THE ANALYSIS OF THE CORRELATION BETWEEN THE GROSS DOMESTIC PRODUCT AND THE FINAL ENERGY CONSUMPTION

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Abstract

The aim of this study is to analyze the correlation between the Gross Domestic Product of Romania and the annual Final Energy Consumption in the period 2000 - 2011. For the analysis of this correlation we used a simple linear regression model taking the Gross Domestic Product as an endogenous variable (dependent variable) and the Final Energy Consumption as an explanatory variable (independent variable). The Gross Domestic Product is one of the most important macroeconomic indicators and reflects the synthetic expression of the results of all economic activities produced in a country over a year. Thus, the Gross Domestic Product represents the total value of all goods and services for final consumption, produced in all branches of the economy, that have a monetary value.

Key words: *Gross Domestic Product, consumption, correlation, energy, regression*

Introduction

In the analysis of the factors that determine the variation in the Gross Domestic Product measured by the expenditure approach, we started from the methodological elements specific to the use of the final output using comparable (constant) prices. Constant prices are in fact the current prices of an earlier period. By using comparable prices to express the final goods and services the real Gross Domestic Product is obtained, i.e. value variances are determined only by quantities, prices remaining unchanged. I considered that this is a source of meaningful and truthful information on the main correlations that influence the evolution of the main macroeconomic aggregate.

The Gross Domestic Product (GDP) can be determined by adding up components that express the use of goods and services that form the final output, that is:

$$GDP = C + G + I + X$$

Where:

C – Consumer spending, means the household expenditure in the economy

G – Government spending, means the sum of all Government spending on goods and services

I – Gross investment, means the spending on new fixed assets

X – Net exports, means the difference between exports and imports

To determine the Final Energy Consumption in the year under consideration the following factors are taken into account:

1. Energy sold by energy suppliers to final consumers, including that consumed by them as their own consumption, as self-supply;

2. Energy used for final personal consumption, other than the own technological consumption, by an energy producer;

3. Energy sold by an energy producer to consumers connected through direct lines to the power plant belonging to said producer, values obtained in the year under consideration.

The Final Energy Consumption is measured in tonnes of oil equivalent (toe).

The econometric analysis model of the GDP - FEC correlation

Starting from the Gross Domestic Product and Final Energy Consumption data we wanted to find the connection in our country between the Final Energy Consumption and variations of the Gross Domestic Product. For this purpose we used linear single factor regression as a method of analysis.

For simple linear regression it is necessary to identify a factorial econometric model of the form:

$$y = f(x) + u$$

Where:

y - actual values of dependent variables

x - actual values of independent variables

u - the residual variable, representing the influences of other factors of the variable y, not specified in the model and considered to be random factors, influencing the variable y

To build a linear regression model we defined the Final Energy Consumption as the independent variable, while the Gross Domestic Product was considered a dependent (result) variable. Thus, the regression model may be expressed as:

$$GDP = a + b \cdot FEC$$

Econometrically, the model considered ought to include the residual component as well, seen as a representation of the differences between the values determined theoretically and those measured in the actual economy.

$$GDP = a + b \cdot FEC + u$$

Where:

GDP - Gross Domestic Product (dependent variable)

FEC - Final Energy Consumption (independent variable)

a, b - Regression model parameters

u - Residual variable

To determine the linear regression model parameters, we considered a range of data on the evolution of two variables in the period 2000 - 2011. These values are shown in Table 1:

The evolution of the Gross Domestic Product and the Final Energy Consumption in Romania, in the period 2000-2011[1]

Table 1

YEAR	Gross Domestic Product - GDP (million RON)	Final Energy Consumption - FEC (thousand toe)
2000	56521	2815
2001	85584	3121
2002	123934	3058
2003	159978	3225
2004	214190	3334
2005	257643	3341
2006	311709	3522
2007	366423	3521
2008	446578	3592
2009	480853	3234
2010	495381	3553
2011	534994	3673

To analyze the correlation between the Gross Domestic Product and Final Energy Consumption shown in the table above, we have established a number of features for the evolution of each value considered in the period under analysis.

