ANALYSIS OF THE GDP IN THE REPUBLIC OF MOLDOVA BASED ON MAJOR MACROECONOMIC INDICATORS

Ştefan Cristian CIUCU*

Abstract

The Republic of Moldova is listed by the International Monetary Fund (IMF) and by the World Bank as a country with a transitional economy and studies of the evolution of the economy are of interest. Data has been gathered for a quantitative analysis of the economy using a multiple regression model (with the aid of computer software tools: Microsoft Excel with the Analysis ToolPak add-in and MathWorks - MATLAB), in order to determine if there is a significant importance of some major macroeconomic indicators to the GDP.

The indicators used in the study are GDP, exports of goods and services (% of GDP), inflation - GDP deflator (annual %), central government debt (% of GDP) and unemployment (% of total labor force).

Keywords: *regression, Moldova, GDP, macroeconomic indicators, transition.*

1. Introduction

The main purpose of this paper will be to determine the importance of the indicators from Table 1 (columns 3 to 5 – explanatory variables) to the GDP (column 1 – dependent variable). This will be done using a multiple regression model in Microsoft Excel, with the Analysis ToolPak add-in.

The export of goods and services indicator reflects growth potential, while the inflation and central government debt indicators represent the macroeconomic stability of a country. It is well known that if the inflation or the central government debt is high, then there might be a problem with the country economy.

Computer-aided analysis of macroeconomic indicators is used in many research articles. An interesting topic is the analysis of the informal economy, which in (Tudorel, Iacob, 2010) is treated. In this study the parameter estimation for the applied regression models was done using EViews software.

Another interesting study, in which reggresion is applied, is (Stancu, 2009), in which an overview of the relationship between economic growth and money laundering is done, rendering a linear regression model (for USA, Russia, Romania and other eleven European countries). Model parameters were obtained using the Excel software.

In (Agalega, 2013), the authors investigate the effect that changes in the inflation and interest rates have on the Gross Domestic Product (GDP) in Ghana over a period of thirty one (31) years from 1980-2010. The SPSS software has been used to analyze data.

There are also other studies based on major macroeconomic indicators, which are of value to the literature. The possibility of determining the Romanian Gross Domestic Product on the basis of a linear model, based on macroeconomic indicators such as unemployment, inflation, exchange rate is analyzed in (Iordache, 2011). Also EViews software is used in this study.

* PhD Candidate, Cybernetics and Statistics Doctoral School, The Bucharest University of Economics Studies (stefanciucu@yahoo.com).

The relationship between sectorial structure and economic growth, analyzing the factors underlying the process of deep structural change in regional employment in Romania is developed in the paper of (Jula, 2013).

Another macroeconomic indicator of great importance to a country economy is education. A study on the evolution of some indicators characterizing higher education in Romania between 1971 and 2011 is done in the paper of (Dragoescu, 2013), with the aid of GRETL computer software.

Other IT in social sciences articles that have an impact on literature are: (Coutinho, 2013), (Cretan, 2012), in which computer software tool Maple is used and (Kadar, 2013), in which JESS economic applications are implemented.

Most of these studies use computer software tools in order to bring new ideas and interpretations of macroeconomic concepts to the scientifically literature.

2. Data used in the study

This paper adopts a country-specific time series data from 1999 to 2012. The data source is *The World Bank* - http://data.worldbank.org.[1] Also, some of the data were calculated by the author. An analysis just between the years 1999 and 2012 is done because data for other years, for some indicators, is unavailable.

Year	GDP (current US$)	Exports of goods and services (% of GDP)	Inflation, GDP deflator (annual %)	Central government debt, total (% of GDP)	Unemployment (% of total labor force)
1999	1.170.785.048	52	44,9	77,9	11,1
2000	1.288.420.223	50	27,3	73	8,5
2001	1.480.656.884	50	12,1	60,8	7,3
2002	1.661.818.168	53	9,8	59,6	6,8
2003	1.980.901.554	53	14,9	52,5	7,9
2004	2.598.231.467	51	8	52	8,1
2005	2.988.172.424	51	9,3	32,4	7,3
2006	3.408.454.198	45	13,4	29,2	7,4
2007	4.402.495.921	47	15,8	23,2	5,1
2008	6.054.806.101	41	9,3	18,4	4
2009	5.439.422.031	37	2,2	27,6	6,4
2010	5.811.622.394	39	11,1	26,3	7,4
2011	7.015.201.446	45	7,7	23,7	6,7
2012	7.252.769.934	44	7,5	37,6	5,6

Table 1. Macroeconomic indicators for the Republic of Moldova

In the above table we have:

- GDP (current US$)[2] - GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate

[1] Consulted on 16 January 2014.
[2] http://data.worldbank.org/indicator/NY.GDP.MKTP.CD

does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.

- Exports of goods and services (% of GDP)[3] - represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments.

- Inflation, GDP deflator (annual %)[4] - as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency.

- Central government debt, total (% of GDP)[5] - debt is the entire stock of direct government fixed-term contractual obligations to others outstanding on a particular date. It includes domestic and foreign liabilities such as currency and money deposits, securities other than shares, and loans. It is the gross amount of government liabilities reduced by the amount of equity and financial derivatives held by the government. Because debt is a stock rather than a flow, it is measured as of a given date, usually the last day of the fiscal year.

- Unemployment, total (% of total labor force)[6] **-** Unemployment refers to the share of the labor force that is without work but available for and seeking employment. Definitions of labor force and unemployment differ by country.

3. Methodology

For the study, the multiple regression model used is:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \epsilon$$

The conditional mean function:

$$E(y|x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k$$

The estimated multiple regression equation:

$$\hat{y} = b_0 + b_1 x_1 + b_2 x_2 + \cdots + b_k x_k$$

where:
b_0 = estimate of β_0;
b_1 = estimate of β_1;
b_k = estimate of β_k;
y = GDP (current US$);
x_1 = exports of goods and services (% of GDP);
x_2 = inflation, GDP deflator (annual %);
x_3 = central government debt, total (% of GDP);
x_4 = unemployment (% of total labor force);
ϵ = random variable.

