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ECONOMETRIC METHODS AND MODELS USED IN THE ANALYSIS OF THE FACTORIAL INFLUENCE OF THE GROSS DOMESTIC PRODUCT GROWTH

Case Study

Keywords
Econometric model,
Economic growth,
Correlation,
Factor of influence,
Parameter

JEL Classification
E17, O11

Abstract

Gross Domestic Product is the most representative synthetic indicator that expresses the evolution of the national economy. This macroeconomic indicator is used in the analysis of the level of the national economy, as well as the dynamic evolution of the national economy. In the forecast studies we rely on GDP evolution. In these situations, we might identify the factors of economic growth, and their influence. On the evolution of GDP have influence some factors: employees, labour productivity, the level of technology, investments and foreign direct investment, imports, exports or net exports, total consumption, and so on. We can analyze the data series and graphical representation. Detailed analysis is performed using econometric methods, parameters which express interdependence, meaning and intensity of correlation. Thus, we estimate the economic developments. The authors studied and proposed some econometric models for the analysis of economic growth/forecast. The novelty is that we adapt some econometric models to macroeconomic analysis.

INTRODUCTION

In this article the authors sought to establish the main methods and models that econometrics offers in view of such an analysis. It is known that gross domestic product exerts a number of factors (variables) that we need to analyze in the perspective of making some decisions. For example, factorial variables, ie those that can determine the evolution of gross domestic product, the most complex indicator of macroeconomic results, can be used for statistical-mathematical-econometric methods. Thus, on the basis of each series of data, relating to one variable or another, one can see the trend of evolution from time to time. Of course, the data itself reveals quantitatively and analyzed in their complexity gives the qualitative essence to the perspective and trend of the national economy. Labor productivity and the number of employees are factors, whether we rely on the production function or simply analyze from the point of view of the two factors, the perspective and the meaning of the influence of these factorial variables on the resultant one. The study, can be deepened by calling to the graphical representation of the data in the series, resulting in this graphical representation and evolutionary trend. Moreover, we can use the index method to establish a series of indices that make sense of the evolution of gross domestic product from one period to the next. For example, the average Gross Domestic Product Growth index compared to the average labor productivity growth index, compared to the average change in the number of employees, all of which give meaning to the analysis. However, the dynamic or territorial analysis of the main macroeconomic indicators should be complemented by econometric analytical methods to express more clearly the existence of the link, the meaning of the link, and especially the intensity of the link. From this point of view, after analyzing the data series, the parallel data series (here we refer to the fact that gross domestic product, labor productivity, number of employees and other factorial variables can be presented in parallel data series) give us the nature or function of that link. For example, for gross domestic product as a resolvable variable compared to labor productivity or the number of employees, the provision of technological means of production, the use of working time, the contribution of branches to the growth of gross domestic product, etc., we can assume hypotheses on the type of function or econometric model used. In this paper the authors identified between the gross domestic product as a resolutive variable and the other all the factorial variables of influence the existence of a correlation (links) with the form of the straight line function. Starting from this, we can consider this linear model of interdependence between the two or more variables, on the basis of which we can construct a simple linear regression function (the link between two variables only) or the linear multiple link (the link between a resolutive variable and several factorial variables). From the mathematical procedure regression model we arrive at the determination of a system of equations by solving the regression parameters. In turn, these regression parameters are the basic elements by which we can estimate the evolution of the gross domestic product in the future forecasting period, or we can recalculate the levels achieved in the oscillatory evolution of these indicators by applying the regression model. The regression function as a econometric model is often used and in this paper the authors have proposed as an objective to establish and solve by the regression function the correlation (interdependence) between the variables on the basis of which they carried out a concrete analysis. In Methodology research and data, based on the statistical data provided by the National Institute of Statistics for all these variables, the regression parameters were calculated, their analysis and interpretation were made, suggesting the possibility to make forecasts for the future, complex or on each variable in part. This study offer some conclusions and recommendations on the use of these econometric methods to determine the factorial influence of variables on the resulting variable. In fact, the variables are just the statistical indicators that we consider to be individualized, based on data or graphical representations or in correlation using other, more complex, econometric methods and models.

