STATISTICAL-ECONOMETRIC MODEL USED FOR THE ANALYSIS OF THE CORRELATION BETWEEN THE GROSS DOMESTIC PRODUCT AND THE LABOUR PRODUCTIVITY

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Abstract
The purpose of this article targets the analysis of the correlation between two variables by using the statistical-econometric model of simple linear regression. A country’s GDP evolution is affected by various factors, but in this article we will focus on the establishment of the dependences between the GDP, as result variable, and the labour productivity, as factorial variable. By simply analysing the statistical data, we can notice that an increase of the labour productivity generates a growth of production volume and a decrease of the production costs. Therefore, we can appreciate that we have a correlation between the two variables under consideration which can be expressed by using the simple linear regression model.

The correlation analysis of the two indicators is based on a series of online data published by the National Institute of Statistics from 1995 to 2015 and aims to set an overview of their evolution, in order to anticipate future evolutions.

Key-words: simple regression, labour productivity, GDP, correlation, evolution

1. Introduction
The Gross Domestic Product (GDP) is a macroeconomic indicator which allows the measuring of the economic output achieved within a country. Thus, the GDP is the most important macroeconomic indicator which reflects the economic activity within a country, for a certain period of time.

The productivity allows the measuring of the efficiency of production systems used in an undertaking’s activity. This efficiency is directly influenced by the production factors used (capital and labour). Thus, the fewer inputs we use to produce a given quantity, the greater the efficiency of an undertaking is.

The labour productivity is the main efficiency indicator of the economic activity and it is expressed as the ratio between the quantity produced (Q) and the amount of work used for its achievement (L).

The statistical-econometric model for the simple linear regression expresses how a result variable/ a dependent variable (endogenous) Y can be explained depending on a factorial or independent variable (exogenous) X or, more precisely, it expresses the influence a variable X exerts on a variable Y.
Literature review


The research methodology

In order to express the correlation between labour productivity and GDP in Romania, we will build a series of data for the evolution of the two economic indicators on a twenty-year period, using information contained in statistical yearbooks of the National Institute of Statistics. We will also follow the progress of gross added value and occupied population.

