ABSTRACT

This paper focuses on various statistical methods to analyze the impact of formal education on the macroeconomic development in Romania and in other EU member states. Generally speaking, the research reveals two trends which are driven, on the one hand, by the need for increased investments in education that generates further benefits and revenue on the long time and contributes to social development, too, and, on the other hand, by the need for quality education, since knowledge plays a key role in the modern society, leading to growth and prosperity.

The study begins with the presentation of international developments and challenges in today’s world, especially in the education sector. In order to analyze the relationship between the economic and the educational indicators provided by EUROSTAT and to focus on developments in certain countries, we used data for 28 countries, i.e. 27 EU member states and the EU average, during 2001-2015. The study uses two statistical methods, i.e. the exploratory method (Principal Components Analysis) and the inferential method (multiple regression). Performing PCA, we came to the conclusion that gross domestic product is strongly influenced by total public expenditure on education and employment rates of tertiary graduates.

Keywords: formal education, economic growth, exploratory statistical method, inferential method, Principal Components Analysis

JEL Classification: C38, O15, O47

1. INTRODUCTION

Given the international context in today’s world, i.e. the second decade of the 21st century, the following relevant assumptions can be issued:

1. The economic cycle is defined by recurrent crises and growth, which often has a dramatic effect on national living standards.
2. Political uncertainty has deepened, posing a major challenge. Thus, in the past few years, the conflicts in the Middle East have intensified, and the negative impact of the “Arab Spring” phenomenon has been felt. Radicalism has grown in the Islamic world, triggering immediate consequences, such as increasing terrorism in the world, wartime migration and economic migration as well.
3. As a result, the European Union has witnessed the rise of populism, while radical, anti-democratic and anti-European movements seem to be ready to take power.

4. Countries that have recently joined the European Union, following the fall of Communism, are facing complex challenges, which have revealed that democracy and prosperity could hardly be achieved unless sustained efforts are undertaken on the long term, implying a change both in mental patterns and in attitude, despite the structural reforms implemented across Europe.

This short overview refers to key issues and complex challenges we face in today’s world. As a result, adequate solutions should be identified to cope with such challenges.

The strategies adopted by the European Union in the 21st century contain major guidelines which could offer us a solution, namely providing universal access to education and equal opportunities, in order to ensure sustainable development worldwide, reduce inequality and poverty, and spread knowledge.

Reliable surveys drafted by OECD (“Education at a Glance”, 2011) show that the net public return on an investment in tertiary education is 91,036 dollars per year, not to mention the new jobs created and the economic development fueled by innovation.

On the other hand, dramatic figures reflect low education levels: high school dropout rates, the lack of skilled workforce, including low literacy rates, i.e. 20% of the European workforce, and poor access to technology, i.e. 25% (“Education for economic growth and inclusion”, European Council).

The need to improve education is a must, not just a luxury or a caprice, since it is essential for achieving economic growth and social inclusion, promoting a healthy state and the active involvement of civil society in the decision-making process, reducing crime and violence, and last, but not least, increasing life expectancy rates.

In addition, the constant increase in the number of higher education graduates that could identify adequate solutions in today’s changing world sets up the basis for solving key issues and brings about social equity.

In the past 15 years, the meetings of EU ministers of education focused on efforts to draft a comprehensive reform strategy, to be implemented by member states, the European officials repeatedly stressing the need to ensure a significant amount of funding to states for education in order to reduce school dropout rates, improve the quality of education, and develop skilled workforce. This would also help decrease poverty and reduce social exclusion.
Recent research reveals two dominant trends: on the one hand, investments in education have increased since the beginning of the century, and, on the other hand, despite this positive development, which has varied across Europe, there is room for further improvement. Although geographic criteria is irrelevant, small North and South European countries top the list of states by spending on education (% of GDP), as follows: Ireland – 7.9%, Denmark – 7.8%, and Cyprus – 7.2%. Central, South-East and South European countries ranked the lowest in terms of education expenditure, i.e. Slovakia – 4.1%, Greece and Romania – 4.4%, each, and Bulgaria – 3.6%.

We all know very well the situation in our country, that’s why I’ll only mention that, despite gradual annual increase, spending on education has failed to reach the 6% target set in the 1995 Education Law.

Europe 2020 strategy elaborated by Brussels show that sustained efforts have been undertaken to improve the situation in this sector. The document defines top priorities and goals in the field of education and training, for the next decade (2011-2020). A halfway report on the implementation of the Strategic framework for European cooperation in education and training was drafted in 2015 to assess the progress achieved and set new priorities in 6 key areas, namely: the quality of learning outcomes to be stimulated in a lifetime perspective, fostering inclusion and equality, developing digital skills, providing support to trainers, ensuring validation and recognition of skills and qualifications, as well as effective investment in quality education and training.

At the same time, the European Commission has recently submitted its Annual Growth Survey 2016 to the Council, kicking-off the 2016 European Semester. The document sets out the economic and social policy priorities and urges EU countries to re-launch investment and focus on innovation, increase competitiveness and reduce unemployment (“Education for Economic Growth and Inclusion”, European Council).

In 2015, the European Council adopted new guidelines to reduce school dropout rates, inviting member states and the European Commission to increase funding to that end. In addition, amid the flow of migrants to Europe, in the summer of 2015, the Council shifted attention to key issues, such as language learning by migrants and their families, migration skills assessment, as well as quality education and training to ensure diversity in schools.