We come up with good estimates using the least squares criterion and we will choose $b_0, b_1, \ldots, b_k$ so as to $min \sum_i (y_i - \hat{y}_i)^2$ (minimize the sum of square errors).

b_1 is the relationship between y and x_1, so if it is positive then that means that y and x_1 are positively related and if it is negative then that means that they are negatively related.

[3] http://data.worldbank.org/indicator/NE.EXP.GNFS.ZS
[4] http://data.worldbank.org/indicator/NY.GDP.DEFL.KD.ZG?page=4
[5] http://data.worldbank.org/indicator/GC.DOD.TOTL.GD.ZS
[6] http://data.worldbank.org/indicator/SL.UEM.TOTL.ZS

Multiple coefficient of determination $R^2 = \frac{SSR}{SST} = 1 - \left(\frac{SSE}{SST}\right)$, where SST = SSR + SSE.

The adjusted R^2, noted $R_a^2 = 1 - (1 - R^2)\left(\frac{n-1}{n-k-1}\right)$.

4. Basic data interpretation

In this section of the article we will take a look at the plots of the indicators and analyze them. Also, in the second part of this section, a descriptive statistics will be made.

In figure 1 we can observe the evolution of GDP (current US$) over the 1999-2012 time period.

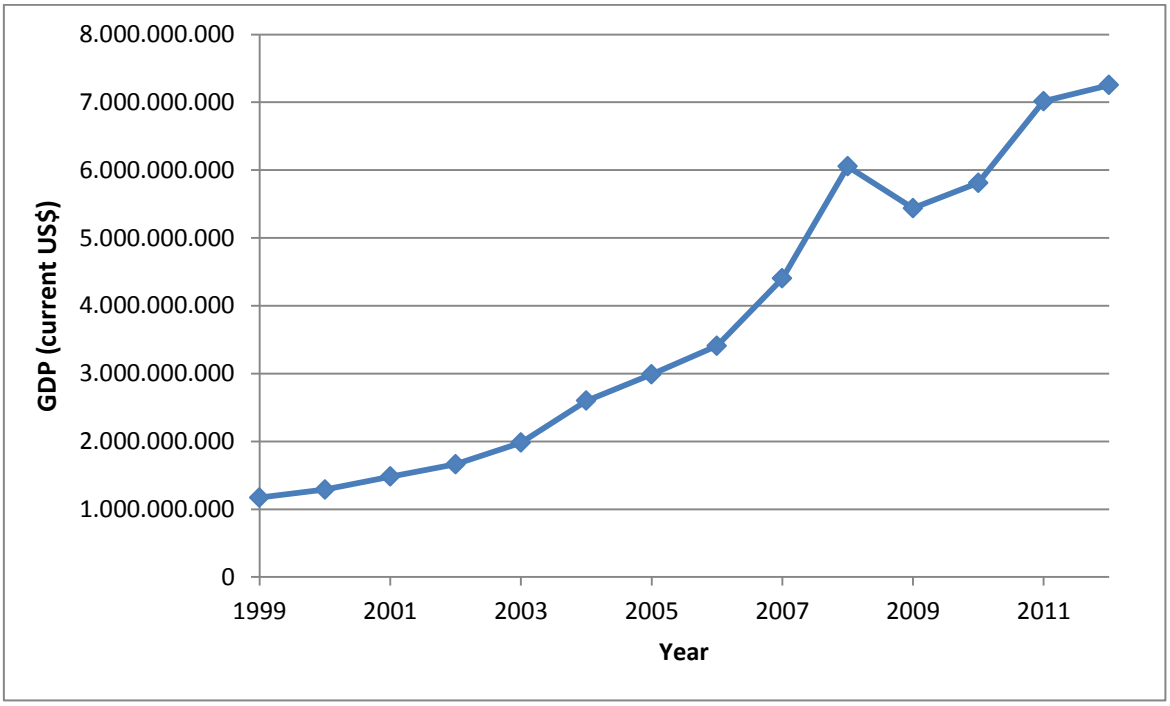

Figure 1. The evolution of GDP over 1995-2012 time period

Analyzing the plot, we can see that the GDP in the Republic of Moldova is on a good path, even though the financial crisis that started in 2007 was a major step back for the economy. In 2011 the GDP reached a value of over 7 billion US$, which is a first in the Republic of Moldova.

The exports of goods and services is a very important factor to any country economy. From figure 2, we can observe that overall evolution of the exports of goods and services (% of GDP) over 1999-2012 time period is not so good. This indicator doesn't have major drops in its value, but for a an economy the exports play an important role. Growth in exports of goods and services involves better employment rate and economic growth. The Republic of Moldova must improve the quality and value of the exports in order to increase the exports rate.

