extends the regression model to include the changes in inventories and the influence of net exports. Anghelache and Anghel (2015) measures the correlation between the evolutions of Direct Foreign Investments sold and Gross Domestic Product. Anghelache, Anghelache and Ursache (2015) present a structural analysis of the FDI evolution.

Anghelache and Anghel (2016), Anghelache, Mitruț and Voineagu (2013), Anghelache (2008), Dornbusch, Fischer and Startz (2007), Newbold, Karlson and Thorne (2010) describe the instruments of macroeconomic and macro-statistics. Atanassov and Kim (2009) analyze the connection between labor and corporate governance, their study is supported by international evidence. Blonigen, Davies, Waddell, and Naughton (2007) evaluate the FDI through the application of spatial autoregressive relations. Büthe and Milner (2008) study the politics of developing countries regarding the foreign direct investments. Censolo and Colombo (2008) analyze the structure of public consumption in a particular type of economy. De Michelis and Monfort (2008) approach the correlations between Gross Domestic Product, regional convergence and European policy oriented towards cohesion, Jones and Wren (2006) approach the correlation between FDI and regional economy. Dobrodolac (2011) develops on the role of econometric models in managerial processes. Dumitrescu, Anghel and Anghelache (2015) develop an econometric model for the analysis of GDP. Ghysels (2001) explains the econometric-based study of time series with seasonal character.

Hanson and Stein (2015) develop on the correlation between monetary policy and real rates on long term. Koulakiotis, Lyroudi and Papasyriopoulos (2012) analyse the impact of inflation on the Gross Domestic Product. Manole, Anghelache, Jweida, Niță and Marinescu (2016) measure the impact of export activities on the economic growth, Pistoresi and Rinaldi (2012) approach a similar topic. Nielsen (2015) discusses on uncertainty of economic growth at global level. Reis (2009) analyzes the properties of the aggregate consumption time series.

## 2. General aspects regarding linear model based on regression function

The regression model is a statistical and econometric instrument used to determinate the relationship of dependence between two variables in a given time horizon. At the macroeconomic level, it is important that a number of result indicators of results is analyzed both static, but dynamic. In this sense, we can identify the direction and pace of development of the considered indicator (variable).

Moreover, it is important to determine if between the considered variables is a correlation and how intense is that connection. Through regression model, we realize this goal. Thus, the calculation of regression parameters, by their sign and size, highlights the existence, direction and intensity established between the analyzed variables.

The regression model can be linear or non-linear. Setting regression model is made after studying data series and graphic representation.

Linear regression model is:

$$y = a + b \cdot x + \varepsilon, \text{ where;}$$

$y$  = the dependent variable (explained);

$x$  = the independent variable (explanatory);

$\varepsilon$  = residual variable;

$a, b$  = regression parameters estimated using regression function based on data series used to define two variables.

From the graphical representation of data series results the possibility that the cloud of points is synthesized by drawing a straight line, because the equation shown above is of a straight line.

In non linear regression model, the function is as follows:

$$y_i = a * x_i^b, \text{ symbols used are the same as in the situation of the linear model.}$$

A nonlinear regression model is resolved by bringing linearity using logarithms and after antilogarithms.

In this context, the initial model becomes:

$$\log y_i = \log a + b * \log x_i ,$$

where:

$\log a$  = parameter of the free term;

$\log y_i$  = dependent variable;

$\log x_i$  = independent variable.

Next, substitutions are made:

$$\log y_i = y'_i$$

$$\log x_i = x'_i$$

$$\log a = a'$$

Applying these substitutions, the model becomes:

$$y'_i = a' + b' * x'_i.$$

From this equation, is determined the equation system from which the regression parameters are calculated. In this case, linear regression model can be simple linear regression or multiple linear regression.

According to the number of variables taken into consideration, models can have the form of simple regression or multiple regression.

### 3. GDP had an oscillating trend in 2009-2016

Analysis of socio-economic development of our country cannot be made only on the basis of data studies which covers and highlights, at a macroeconomic level the development stage of the country, resulted in the evolution of GDP. Individual analysis of the evolution of this indicator, although it is likely to highlight the macroeconomic situation which Romania transits, is not sufficiently eloquent, some opinions and points of view leading to the conclusion that, perhaps, the concrete conditions in our country are particular, or, the analysis tries to identify, at any costs, only the negative aspects.