Thus, it can be seen both from the study of the data under analysis, that in the period considered, the Gross Domestic Product of Romania calculated by the expenditure approach in comparable prices saw a steady growth from year to year. Between 2000 and 2007 there was an rise in the Gross Domestic Product, the difference from one year to another being fairly constant, except for the difference between 2007 and 2008 which was higher. Thus, in the period 2008 - 2011 due to the economic - financial crisis that affected our country as well from the second half of 2008, the differences between the values of the real Gross Domestic Product of Romania from year to year are smaller compared to the period 2004-2007.

We have conducted several statistical tests showing the frequency distribution of the series analyzed. The results of these tests indicate an average value of the indicator for the period considered of 294.482 billion RON, ranging from a minimum of 56.521 billion RON (at the end of 2000) and a maximum of 534.994 billion RON (at the end of 2011).

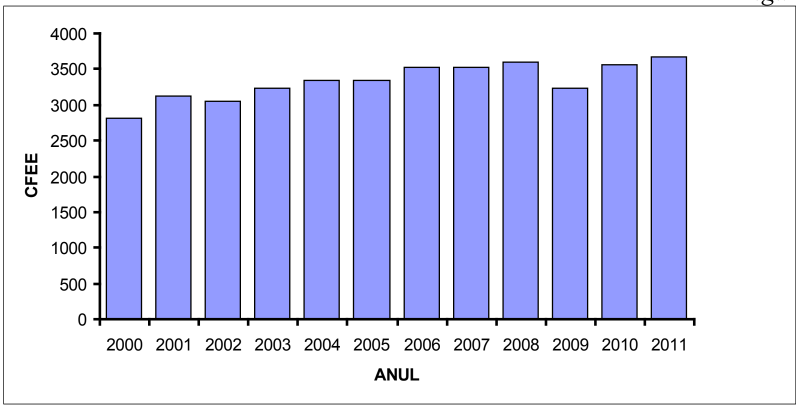
The analysis of the values of the statistical tests conducted indicates that the distribution of the values of the Gross Domestic Product for the period considered was almost symmetrical, as the value of the Skewness test (which shows the degree of asymmetry of the probability distribution function of the series around its mean) is approximately zero, close to the normal distribution. The Kurtosis value measures the amplitude of the probability density function, its flattening as against the probability density function of the normal distribution. This value is lower than 3, which indicates that the distribution is platykurtic.

A similar analysis was conducted for the evolution of the Final Energy Consumption in the period 2000 – 2011, shown graphically in Figure 1.

1. INS – National Institute of Statistics, http://www.insse.ro/

The evolution of the Final Energy Consumption in Romania in the period 2000 – 2011[1]

Figure 1



It can be seen that the evolution of the Final Energy Consumption in the period under analysis, had a relatively small but steady increase from year to year, except in 2009, when there was a decrease compared to the previous year, due to the economic crisis. Thus, it can be noticed that in this period the value of this indicator is significantly lower compared to the period immediately preceding it.

The range of the analyzed indicator shows that the value of the Final Energy Consumption ranges from 2.815 million tonnes of equivalent oil in 2000 to 3.673 million tonnes of oil equivalent at the end of 2011. We could also determine that the average value of this indicator for the period 2000 - 2011 is 3.332 million tonnes of oil equivalent.

As can be seen, the values for the Skewness test allow us to argue that the distribution considered is not perfectly symmetrical. The value of the Kurtosis test is also lower than 3, which shows that, as in the case of the Gross Domestic Product, the distribution is platykurtic.

The correlation between GDP and FEC

The two previous analyses allowed us to draw a conclusion regarding the analysis of the correlation between the two indicators investigated, the Gross Domestic Product and the Final Energy Consumption. Thus, it can be noticed that the evolution of the two macroeconomic indicators is similar, with increases in the period 2000-2008 and a stagnation (with a slight decrease) in the period immediately following it.