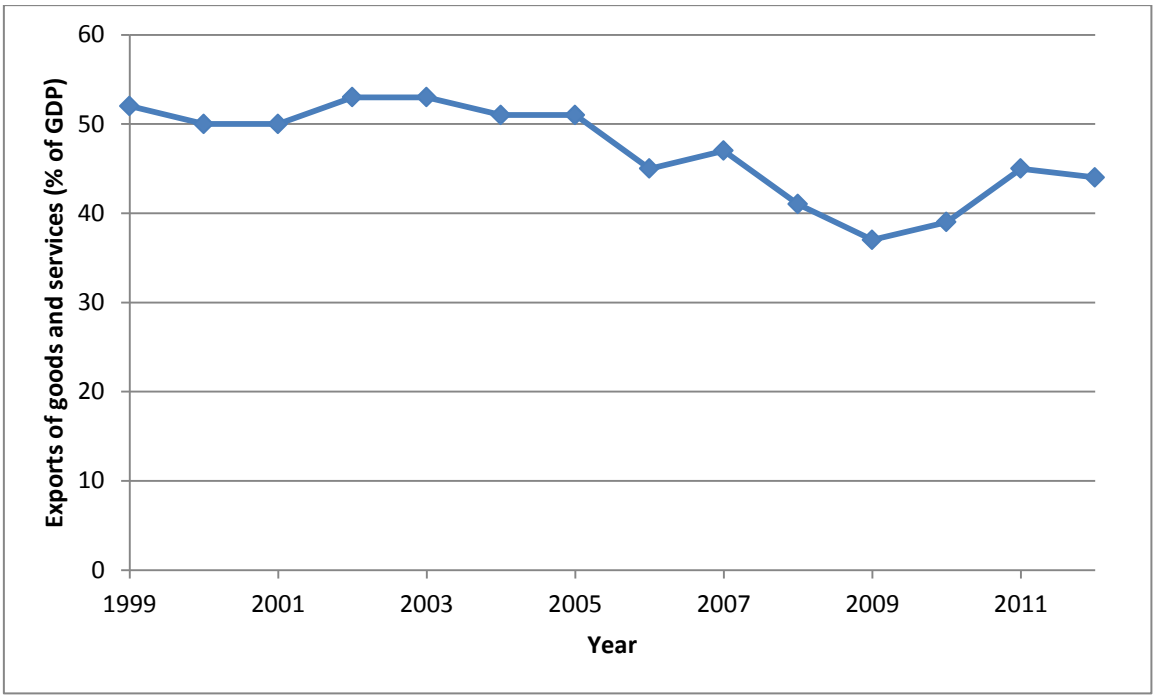

Figure 2. The evolution of the exports of goods and services (% of GDP) over 1999-2012 time period

In figure 3, the evolution of the inflation, GDP deflator (annual %) over 1999-2012 time period is plotted. It can be noticed that this indicator dropped significantly from 1999 to 2002. After 2002, it is rather unstable, increasing and dropping depending on the period of time.

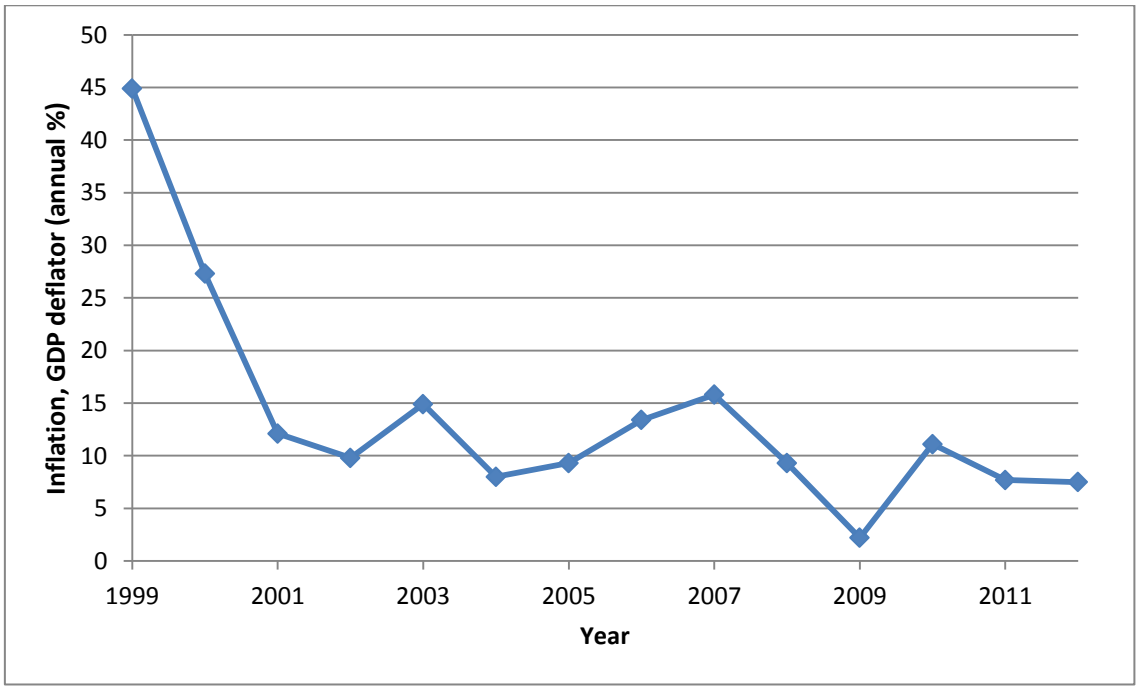

Figure 3. The evolution of the inflation, GDP deflator (annual %) over 1999-2012 time period

The evolution of the central government debt, total (% of GDP) is a major macroeconomic indicator. In the Republic of Moldova the government debt had a decreasing

trend until 2009 and in 2011 started again to grow. In 2012 it reached a level higher than in 2005.