LITERATURE REVIEW

Alfaro, Chanda, Kalemli-Ozcan and Sayek (2004) develop on the role of foreign direct investments in sustaining the economic growth, particularly the position of local financial markets in this context, Anghelache and Anghel (2015) study the correlation between FDI balance and GDP at the European level, Anghelache, Partachi, Sacală and Ursache (2016), Anghelache and Manole (2012) apply econometric techniques in the scope of this type of analysis. Anghel, Anghelache, Dumitrescu and Dumitrescu (2016) describe the evolution of the Gross Domestic Product of Romania by emphasizing the influence of selected factor variables, while Anghel, Diaconu and Sacală (2015) focus on the uses categories in the study of Romania's GDP, Dumitrescu, Anghel and Anghelache (2015) evaluate the role of structural variables on the GDP evolution. Bardsen Nymagen and Jansen (2005), Corbore, Durlauf and Hansen (2006), Anghelache and Anghel (2016), Guijarati (2005) present the concepts and instruments of econometrics, together with illustrative case studies. Cicak and Soric (2015) analyse the correlation between foreign direct investments, for the case of countries with economies in transition. Koulakiotis, Lyroudi, Papasyriopoulos (2012) study the situation of inflation and Gross Domestic Products in the European economies. Anghelache and Anghel (2015) describe the usefulness of statistical-econometric models and methods in the analysis of the Gross Domestic Product. Céspedes and Velasco (2012) study the dynamics of macroeconomic performances under the impact of major dynamics of prices for commodities. Anghelache, Soare and Popovici (2015) consider the influence of the final consumption on the Gross Domestic Product, while Anghelache, Manole and Anghel (2015) develop a study based on multiple regression where the GDP is considered the main indicator, while final consumption and gross investments form the influence factors. Büthe and Milner (2008) consider the application of international trade agreements as instruments for increasing the foreign direct investments. An in-depth analysis of the final consumption is presented by Anghelache, Manole and Anghel (2015). Anghelache, Anghel and Sacală (2014), Anghelache, Anghel, and Popovici (2016) realize top-level analyses of the Romanian Gross Domestic Product. Lucas and Moll (2014) approach some issues on knowledge development. Anghelache and Anghel (2016) develop on the basics of economic statistics, their approach aims both the theoretical framework and practical study. Capinski and Zastawniak (2003) is a reference work in the field of financial mathematics. De Michelis and Monfort (2008) develop on the European cohesion policy, in relation to regional convergence and the Gross Domestic Product. Dornbusch, Fischer and Startz (2007) is a comprehensive reference on macroeconomic topics. Garín, Lester and Sims (2016) evaluate the desirable character of targeting nominal Gross Domestic Product. Guner, Ventura and Yi (2008) consider the macroeconomic effects of policies depending on size of companies.

RESEARCH METHODOLOGY AND DATA

In this article, the authors emphasized the analysis of the Gross Domestic Product series, the Gross Domestic Product Index, labor productivity, the Gross Gross Value Index, the census index of the employed population and the index of the increase in the number of employees. The data series are presented in table no. 1.

From the study of the data series in Table 1 shown, both in absolute figures (Gross Domestic Product and Labor Productivity) and in relative figures (Gross Domestic Product Indices, gross value added, employed population and number of employees) were registered The same developments. With small oscillations, in absolute terms, GDP and labor productivity have risen steadily. The GDP growth index, on the growth trend in absolute figures, registered significant leaps until 2008, when the financial crisis started in Romania. The crisis period was characterized by temperate growth indices, even a negative trend (-2.64) in 2009. The same trend was registered by the gross value added, the employed population and the number of employees. In conclusion, the simple study of the databases shows that GDP, in absolute or relative value, as a resolvable variable, is influenced by all the other factorial variables. The graphical representation of all these indicators (statistically variable) further highlights a correlative evolutionary trend. In this context, for the quantification of the existing correlation between GDP and each of the factorial variables or between GDP and all other variables, the authors used simple and multiple linear regression models. The linear regression functions are of the form:

- linear linear regression:

$$y_i = a + bx_i + \varepsilon$$

where:
y_i = resulting variable;
x_i = factorial variable;
a, b = regression parameters;
ε = residual variable.

- multiple linear regression:

$$y_i = a_0 + a_1x_1 + a_2x_2 + \cdots + a_nx_n + \varepsilon$$

where:
y_i = resulting variable;
$x_1, x_2 \ldots x_n$, = factorial variables;
a_0 = regression parameter, free term;
$a_1, a_2 \ldots a_n$ = the regression parameters associated with each variable;
ε = residual variable.