Therefore, we will conduct a comparative analysis of how this GDP indicator evolved between 2001-2016 and 1997-2000 period, based on indexes based chain (comparing the level of the current year to the previous year) and into a context that suits us, central and eastern European countries.

This eventually analysis is more edifying than a single analysis, which could be "affected" by the interpretation that may be insufficiently relevant due to internal conditions or to an exhaustive comparison with all European countries which can also generate interpretations, such as a number of European countries have social, economic conditions, different from those in our country.

The only way to a concrete analysis of these elements regarding the GDP evolution is a comparative study of the evolution in Romania and in other central and eastern European countries such as Czech Republic, Hungary, Poland, Slovenia, Slovakia, Bulgaria, Latvia, Lithuania, Estonia and Cyprus.

These ten countries establish, along with Romania, the core countries of Central and Eastern European countries which have embarked on the same path in roughly similar conditions. It is not included in this analysis the situation of European states that emerged from the disintegration of the former USSR nor entirely those resulting from the disjunction of the former SFRY. Also Albania, which currently does not report essential and accurate data about the socio-economic development cannot be taken into consideration.

This element appeared as essential in the analysis conducted by economists, who started from the fact that such macro stabilization, on the background of a change and in the context of credibility of suggested electoral programs, can be hopeful.

Compared with Latvia, Lithuania, Hungary, Poland, Slovakia and the Czech Republic, Romania registered in 2001-2013 some annual average increase of GDP growth rate, although in 2009-2011 has manifested the decrease under the impact of the crisis and inefficiency of the governance program.

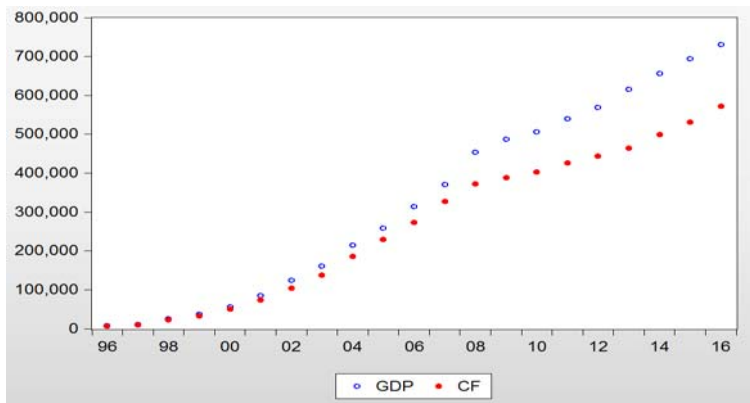
We conclude that, in terms of economic level, Romania was in a good situation until 2008, being alarming the decrease from 2009-2010 and the insignificant pace from 2011-2012. 2013 shows a revival, with a growth of 3.4% and in 2014 the growth was 3.1% over the previous year, and in 2015 the increase was 3.8% compared to 2014.

The way that GDP evolved in 2015 until present day is conclusive, given that this indicator covers also services, so all the activities of the national economy. It means that those transfers of activities have been realized from one sector to another which is likely to stimulate the strengthening of market economy, but only to increase the desire to invest in specific economic sectors of Romania, on the condition that quantitative and qualitative level of costs of domestic and international market are accepted. Deficiency crisis programs from 2009-2012 is lacking proactive anti-crisis measures that would certainly have positive effects. 2013-2016 period marked a reversal based on a more realistic allocation of resources.

#### **4. Analysis of the correlation between GDP and final consumption**

In the proposed linear regression model, final consumption, as a factor of influence, it will be considered an independent variable and influenced indicator, GDP, variable outcome. Estimation of linear regression model is based on data on the two indicators collected for the period 1996-2016.

Graphical representation of the two sets of values, for the period mentioned, is shown in the figure below:



Distribution of the values according to the above chart allows us to conclude that the trend of development for the two indicators is similar, which leads to the conclusion that there was a direct correlation, linear between GDP and final consumption.