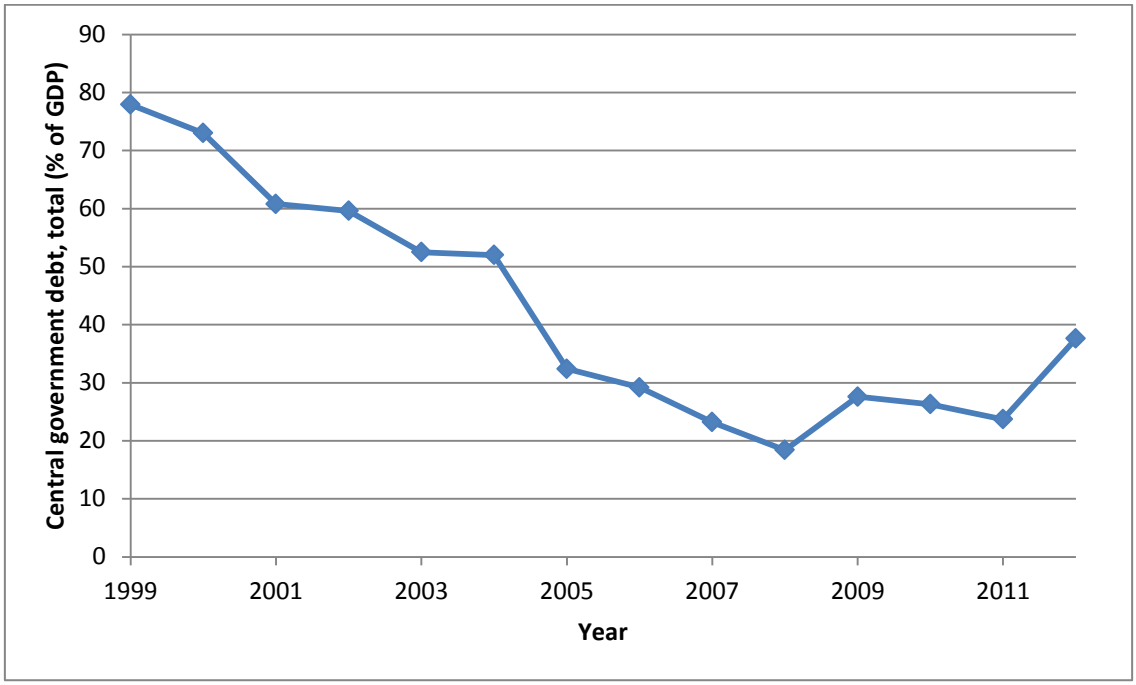

Figure 4. The evolution of the central government debt, total (% of GDP) over 1999-2012 time period

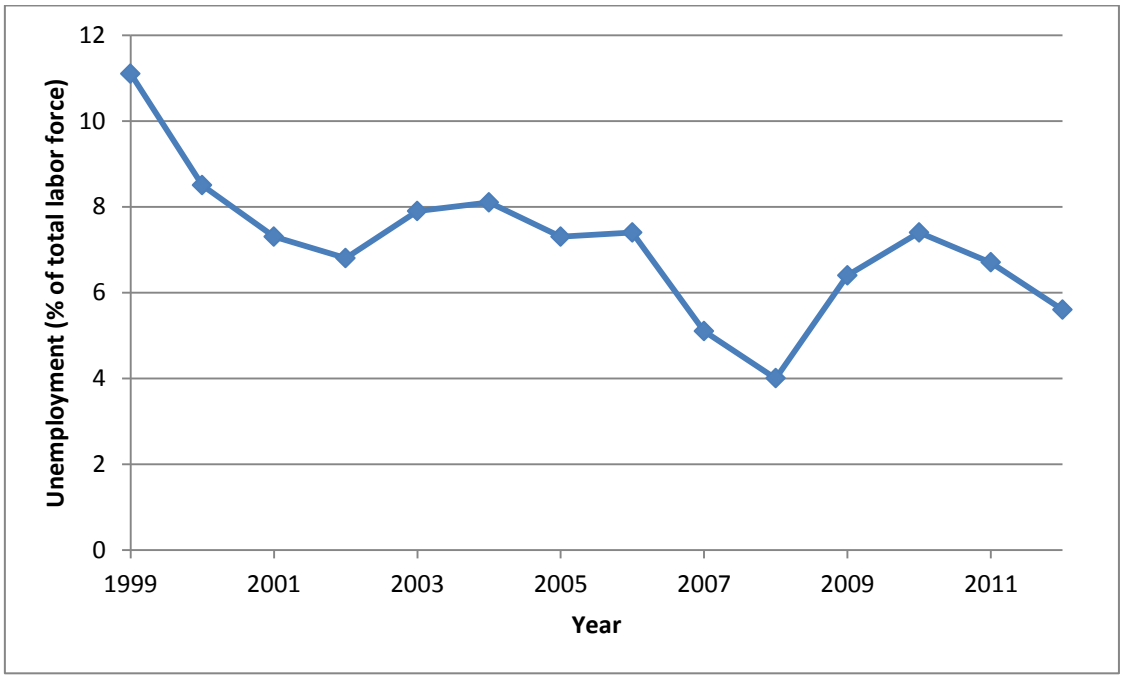

Figure 5. The evolution of unemployment (% of total labor force) over 1999-2012 time period

Employment is a major factor of a country economy. For a country to prosper, the unemployment rate must be low. In 1999 the unemployment was high is the Republic of Moldova and it dropped until 2002. The best unemployment rate was in 2008, when also the country's GDP was high. Between 2008 and 2010, the unemployment rate increased once

more, but from 2010 to 2012 it started to decrease, reaching a level a little higher than in 2007.

In table 2, a descriptive statistics is shown for our data:

	GDP	*Exports of goods and services (% of GDP)*	*Inflation, GDP deflator (annual %)*	*Central government debt, total (% of GDP)*	*Unemployment (% of total labor force)*
Mean	3753839842,3571	47	13,8071	42,4429	7,1143
St. Dev.	2203991278,4432	5,2915	10,6215	19,7971	1,6746
Min.	1170785048	37	2,2	18,4	4
Max.	7252769934	53	44,9	77,9	11,1
Count	14	14	14	14	14

Table 2. Descriptive statistics

5. Data analysis

We will start our analysis with **the correlation matrix** of the variables involved in the model, then we will take a look at the **ANOVA table** for these variables and at last a **multiple regression model** will be developed.

Indicator	*GDP*	*Exports of goods and services (% of GDP)*	*Inflation, GDP deflator (annual %)*	*Central government debt, total (% of GDP)*
Exports of goods and services (% of GDP)	-0,801116935			
Inflation, GDP deflator (annual %)	-0,555822373	0,4500118		
Central government debt, total (% of GDP)	-0,820260388	0,723804638	0,677442653	
Unemployment (% of total labor force)	-0,666661851	0,525186275	0,723811333	0,761233039

Table 3. Correlation matrix

From table 3, the correlation matrix, the relationship between the variables can be seen. For example, between central government debt, total (% of GDP) and exports of goods and services (% of GDP) we have a moderate positive relationship.

From the ANOVA table (table 4), we can establish the overall significance of the model (it is well known that the ANOVA table splits the sum of squares into its components)[7].

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	48635507006418500000	12158876751604600000	7,54012	0,00597272325
Residual	9	14513001214478400000	1612555690497590000		
Total	13	63148508220896800000			

Table 4. Analysis of variance (ANOVA)

In the fifth column - labeled F - we have the overall F-test of:

[7] http://cameron.econ.ucdavis.edu/excel/ex61multipleregression.html

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$$

Versus

$$H_A: at\ least\ one\ \beta_i\ not\ equal\ to\ 0$$

The p-value for the F-test is equal to 0,00597272325, this indicates rejection of the null hypothesis.