By replacing the variables considered in the above-described regression functions and by solving the resulting equation systems we obtain the regression parameters on the basis of which we will deepen the analysis.

- **The correlation between GDP and labor productivity**

The regression model becomes:
$\text{PIB} = \text{C}(1) + \text{C}(2)\text{WM} + \varepsilon$,
where C(1) și C(2) are the regression parameters.
Estimation of the regression parameters is done by the least squares method, using the Eviews software in this regard, the results being presented in figure no. 4.
The regression model established by estimating the parameters is:
PIB = 13257,08 + 9,840424 WM + ε
The regression model is characterized by significant values of R-squared and Adjusted R-squared parameters, respectively over 99.7%. This is the possibility to explain the variation of the Gross Domestic Product by the labor productivity

dynamics, to over 99.7%. The value of parameter C(2) shows that, with a unit labor productivity increase, GDP will increase by more than 9.84 units of currency. We consider that the value of the coefficient C(1), sensitively higher than the regression coefficient, indicates the presence of additional influence factors on the dependent variable.
Next, we can use the same model to calculate the regression parameters specific to the correlation between GDP and each resulting variable. Also, correlation models can be constructed between variables considered factorial, but only after a thorough database study and graphical representation.

- **Multiple regression model using absolute values**

In this regression model we used indicators expressed in absolute figures given in table no. 2 and graphically represented in figure no. 5, resulting in the estimated parameters in figure no. 6.

The regression model established on the basis of the estimated parameters is of the form:

$$GDP = 6396{,}532 + 6{,}398910\ WM + 0{,}393516\ VAB + 4{,}275748\ POC - 7{,}876439\ EMP + \varepsilon$$

Analyzing the coefficients of the estimated regression model, we note that three of the four factorial variables exert a positive influence on the Gross Domestic Product. In order of the significance level of influence, the most important factor is labor productivity: an increase in a unit of labor productivity generates a plus of more than 6.39 monetary units of the independent variable. The increase by one person of the value of the employed population leads to an increase of the GDP by over 4.27 lei. The increase in gross added value leads to a sub-unitary increase of GDP, respectively to one u.m. We add a plus of 0.39 of the Gross Domestic Product. Instead, the number of employees exerts a negative influence on the main indicator. The high C (1) coefficient indicates the existence of additional factors that influence GDP and whose overall impact is positive. The R-squared and Adjusted R-squared tests associated with the model attest to model quality and recommendation for use in later analyzes.

- **Multiple regression model using indices**

The multiple regression model used is based on the data of the indicators expressed in relative sizes, the growth indices presented in table no. 3 and graphically represented in Fig. 7.
The multiple regression model, introducing the estimated regression parameters presented in figure no. 8, is of the form:

$$IPIB = -1{,}650543 + 0{,}524385\ IWM + 41{,}17533\ IVAB + 46{,}02154\ IPOC - 84{,}22157\ IEMP + \varepsilon$$

As the associated indicator (Gross Domestic Product), the GDP index is influenced by the indices corresponding to the four macroeconomic indicators, and this influence explains the IPIB variation in the proportion of over 98%. The most significant influence is recorded in the index of growth of the employed population: the increase by one percentage point of this indicator leads to a 46% increase in the GDP index. For the gross added value index, the regression coefficient is 41.17. While the index of the number of employees exerts a negative influence, characterized by a coefficient of -84.22, the labor productivity index is characterized by the lowest positive influence on the independent variable. It is worth noting the high and, at the same time, negative value of the free expression of other factorial variables of IPIB, whose combined impact is negative.