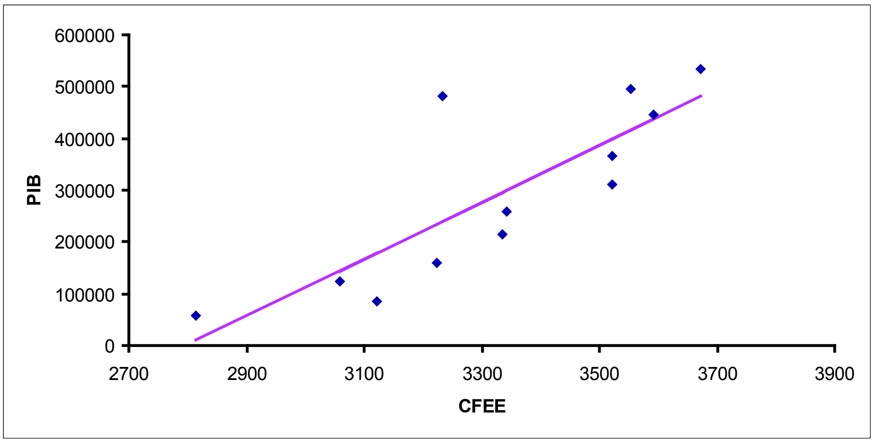
Based on these findings, we can say that there is an interdependence between the Gross Domestic Product and the Final Energy Consumption.

To identify the type of regression function we made a graph of pairs of points that include the values of the Gross Domestic Product and the corresponding Final Energy Consumption, shown in Figure 2.

1. INS – National Institute of Statistics, http://www.insse.ro/

The Gross Domestic Product – Final Energy Consumption correlogram

Figure 2



Using the correlogram we can describe the relation between the two variables. The graph shows that the Gross Domestic Product (the dependent variable) is influenced by the Final Energy Consumption (the independent variable), as well as by other unidentified factors. This observation is based on the presence of scattered points. The influence of these unidentified factors will be eliminated by adjustment, i.e. by establishing the theoretical regression line.

We can also see that the points distribution can be plotted as a straight line. Consequently, the econometric model that describes the relation between the two variables is a linear single factor model of the form:

$$y = a + b \cdot x + u$$

In the above equation a and b are the parameters of the model and the fact that b > 0, that is a positive slope, shows a direct linear relation between the two variables. The residual variable u represents the estimated values of the residual variable.

When there is a linear relation between the two variables considered, the values of the dependent variable are estimated by the relation $\hat{y}_i = \hat{a} + \hat{b} \cdot x_i$ and the residual variable, $\hat{u}_i = y_i - \hat{y}_i$.

The main problem of any regression model is determining the model parameters, an operation that can be performed using the method of least squares. To interpret the results obtained using the linear regression model we need to establish, from the start, whether it can be considered correct.

It can be seen that the probability for this model to be correct is good, approximately 68%, this conclusion being drawn from the values determined for the R - squared tests (0.6812) and Adjusted R - squared tests (0.64935), which measure how accurately the estimated regression equation manages to explain the value of the dependent variable in the sample. This statistic can be interpreted as the degree to which the variance of the dependent variable is explained by the independent variable.

Additionally, the validity of this regression model is confirmed by the values of the F - test (21.37). These tests represent the associated statistic whose null hypothesis is that all regression coefficients, except the constant, are zero. The risk level reflected by the value of the Prob (F - statistic) test is the level of marginal significance of the F - test.

The Durbin-Watson statistic test (1.1529) is a measure of the serial correlation in the residuals. In this case, its value is lower than 2, which shows a positive serial correlation. From the Durbin-Watson distribution table for $k=1$ and n=12 we take the values $d_L = 0{,}697$ and $d_U = 1{,}023$ with the significance level α=0,01, demonstrating that the values of the residual variable $\hat{u}_i$ are independent, i.e. there is no autocorrelation.