After we run the regression analysis in Microsoft Excel (with the Analysis ToolPak add-in), the multiple regression equation can be written:

$$\hat{y} = 15559306679{,}47 - 183853731{,}52x_1 + 4075541{,}924x_2 - 45597448{,}06x_3 - 180668463{,}85x_4$$

Multiple R	0,8775971
R Square	0,7701767
Adjusted R Square	0,6680330
Standard Error	1269864437,84272
Observations	14

Table 5. Regression statistics

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	15559306679,47	4202842265,56	3,702091512	0,004904653	6051816944,33	25066796414,61
Exports of goods and services (% of GDP)	-183853731,52	96799289,9	-1,899329341	0,089984529	-402828938,52	35121475,48
Inflation, GDP deflator (annual %)	4075541,924	50190567,29	0,081201352	0,937058928	-109463409,39	117614493,23
Central government debt, total (% of GDP)	-45597448,06	35144357,17	-1,29743298	0,226750352	-125099507,37	33904611,25
Unemployment (% of total labor force)	-180668463,85	360551903,96	-0,501088642	0,628334818	-996293535,95	634956608,25

Table 6. Regression output

The multiple correlation coefficient (Multiple R) is equal to 0,8775971. So, the correlation among the independent and dependent variables is positive.

The coefficient of determination, $R^2 = 0{,}7701767$, meaning that 77,01% of the variability of the GDP is explained by exports of goods and services (% of GDP), Inflation, GDP deflator (annual %), central government debt, total (% of GDP) and unemployment (% of total labor force).

The standard error, $SE = 1269864437{,}84272$, that means that the typical deviation between the actual GDP and what the model says that it should be it is equal to about 1.269.864.437,84272 units.

Also, from table 6, looking at the coefficients column, we can see that we have a negative relationship with the exports of goods and services (% of GDP), central government debt, total (% of GDP) and unemployment (% of total labor force) and a positive relationship with inflation, GDP deflator (annual %).

The t Stat column gives the computed t-statistic for:

$$H_0: \beta_j = 0$$

against

$$H_a: \beta_j \neq 0$$

The p-values from table 6, gives the p-value for test of:

$$H_0: \beta_j = 0$$

against

$$H_a: \beta_j \neq 0$$

From the p-value for each indicator, we can say that the indicators are significant.

The last two columns of table 6, tells us that there is a 95% confidence that the actual impact of an indicator is between the lower and the upper value.

6. Detecting multicollinearity using variance inflation factors

In this section we will take a look at the multicollinearity using variance inflation factors. If there is multicollinearity, then the estimated coefficients are inflated.
For a good regression model, the correlation between the independent variables must be none or weak. The VIF is equal to 1 when there is no collinearity.
We will use:

$$VIF_j = \frac{S_{x_j}^2 (n-1) SE_{b_j}^2}{S^2}$$

So, for each indicator, the VIF is equal to:

Indicator	VIF
Exports of goods and services (% of GDP)	2,115
Inflation, GDP deflator (annual %)	2,291
Central government debt, total (% of GDP)	3,902
Unemployment (% of total labor force)	2,939

Table 7. Variance inflation factors

Even through our results are between 2 and 3, we can say that our variables are well chosen. If there was a VIF value greater or close to 5, than we would definitely had to remove it from the model.

7. Residual Analysis - Checking the Independence Assumption

In order to have confidence that the model is good, in this section we check the residuals for any pattern.

In table 8, for each observation we have a predicted GDP, residuals and standard residuals.

Observation	*Predicted GDP*	*Residuals*	*Standard Residuals*
1	624443320,6	546341727,4	0,517079633
2	1613586747	-325166524,2	-0,307750586
3	2324729533	-844072648,9	-0,798864069
4	1908845762	-247027593,5	-0,233796781
5	2054637596	-73736042,29	-0,069786736
6	2380888851	217342615,7	0,205701733
7	3424431809	-436259384,8	-0,412893307
8	4672108907	-1263654709	-1,19597329
9	5003304900	-600808979	-0,568629615
10	6497539328	-442733226,5	-0,419020409
11	6350917071	-911495039,5	-0,862675313
12	5898090149	-86467755,26	-0,081836537
13	5026132207	1989069239	1,882534575
14	4774101613	2478668321	2,345910703

Table 8. Residual Output

First we plot the residuals over time (figure 6).