CONCLUSION

In this article, the authors focused on highlighting the main statistical, econometric or mathematical methods or all in one place in analyzing the evolution of gross domestic product. Of course, this evolution is presented precisely at each point in Methodology research and data, allowing those wishing to deepen the analysis to use the same methods, the same extension models of the analysis. The emphasis was put on the use of the data series method, the graphical representation method, the evolution index method, or the simple and multiple linear regression models that they applied to the study of gross domestic product evolution over a sufficiently long period of time for data to have the essence and meaning desired in the analysis. Interpretation of regression parameters and then their use highlighted the extent to which each of the applied factor variables have meaning, intensity and direction of influence on the gross domestic product, allowing the researcher or the manager to choose the optimal variant he wishes to Use it in the analysis of gross domestic product development. Of course, the analysis can be deepened by interpreting the gross domestic product structure, by resources and utilities, as well as interpreting the influence of private consumption, final consumption, or investment on gross domestic product growth. All those are elements of possible expansion and development of the evolution of gross domestic product. Certainly, other macroeconomic outcome indicators can be analyzed over a period of time or forecasting using the same methods. Designed models can be completed, can be simplified, but they are an accurate and useful statistical and econometric instrument in macroeconomic analyzes. The authors consider that the models agreed in this article are concrete theoretical and practical examples that highlight the usefulness of using these methods and econometric models in macroeconomic analyzes. At each point in Methodology research and data, the authors also recorded the mathematical functions that can be used to perform these analyzes.

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TABLES

In this article, we used the following abbreviations: GDP - Gross Domestic Product (the abbreviation of Gross Domestic Product in Romanian language is PIB); IGDP - Index of Gross Domestic Product (the abbreviation of Index of Gross Domestic Product in Romanian language is IPIB); LP - Labour Productivity (the abbreviation of Labour Productivity in Romanian language is WM); ILP - Index of Labour Productivity (the abbreviation of Index of Labour Productivity in Romanian language is IWM); GVA - Gross Value Added (the abbreviation of Gross Value Added in Romanian language is VAB); IGVA - Index of Gross Value Added (the abbreviation of Index of Gross Value Added in Romanian language is IVAB); POC - Occupied population; IPOC - Index of Occupied population; EMP - Employees; IEMP - Index of Employees.

Table No.1

Evolution of the main macroeconomic indicators during 1995-2016 period

Year	GDP	IGDP	LP	IGVA	IPOC	IEMP
1995	7656,7	0	760,2	0	0	0
1996	11463,5	49,72	1155,6	1,50173893	0,987991151	0,974578
1997	25689,1	124,09	2643,3	2,20059604	0,962042862	0,916048
1998	37257,9	45,03	3074,4	1,39932077	1,203103181	0,959703
1999	55479,4	48,91	4527,1	1,4811308	0,999981576	0,899088
2000	81275,3	46,5	6752,6	1,47732441	0,99228034	0,997339
2001	118327,2	45,59	9957,5	1,45838189	0,989388763	0,992847
2002	152630	28,99	14301,6	1,29139429	0,898341982	1,000362
2003	198761,1	30,22	18354,6	1,2867562	0,999519527	1,008729
2004	248747,6	25,15	23477,4	1,25617547	0,983394815	0,999507
2005	290488,8	16,78	27541,5	1,15499015	0,984782794	1,029601
2006	347004,3	19,46	32609,5	1,19417067	1,006852124	1,024978
2007	418257,9	20,53	39334,1	1,20600411	1,003654603	1,051502
2008	524388,7	25,37	48958	1,26321212	1,000117461	1,013505
2009	510522,8	-2,64	49120,9	0,98459482	0,98687793	0,932499
2010	533881,1	4,58	52099,5	1,03718532	0,990598291	0,938827
2011	565097,2	5,85	54593,8	1,03941818	0,991928878	1,017348
2012	595367,3	5,36	60413,9	1,05337269	0,951894915	1,025039
2013	637456	7,07	65512,6	1,07487611	0,991220663	1,005014
2014	668143,6	4,81	68469,4	1,05308641	1,007608467	1,020741
2015	712832,3	6,69	73330,9	1,0586477	0,988465013	1,02867
2016	759227,6	4,8	75530,83	1,20838071	0,960236712	1,057596