<table>
<thead>
<tr>
<th>Year</th>
<th>Gross Domestic Product (in millions of Romanian Lei)</th>
<th>GDP growth index over the previous year (%)</th>
<th>Labour productivity per occupied person (Romanian Lei per person)</th>
<th>Labour productivity growth index per occupied person over the previous year (%)</th>
<th>Gross Added Value (in millions of Romanian Lei)</th>
<th>Occupied population (thousands of people)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>7656,7</td>
<td>0</td>
<td>760,2</td>
<td>0</td>
<td>7217,1</td>
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<td>49,72</td>
<td>1155,6</td>
<td>52,01</td>
<td>10838,2</td>
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<td>124,09</td>
<td>2643,3</td>
<td>128,74</td>
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<td>1998</td>
<td>37257,9</td>
<td>45,03</td>
<td>3074,4</td>
<td>16,31</td>
<td>33374,5</td>
<td>10855,6</td>
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<td>1999</td>
<td>55479,4</td>
<td>48,91</td>
<td>4527,1</td>
<td>47,25</td>
<td>49432,0</td>
<td>10855,4</td>
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<td>2000</td>
<td>81275,3</td>
<td>46,50</td>
<td>6752,6</td>
<td>49,16</td>
<td>73027,1</td>
<td>10771,6</td>
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<td>2001</td>
<td>118327,2</td>
<td>45,59</td>
<td>9957,5</td>
<td>47,46</td>
<td>106501,4</td>
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<td>2002</td>
<td>152630,0</td>
<td>28,99</td>
<td>14301,6</td>
<td>43,63</td>
<td>137535,3</td>
<td>9573,9</td>
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<td>2003</td>
<td>198761,1</td>
<td>30,22</td>
<td>18354,6</td>
<td>28,34</td>
<td>176974,4</td>
<td>9569,3</td>
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<td>2004</td>
<td>248747,6</td>
<td>25,15</td>
<td>23477,4</td>
<td>27,91</td>
<td>222310,9</td>
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<td>2005</td>
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<td>16,78</td>
<td>27541,5</td>
<td>17,31</td>
<td>256766,9</td>
<td>9267,2</td>
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<td>2006</td>
<td>347004,3</td>
<td>19,46</td>
<td>32609,5</td>
<td>18,40</td>
<td>306623,5</td>
<td>9330,7</td>
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<td>2007</td>
<td>418257,9</td>
<td>20,53</td>
<td>39334,1</td>
<td>20,62</td>
<td>369789,2</td>
<td>9364,8</td>
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<td>2008</td>
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<td>25,37</td>
<td>48058,0</td>
<td>24,47</td>
<td>467122,2</td>
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<td>2009</td>
<td>510522,8</td>
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<td>49120,9</td>
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<td>459926,1</td>
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<td>4,58</td>
<td>52099,5</td>
<td>6,06</td>
<td>477028,6</td>
<td>9156,1</td>
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<tr>
<td>2011</td>
<td>565997,2</td>
<td>5,85</td>
<td>54593,8</td>
<td>4,79</td>
<td>495832,2</td>
<td>9082,2</td>
</tr>
<tr>
<td>2012</td>
<td>595367,3</td>
<td>5,36</td>
<td>60413,9</td>
<td>10,66</td>
<td>522296,1</td>
<td>8645,3</td>
</tr>
<tr>
<td>2013</td>
<td>632455,6</td>
<td>7,07</td>
<td>65512,6</td>
<td>6,44</td>
<td>561403,6</td>
<td>8569,4</td>
</tr>
<tr>
<td>2014</td>
<td>668143,6</td>
<td>4,81</td>
<td>68469,4</td>
<td>4,51</td>
<td>591206,5</td>
<td>8634,6</td>
</tr>
<tr>
<td>2015</td>
<td>712832,3</td>
<td>6,69</td>
<td>73330,9</td>
<td>7,10</td>
<td>625879,4</td>
<td>8535,0</td>
</tr>
</tbody>
</table>

Source: http://statistici.insse.ro
GDP evolution from 1995 to 2015

Analysing the data from the table above, we can notice that, since 1999 and up to 2008, the total amount of GDP increased continuously. Thus, GDP’s biggest growth over the previous year was in 1997, when the GDP increased by 124.09% compared to 1996.

The economic crisis that erupted in 2008 exerted a direct influence over the GDP, which is why in 2009 the GDP has decreased by 2.64% compared to 2008. This is the only decrease in GDP recorded in the last 20 years.

Labour productivity evolution from 1995 to 2015

Regarding labour productivity expressed as the ratio between the gross added value and the occupied population, we can notice that, from 1991 to 2015, the labour productivity recorded successive increases. The rhythm of these increases, in relation with the previous year, was alert from 1995 to 2008 (e.g.: 47.25% in 1999 compared to 1998, 43.63% in 2002 compared to 2001) and slower from 2009 to 2015 (e.g.: 4.79% in 2011 compared to 2010, 7.10% in 2015 compared to 2014).

Similar to the GDP evolution previously described, in 1997, labour productivity increased by 128.74% compared to 1996 and this amount was the biggest amount recorded in the last 20 years.

Correlation analysis between GDP and labour productivity from 1995 to 2015

By using the production method, it can be stated that the GDP represents the summation of gross added value and product taxes, with the removal of the subsidies on products.

Considering the series of data published by the National Institute of Statistics and used in the graphic above, we find that the main element which causes GDP’s evolution is the gross added value, which has a share in the GDP above 80%.

Taking into account the individual analysis previously expressed regarding the two indicators, we appreciate that, from 1995 to 2008 and from 2009 to 2015, both GDP and labour productivity have increased successively, the annual growth’s index amount reported to previous years being comparable.