Estimation of the parameters of the regression model proposed was realized using a dedicated software application, the results being shown in the figure below:

Dependent Variable: GDP  
Method: Least Squares (Gauss-Newton / Marquardt steps)  
Date: 03/03/17 Time: 12:59  
Sample: 1996 2016  
Included observations: 21  
GDP = C(1)+C(2)\*CF

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-14289.11	6551.944	-2.180897	0.0420
C(2)	1.300769	0.020186	64.43923	0.0000
R-squared	0.995445	Mean dependent var		329688.3
Adjusted R-squared	0.995205	S.D. dependent var		251433.7
S.E. of regression	17409.92	Akaike info criterion		22.45786
Sum squared resid	5.76E+09	Schwarz criterion		22.55734
Log likelihood	-233.8075	Hannan-Quinn criter.		22.47945
F-statistic	4152.415	Durbin-Watson stat		0.375157
Prob(F-statistic)	0.000000			

We note the quality of the regression model, certified by the values of R-squared tests and Adjusted R-squared, which exceed 0.995.

Thus, the equation model may be written in the following form:

$$\text{GDP} = -14289,11 + 1,300769 \text{ CF.}$$

Parameters of the Regression model allow the demarcation of some useful conclusions for the research approach. For an increase in final consumption of 1 leu, GDP will record an addition of 1.3 lei. The high and negative value of the free term indicates the existence of other influencing factors for the GDP, factors that were not considered in the analysis. These factors show an adverse effect on GDP.

### 5. Highlighting the connection between GDP and other macroeconomic indicators using multiple linear regression mode

Information obtained by using simple linear regression model is not always sufficient to characterize the evolution of an economic phenomenon and, especially, to identify possible future development. To retrieve these shortcomings, in the expertise literature were introduced multiple regression models in which the evolution of the dependent variable is defined by two or more variables factor.

Starting from a series of data regarding the evolution of GDP in the last fourteen years, and of the turnover domestic trade in Romania – broken down on turnover in retail trade conducted by companies which have majority ownership of state and trading companies with private majority ownership – we propose a multiple regression model that allows us to analyze the links between these indicators.

For this purpose, we consider as resultant variable the GDP value, and as the variable, relative the value of the turnover in retail trade by ownership. Data were processed from TEMPO Online data base of the National Institute of Statistics of Romania. Some data were extrapolated by the authors.

The structure of the proposed multiple regression model is as follows:

$$GDP = a + b_1 * TPR + b_2 * TPB,$$

Where:

TPR = turnover in retail trade, companies with majority private capital;

TPB = turnover in retail trade, companies with majority state ownership.

The estimation results of the regression model:

Dependent Variable: GDP  
 Method: Least Squares (Gauss-Newton / Marquardt steps)  
 Date: 03/04/17 Time: 12:48  
 Sample (adjusted): 1997 2016  
 Included observations: 20 after adjustments  
 GDP=C(1)+C(3)\*TPR+C(4)\*TPB

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	103836.1	31207.67	3.327261	0.0040
C(3)	1.961810	0.497023	3.947122	0.0010
C(4)	-25.84415	8.549222	-3.022983	0.0077

R-squared	0.882371	Mean dependent var	345775.1
Adjusted R-squared	0.868532	S.D. dependent var	246628.7
S.E. of regression	89423.80	Akaike info criterion	25.77764
Sum squared resid	1.36E+11	Schwarz criterion	25.92700
Log likelihood	-254.7764	Hannan-Quinn criter.	25.80680
F-statistic	63.76111	Durbin-Watson stat	0.503651
Prob(F-statistic)	0.000000		

The model is characterized by significant values of R-squared tests and Adjusted R-squared, higher than 0.86.

Equation model can be represented as follows:

$$GDP = 103836.1 + 1.961810 \times TPR + (-25,84415) \times TPB.$$



The influences of the factors on GDP can be described as follows:

- Turnover of private owned companies exert a positive influence, respectively an increase with 1 leu of the indicator, GDP increases by 1.96 lei.
- Turnover related to companies with majority public capital has a negative impact on GDP.
- The value of the free term is highly compared with the regression coefficients associated with the independent variables, allowing us to consider that on the GDP are other factors that were not considered in this study.

## 6. Conclusions

The Gross Domestic Product of Romania is influenced in a significant manner by the final consumption, as the regression model applied is characterized by high values of the R-squared and Adjusted R-squared tests. If the final consumption rises by 1 unit, the Gross Domestic Product will be greater, by 1.3 units. The analysis of the turnover of companies in retail trade outlines a positive impact in the case of privately-owned companies, while a negative influence is observed in the situation of public companies. Both regression estimations outlined the existence of additional factors, not taken into consideration at the construction of the models. Furthermore, these factors, in the case of the final consumption-based model are posing a negative effect on the main indicator.

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