The hypothesis of homoscedasticity of errors for this model was tested using the White test. Analyzing the results, we find:

$F - statistic = 0{,}1827 < F_{0.05:1} = 4{,}7472$ and $obs * R - squared = 0{,}2153 < \chi^2_{0.05:1} = 3{,}8410$

The estimators of the model parameters are not relevant for a significance level α=0,05, so the hypothesis of homoscedasticity is confirmed.

Based on the above, we can consider that the regression model describing the correlation between the Gross Domestic Product and the Final Energy Consumption is correct and reflects the evolution of the two macroeconomic indicators, without taking into account the fact that the evolution of the Gross Domestic Product is determined by the other factors as well, which were not analyzed.

Thus, it is possible to transcribe the linear single factor regression model as:

$$\text{GDP} = -1539118{,}3 + 550{,}25 \cdot \text{FEC}$$

This regression model allows us to establish a series of aspects regarding the relation between the two variables considered.

Addendum

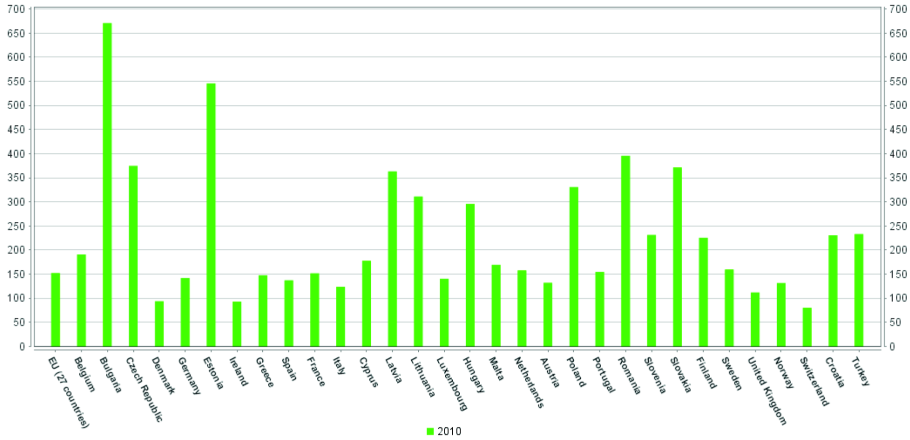
One of the most important parameters that describe the overall energy efficiency of the economy of a country is the energy intensity of the economy. The energy consumption of a country depends on the state and structure of its economy, its geographical location, its territory, but also a large set of other factors. But, even in this situation, countries with similar weather conditions and comparable economic structures differ widely depending on the energy efficiency of the economy, confirming thus that a sustainable national policy on energy is a decisive factor. The energy intensity of the economy is an indicator representing the Gross Domestic Energy Consumption and the Gross Domestic Product ratio for the calendar year.

Figure 3 shows graphically the values of the Energy Intensity of the Economy indicator for the European countries and the 27 countries belonging to the European Union.

It can be noticed that the indicator for Romania in 2010 is 396, which puts us on the third place after Bulgaria and Estonia. The indicator for the economy of Romania is more than double that for the developed countries in the European Union, namely France and Germany, which shows a much lower energy efficiency compared to these countries.

The Energy Intensity of the Economy indicator for the European countries in 2010[1]

Figure 3



Conclusion

We notice that there is a direct relation between the Gross Domestic Product and the Final Energy Consumption in our country in the period 2000 - 2011. Thus, we can say that an increase of one unit in the Final Energy Consumption will lead to an increase of 550.25 currency units in the Gross Domestic Product value.

The analysis of the regression model shown above can not be considered complete without mentioning the important value of the constant term. This value means that the factors not included in the model have a large influence on the Gross Domestic Product. The negative value of the constant term shows that the variables that were not previously included in the econometric model have, as a whole, mainly a negative effect on the evolution of the Gross Domestic Product.

The situation shown above can be considered normal given that, in Romania, the economic growth in recent years has been based almost exclusively on a policy of stimulating consumption, especially regarding its private component, rather than a policy of economic growth by boosting production, investment in new goods production units or efficient energy consumption.

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