Note. Data source: National Institute of Statistics, data processed by authors

Table No.2

Evolution of some macroeconomic indicators during 1995-2016 period

Year	GDP	LP	GVA	POC	EMP
1995	7656,7	760,2	7217,1	9493	6047,678
1996	11463,5	1155,6	10838,2	9379	5893,936
1997	25689,1	2643,3	23850,5	9023	5399,128
1998	37257,9	3074,4	33374,5	10855,6	5181,562
1999	55479,4	4527,1	49432	10855,4	4658,682
2000	81275,3	6752,6	73027,1	10771,6	4646,287
2001	118327,2	9957,5	106501,4	10657,3	4613,051
2002	152630	14301,6	137535,3	9573,9	4614,72
2003	198761,1	18354,6	176974,4	9569,3	4655
2004	248747,6	23477,4	222310,9	9410,4	4652,704
2005	290488,8	27541,5	256766,9	9267,2	4790,431
2006	347004,3	32609,5	306623,5	9330,7	4910,088
2007	418257,9	39334,1	369789,2	9364,8	5162,967
2008	524388,7	48958	467122,2	9365,9	5232,694

2009	510522,8	49120,9	459926,1	9243	4879,48
2010	533881,1	52099,5	477028,6	9156,1	4580,989
2011	565097,2	54593,8	495832,2	9082,2	4660,461
2012	595367,3	60413,9	522296,1	8645,3	4777,152
2013	637456	65512,6	561403,6	8569,4	4801,104
2014	668143,6	68469,4	591206,5	8634,6	4900,684
2015	712832,3	73330,9	625879,4	8535	5041,186
2016	759227,6	75530,83	756300,6	8195,62	5331,54

Note. Data source: National Institute of Statistics, data processed by authors

Table No.3

Evolution of indexes for growth of some macroeconomic indicators during 1995-2016 period

Year	IGDP	IWM	IVAB	IPOC	IEMP
1995	0	0	0	0	0
1996	49,72	52,01	1,501739	0,987991	0,974578
1997	124,09	128,74	2,200596	0,962043	0,916048
1998	45,03	16,31	1,399321	1,203103	0,959703
1999	48,91	47,25	1,481131	0,999982	0,899088
2000	46,5	49,16	1,477324	0,99228	0,997339
2001	45,59	47,46	1,458382	0,989389	0,992847
2002	28,99	43,63	1,291394	0,898342	1,000362
2003	30,22	28,34	1,286756	0,99952	1,008729
2004	25,15	27,91	1,256175	0,983395	0,999507
2005	16,78	17,31	1,15499	0,984783	1,029601
2006	19,46	18,4	1,194171	1,006852	1,024978
2007	20,53	20,62	1,206004	1,003655	1,051502
2008	25,37	24,47	1,263212	1,000117	1,013505
2009	-2,64	0,33	0,984595	0,986878	0,932499
2010	4,58	6,06	1,037185	0,990598	0,938827
2011	5,85	4,79	1,039418	0,991929	1,017348
2012	5,36	10,66	1,053373	0,951895	1,025039
2013	7,07	8,44	1,074876	0,991221	1,005014
2014	4,81	4,51	1,053086	1,007608	1,020741
2015	6,69	7,1	1,058648	0,988465	1,02867
2016	4,8	7,313	1,208381	0,960237	1,057596