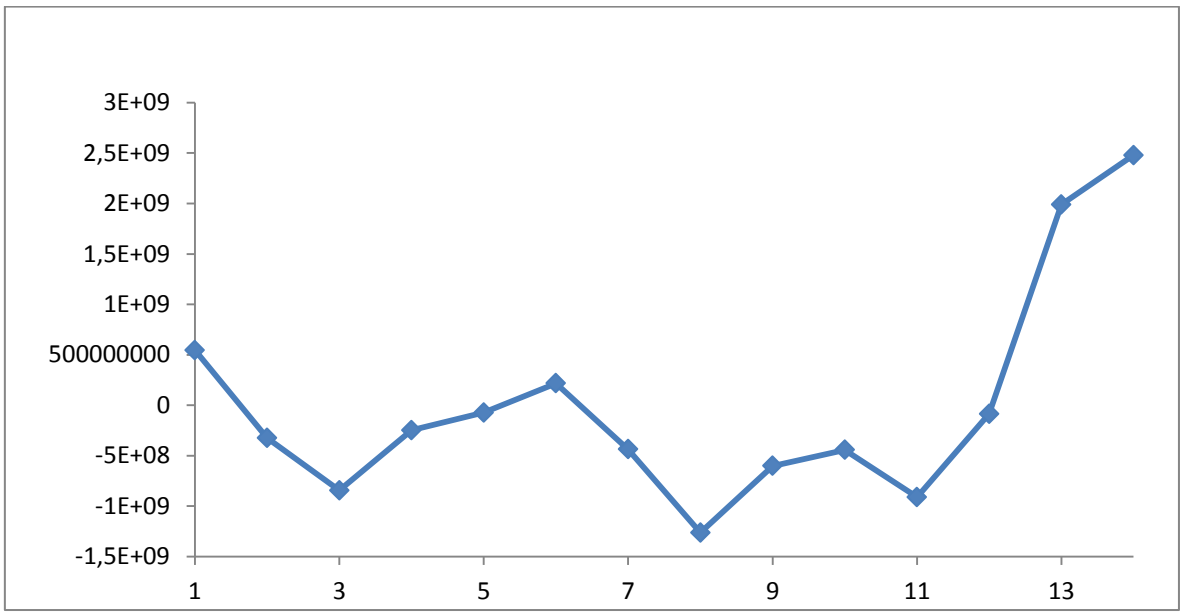

Figure 6. Residuals plot over time

Second, we plot the residuals vs. each of the x-variables in the model.