As we have shown above, in 2009, the GDP decreased by 2.64% compared to 2008, but the labour productivity per occupied population increased by 0.33%, which can be explained following the gross added value and occupied population evolution for the time horizon under discussion.

Thus, in 2009, both gross added value and occupied population level decreased by 1.5% and 1.3%. Given the fact that the decrease rhythm of occupied population level was slower than the decrease of gross added value, the labour productivity per occupied person increased in 2009 compared to 2008, but the GDP decreased. Reversed evolution can be observed in the graphic below:
To outline the correlation between the two macroeconomic variables, we consider, at first, the statistical analysis of the corresponding data series. We have applied the instruments of a dedicated analysis software, and the analysis of the GDP series (identified as PIB) revealed the following:

![GDP Series Analysis](chart1.png)

The lowest value was 7656, recorded in 1995. The highest value was measured in 2015, and the average value for the series is 320987.

![Productivity of Labor](chart2.png)

The productivity of labor is characterized by the following statistical measures: minimum value, 760,2 (in 1995), maximum of 73330,9, recorded in 2015, a mean of 31285.16.

Next, we represented the two measures in a single chart, for an overview of the potential correlation between their datasets.
The joint graphical representation allows us to state that there is a visible correlation between the variables, and the estimation of an equation is likely to lead to favorable results. Therefore, by capitalizing the least squares method, we reached the following:

Dependent Variable: PIB
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 11/15/16  Time: 17:43
Sample: 1995 2015
Included observations: 21
PIB=C(1)+C(2)*WM

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C(1)</td>
<td>13426.00</td>
<td>5098.30</td>
<td>2.633377</td>
<td>0.0164</td>
</tr>
<tr>
<td>C(2)</td>
<td>0.830802</td>
<td>0.128308</td>
<td>76.61924</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

R-squared: 0.996774
Adjusted R-squared: 0.996604
S.E. of regression: 14404.36
Sum squared resid: 3.94E+09
Log likelihood: -229.8278
F-statistic: 5870.509
Prob(F-statistic): 0.000000

The econometric model can be written under the following form:

GDP = 13426 + 9.830892 * WM

The meaning of the model is that, for a unit increase of the productivity, the Gross Domestic Product shall grow by more than 9.83 units.
Also, it is to be noted the high value of the free term, which is an incentive for further analyses, that are to exploit additional factors and reveal their influence.

The tests show that the model is reliable enough to be used in future studies. The values of R-squared and adjusted R-squared are close to unit.

The next analysis is based on the correlation between the indices of the two measures, GDP and productivity. We have followed the same methodology, and first we have represented the statistical tests for each variable.

The GDP index (IPIB) varied between a negative minimum of -2.64 and a maximum of 124.09.

The productivity index (IWM) has a mean of 26.83, for a minimum of 0 and a maximum of 128.74.

The graphical representation of the correlation reveals the similar trends of the two indices.
The estimation of the parameters, based on the LSM, led to the following results:

![Graph showing IPIB and IWM]

The model can be written as:

$$IPIB = 1.260734 + 0.943362 \times IWM.$$  

The statistical tests of the model, even if their values are lower than the levels recorded for the previous model, are still above 0.92, thus conferring reliability to the model.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C(1)</td>
<td>1.250734</td>
<td>2.287987</td>
<td>0.555087</td>
</tr>
<tr>
<td>C(2)</td>
<td>0.943362</td>
<td>0.058181</td>
<td>15.21420</td>
</tr>
</tbody>
</table>

The model can be written as:

$$IPIB = 1.260734 + 0.943362 \times IWM.$$
Conclusions

From 2009 to 2015, the GDP continued to increase, but the annual growth index over the previous year remains quite low compared to the annual growth index over previous year for the 1995-2008 period.

The analysis by econometric models outlined the correlation between the Gross Domestic Product and the productivity, both as measures and as indices, the statistical tests of the models have values close to 1. The models are, therefore, suited for further analyses.

However, in the case of the correlation between the measures, the value of the free term outlines the need for further research, that is to explain the influence on the main indicators by additional factors.

References