Note. Data source: National Institute of Statistics, data processed by authors

FIGURES

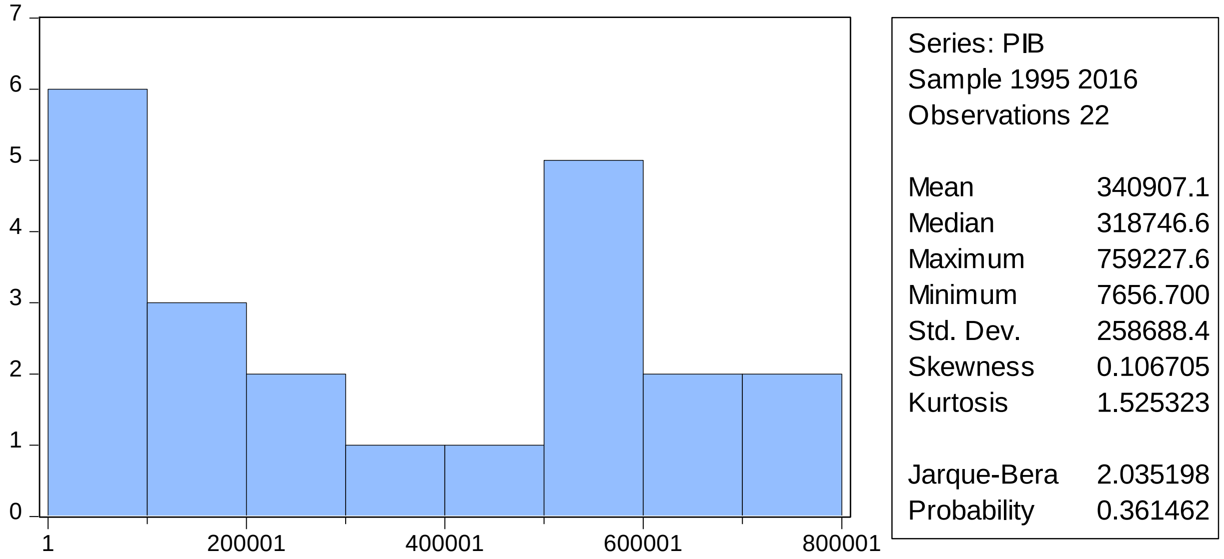

Figure No. 1. Graphic representation of the Gross Domestic Product series

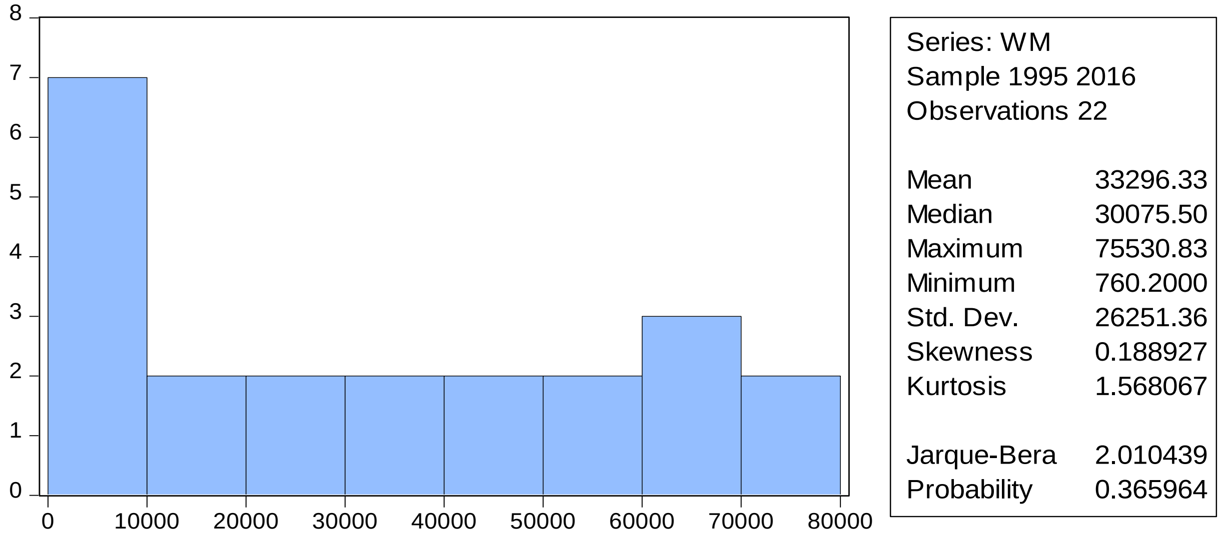

Figure No. 2. Graphic representation of the Labour Productivity series

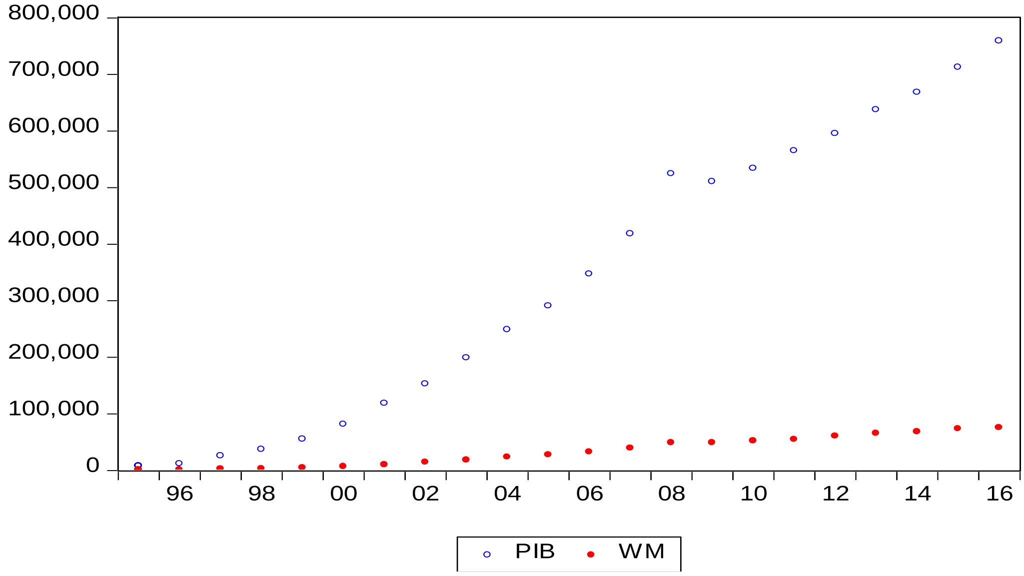

Figure No. 3. Corelogram Gross Domestic Product / Labour productivity

Dependent Variable: PIB
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 03/12/17 Time: 20:59
Sample: 1995 2016
Included observations: 22
PIB = C(1)+C(2)*WM

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	13257.08	4910.590	2.699693	0.0138
C(2)	9.840424	0.116838	84.22315	0.0000

R-squared	0.997188	Mean dependent var	340907.1
Adjusted R-squared	0.997048	S.D. dependent var	258688.4
S.E. of regression	14055.42	Akaike info criterion	22.02591