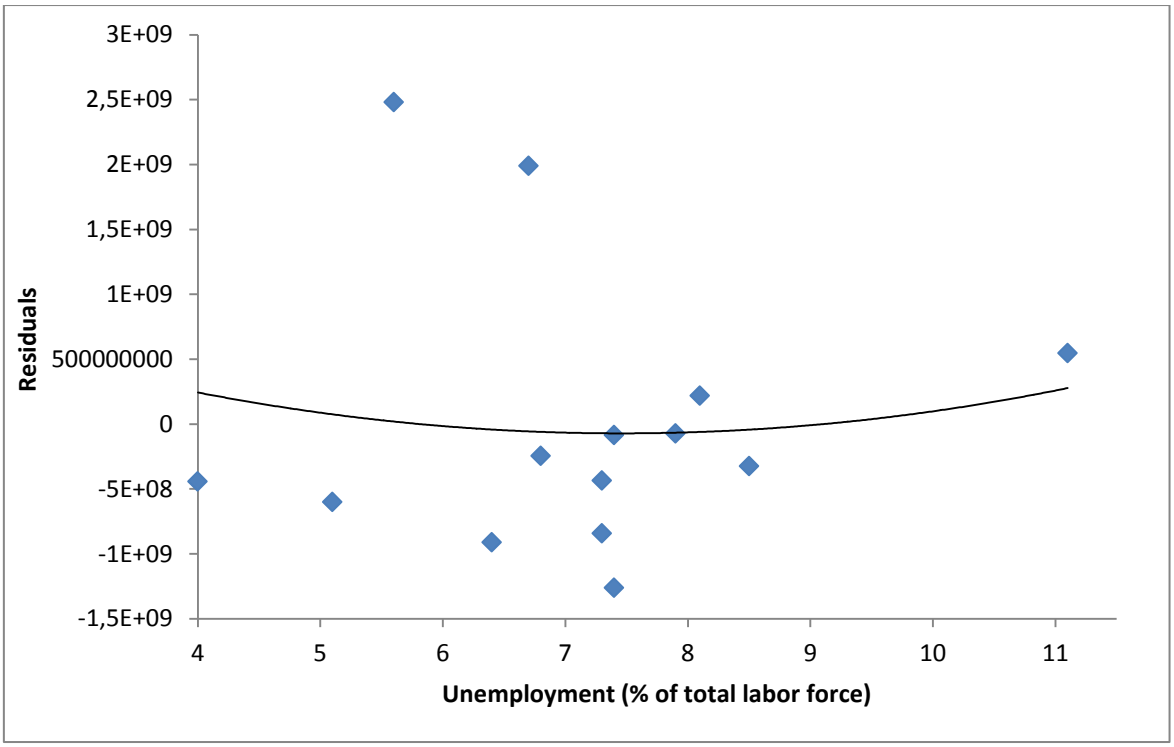

Figure 7. Unemployment (% of total labor force) Residual Plot

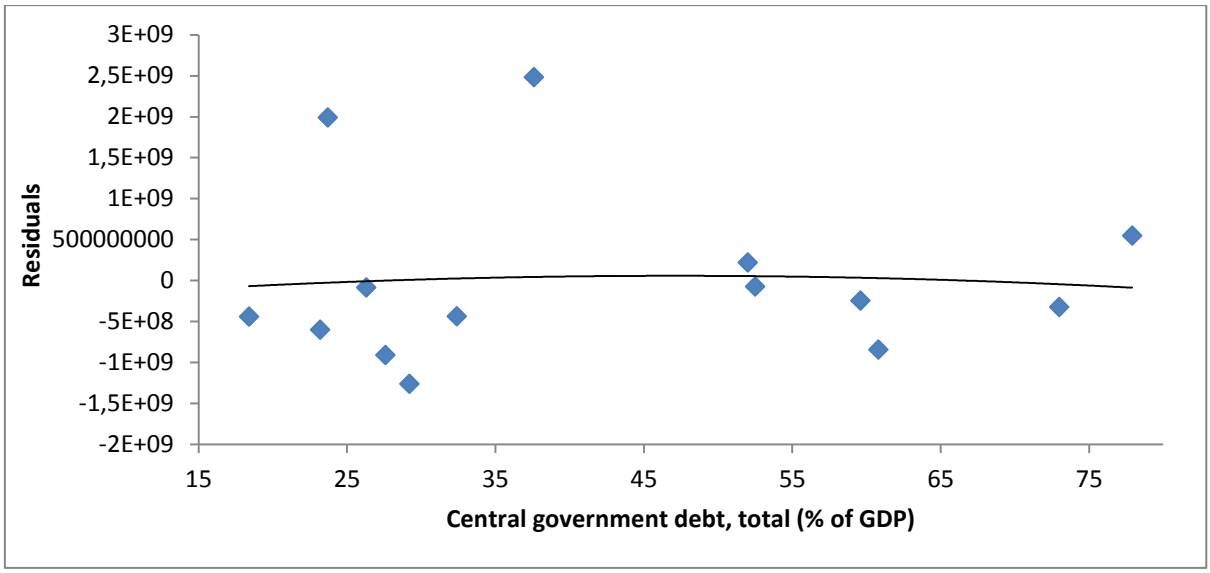

Figure 8. Central government debt, total (% of GDP) Residual Plot

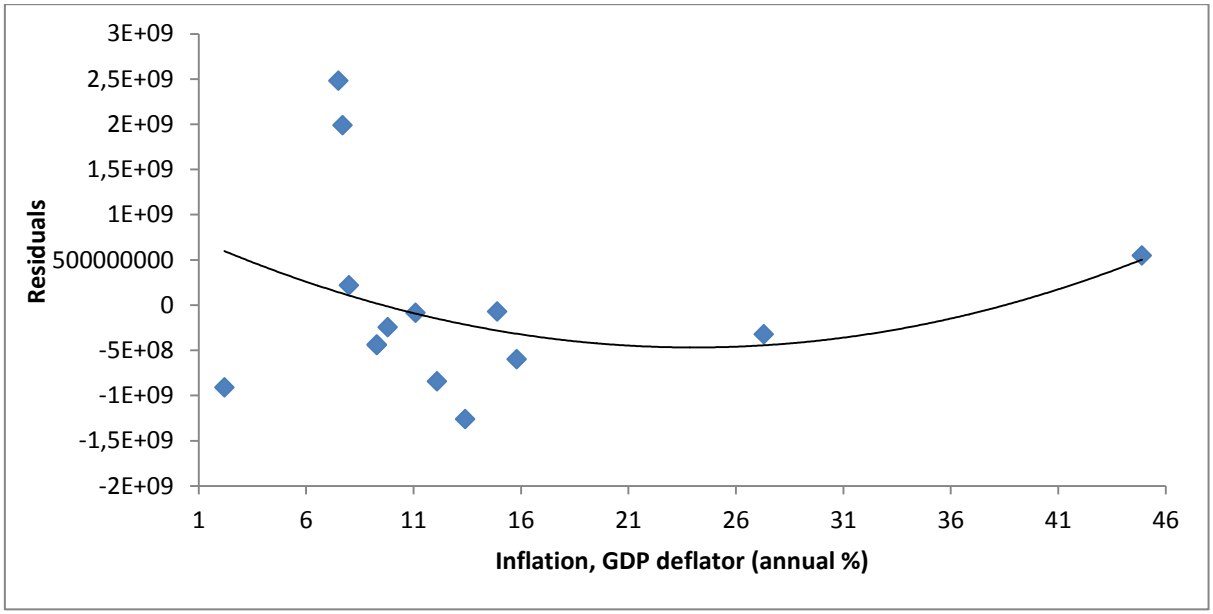

Figure 9. Inflation, GDP deflator (annual %) Residual Plot

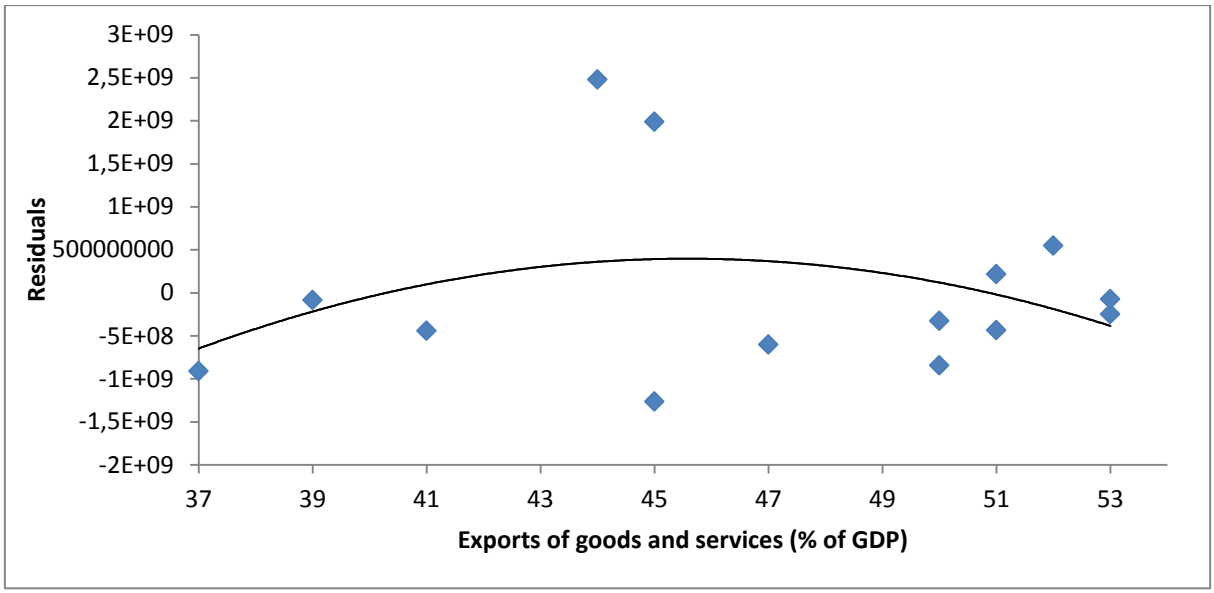

Figure 10. Exports of goods and services (% of GDP) Residual Plot

Independence would be violated over time if the plot shows significant curvature.

By looking at the plots (figures 7, 8, 9 and 10) we can not notice any major pattern. A polynomial trendline has been added to each plot in order to easier check for curvature. We can notice some curvature mostly in figures 9 and 10, but it is not that significant.

8. Checking the Constant Variance Assumption

By plotting residuals vs. fitted values, we can check the regression assumption of independence. The residuals should be randomly scattered.