Sum squared resid	3.95E+09	Schwarz criterion	22.12510
Log likelihood	-240.2850	Hannan-Quinn criter.	22.04928
F-statistic	7093.538	Durbin-Watson stat	0.548601
Prob(F-statistic)	0.000000		

Figure No. 4. Parameter estimation regression model GDP / Labour productivity

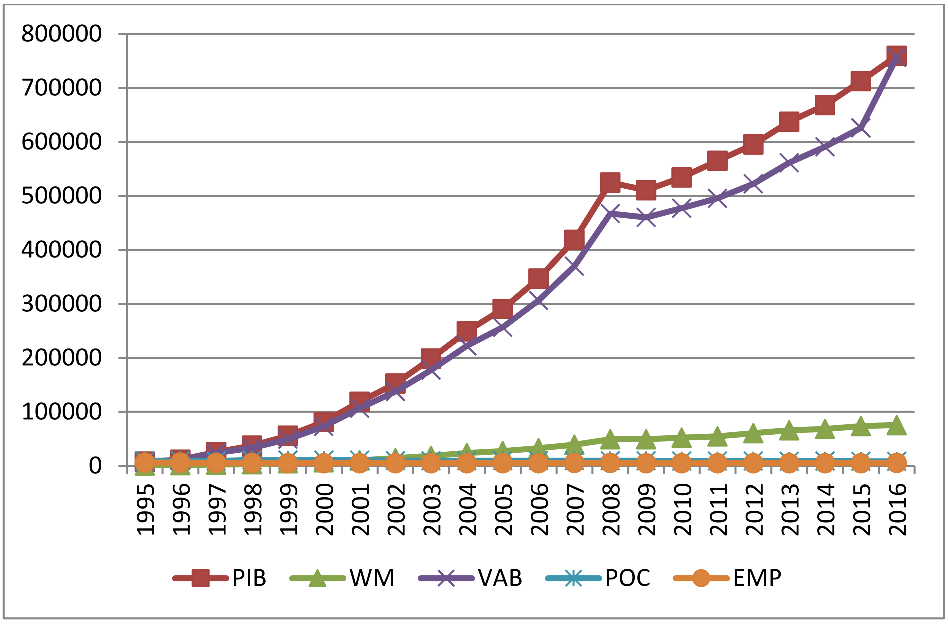

Figure No. 5. Graphic representation of Gross Domestic Product and factorial variables during 1995-2016 period

Dependent Variable: PIB
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 03/14/17 Time: 18:09
Sample: 1995 2016
Included observations: 22
PIB = C(1)+C(2) * WM + C(3)*VAB+C(4)*POC+C(5)*EMP

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	6396.532	82798.21	0.077254	0.9393
C(2)	6.398910	0.971396	6.587333	0.0000
C(3)	0.393516	0.104697	3.758602	0.0016
C(4)	4.275748	5.695954	0.750664	0.4631
C(5)	-7.876439	6.950829	-1.133165	0.2729