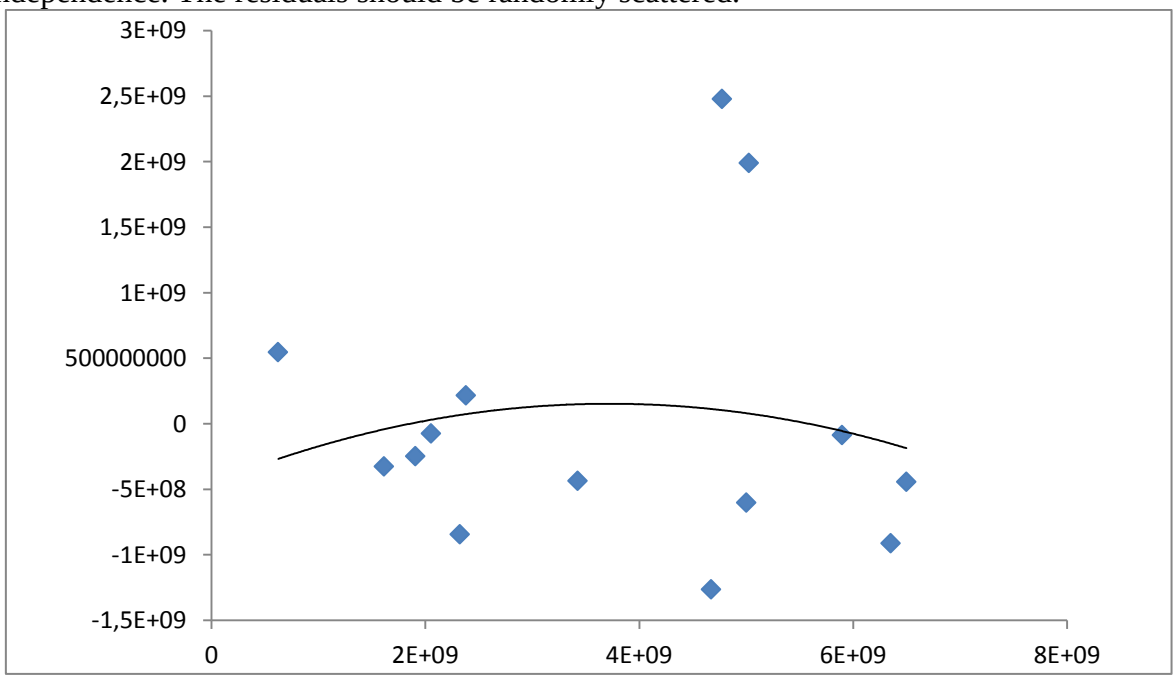

Figure 11. Residuals vs. predicted GDP plot

From figure 11, we can see that the residuals are randomly scattered. If a cone shape or inverse cone shape would be the shape of the scatter, then we would have a violation of constant variance (also called homoscedasticity).

Also, there is a little bit of curvature, but is not so significant to have a violation of independence.

9. Conclusions

The GDP is influenced by a lot of macroeconomic indicators. In this study, a multiregression model based on five major macroeconomic indicators has been proposed.

As seen 77,01% of the variability of the GDP is explained by exports of goods and services (% of GDP), inflation, GDP deflator (annual %), central government debt, total (% of GDP) and unemployment (% of total labor force).

IT software like Excel or Matlab (and many others) are great tools in analyzing data and developing models. These kind of software helps the user in mathematics and data management.

This article has achieved two major goals: developing of a multiregression model and showing the power of IT in social sciences. In the future, it can be developed by running more tests to the data, also using software tools: the *Jarque–Bera test, Durbin-Watson test* or *Goldfeld–Quandt test.*

References

- Andrei, Tudorel, Iacob, Andreea Iluzia, Stancu, Stelian, Oancea, Bogdan, Quantitative Techniques used for the Informal Economy Analysis at National and Regional Level, Informatica Economica, vol. 14, issue 3, pages 153-164, 2010.
- Stancu, Ion, Rece, Daniel, The Relationship between Economic Growth and Money Laundering – a Linear Regression Model, Theoretical and Applied Economics Journal, Vol**.** 09(538), Issue (Month): 09 (538), pages**:** 3-8, 2009.
- Agalega, Evans, Antwi, Samuel, The Impact of Macroeconomic Variables on Gross Domestic Product: Empirical Evidence from Ghana, International Business Research; Vol. 6, No. 5; 2013.
- Iordache, Ana Maria Mihaela, Tudorache, Ionela Catalina, Iordache, Mihai Tiberiu, An Econometrical Model for Calculating the Romanian Gross Domestic Product, Journal of information systems & operations management, Vol. 5.2.1 – special issue, 2011.
- Jula, Dorin, Jula, Nicolae Marius, Economic Growth and Structural Changes in Regional Employment, Journal for Economic Forecasting, issue 2, pages 52-69, 2013.
- Dragoescu, Raluca Mariana, Changes in Romanian higher education after 1990, Romanian Statistical Review nr. 3, pages 28-36, 2013.
- http://cameron.econ.ucdavis.edu/excel/ex61multipleregression.html [consulted on 07.02.2014]
- Coutinho, C., Creţan, A., Jardim-Goncalves, R., Sustainable Interoperability on Space Mission Feasibility Studies. Computers in Industry Journal, special issue on "Interoperable Enterprises" (ISI Thomson Reuters Journal - http://scientific.thomson.com/cgi-bin/linksj/search.cgi), ISSN: 0166-3615, EISSN: 1872-6194, Publisher: ELSEVIER, Volume 63, Issue 8, 2013, pp. 925–937.
- Creţan, A., Coutinho, C., Bratu, B., Jardim-Goncalves, R., NEGOSEIO: A framework for negotiations toward Sustainable Enterprise Interoperability. Annual Reviews in Control – A Journal of IFAC, the International Federation of Automatic Control, ISSN: 1367-5788, Publisher: ELSEVIER, Volume 36 (2), pp. 291–299, 2012, DOI information: 10.1016/j.arcontrol.2012.09.010.
- Kadar, M., Muntean, M., Cretan, A., Jardim-Goncalves, R. - A Multi-Agent Based Negotiation System for Re-establishing Enterprise Interoperability in Collaborative Networked Environments. Proceedings of the 15th International Conference on Computer Modelling and Simulation (UKSim 2013), Cambridge, United Kingdom, 10-12 April 2013, pp. 190-195, DOI: 10.1109/UKSim.2013.66, ISBN 978-0-7695-4994-1, Print ISBN: 978-1-4673-6421-8.