R-squared	0.998658	Mean dependent var	340907.1
Adjusted R-squared	0.998343	S.D. dependent var	258688.4
S.E. of regression	10531.72	Akaike info criterion	21.55889
Sum squared resid	1.89E+09	Schwarz criterion	21.80685
Log likelihood	-232.1478	Hannan-Quinn criter.	21.61730
F-statistic	3163.235	Durbin-Watson stat	0.515229
Prob(F-statistic)	0.000000		

Figure No. 6. Parameter estimation regression model GDP_LP_GVA_POC_EMP

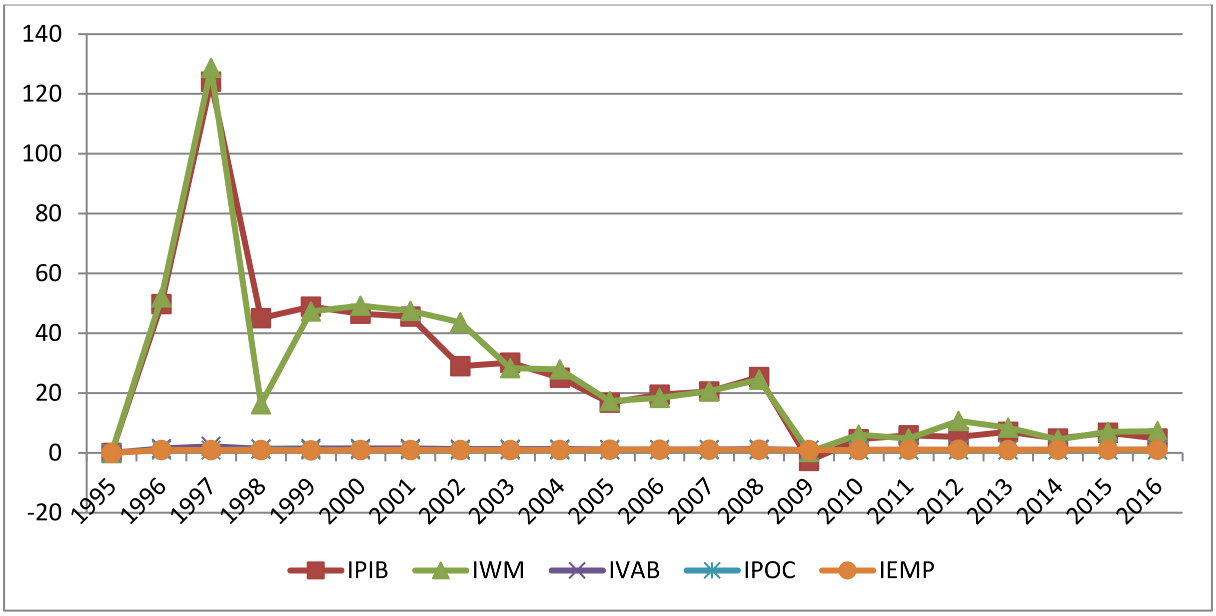

Figure No. 7. Graphic representation of Gross Domestic Product growth indices and other factorial variables during 1995-2016

Dependent Variable: IPIB
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 03/14/17 Time: 19:09
Sample: 1995 2016
Included observations: 22
IPIB=C(1)+C(2)*IWM+C(3)*IVAB+C(4)*IPOC+C(5)*IEMP

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.650543	3.796786	-0.434721	0.6692
C(2)	0.524385	0.207478	2.527423	0.0217
C(3)	41.17533	21.71722	1.895976	0.0751
C(4)	46.02154	24.33674	1.891031	0.0758
C(5)	-84.22157	11.83200	-7.118119	0.0000

R-squared	0.984943	Mean dependent var	25.58455
Adjusted R-squared	0.981401	S.D. dependent var	28.00838
S.E. of regression	3.819781	Akaike info criterion	5.714980
Sum squared resid	248.0423	Schwarz criterion	5.962944
Log likelihood	-57.86477	Hannan-Quinn criter.	5.773392
F-statistic	278.0159	Durbin-Watson stat	1.958155
Prob(F-statistic)	0.000000		

Figure No. 8. Parameter estimation regression model IGDP_ILP_IGVA_IPOC_IEMP