2. LITERATURE REVIEW

The standard method of estimating the effect of education on economic growth is to estimate cross-country growth regressions where average annual growth in GDP per capita over several decades is expressed as a function
of measures of schooling and a set of other variables deemed important for economic growth.

Regarding literature review, one of the promoters of the role of education in economics is Robert Barro. Following the classical contributions by (Barro, 1991) and (Barro, 1996) a vast early literature of cross-country growth regressions tended to find a significant positive association between quantitative measures of schooling and economic growth. In another work of (Barro, 1999) the schooling quality influence, using test scores, over economic growth, is measured.

The study (Hanushek and Kimko, 2000) concludes that the results in mathematics and science, in 31 countries, are strongly correlated with indicators of economic growth.

In (Sala-i-Martin et al, 2004) primary schooling turns out to be the most robust influence factor on growth in GDP per capita in 1960-1996 in the extensive robustness analysis of 67 explanatory variables in growth regressions on a sample of 88 countries.

(Khattak and Khan, 2012) investigates the contribution of education on economic growth in Pakistan. To this end, the author used as Ordinary Least Squares estimation techniques and Johansen Cointegration test. The study shows that elementary as well secondary education contributes to real GDP per capita in Pakistan.

In (Ciucu and Dragoescu, 2014) the influence of primary, secondary and tertiary education over the GDP growth was analyzed for Bulgaria, Czech Republic and the Netherlands, using regression models.

3. METHODOLOGY

The specific, educational indicators used in this paper are the predictors, i.e.:

1) School expectancy – SE
2) Total public expenditure on education- PEE
3) At least upper secondary educational attainment, age group 20-24 years - % - USEA
4) Tertiary educational attainment, age group 30-34 years- TEA
5) Employment rates of recent graduates - % - ERRG
6) Employment by educational attainment level, annual data, age class-15-64 years, tertiary education - EEAL
7) Population by educational attainment level, sex and age - % - PEAL

The broadest indicator of economic output and growth is the Gross Domestic Product or GDP, expressed in million of Euros, which represents the
dependent variable.

To illustrate the impact of education on the long term, the relationship between variables is considered as asynchronous (for example, there is a 4-year gap between GDP and PEE). To analyze the impact of education, statistical data provided by EUROSTAT are processed by STATISTICA software, following logarithmic transformations.

In order to analyze the relationship between the economic and educational indicators in EU member states, I resorted to an exploratory, multidimensional scaling method, i.e. Principal Components Analysis or PCA. The study uses also a statistical method, i.e. the inferential method, multiple regression estimation.

As you know, in multiple regression, main source in $\beta$-coefficient is represented by the redundancy of the predictors. In statistical analysis, it is revealed by the strong correlation between explanatory variables. Regression coefficients get affected by the strong correlation between the predictors, i.e. the estimation $E_y$ will be achieved with significant errors, although $R^2$ is close to 1. Ridge regression helps us get stable and accurate coefficients, as it follows,

$$b(k) = (X'X + kI)^{-1}X'y$$

where $k$ is a positive constant to be determined.

4. EMPIRICAL RESEARCH AND COMMENTS

In order to analyze the relationship between economic and educational indicators as well as the developments and trends in countries by average growth, I report a study of 11 groups of 28 individuals, i.e. 27 EU member states and, respectively, the EU average. The cases used in analysis are assigned values recorded during 2001-2011 (actually, the period analyzed is 2001-2015, showing a 4-year gap between values), i.e. 2464 log-transformations are applied for further PCA analysis.

We use:
- active variables (which participate to the construction of the factorial axes): SEA; PEE; USEA; TEA; ERRG; EEAL; PEAL;
- supplementary variable (which does not participate to the construction of the factorial axes but is used for cross-validation): GDP;
- The countries were grouped, according to the year, into active and supplementary cases.

Active cases are the EU countries with values assigned to variables in 2001 - the starting year for this study. The rest of the cases covered for further observation and analysis until 2015, as compared to 2001, are supplementary cases.
The situation in EU member states in 2001

To get the dimension of the projective space and where the relationship between variables will be more easier to observe, we can examine the Eigenvalues, resulting from the diagonalized correlation matrix of the active variables (Table 2.1).

Eigenvalues of the correlation matrix of the active variables play an important role in computing the principal components. In the eigenvalues table, the first two dimensions offer a quality of representation, in the new space, of 68.04%. Thus, the projection will be the factor plane (the subspace of 2 dimensions which we are looking for is spanned by the first 2 eigenvectors of the matrix A associated with the largest eigenvalues) and 68.04% of cumulative variance (explained) can be attributed to the number of factors.

### Eigenvalues of correlation matrix

Table 2.1

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>% Total - variance</th>
<th>Cumulative - Eigenvalue</th>
<th>Cumulative - %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.848527</td>
<td>40.69324</td>
<td>40.6932</td>
</tr>
<tr>
<td>2</td>
<td>1.914830</td>
<td>27.35472</td>
<td>68.0480</td>
</tr>
<tr>
<td>3</td>
<td>1.247682</td>
<td>17.82403</td>
<td>85.8720</td>
</tr>
<tr>
<td>4</td>
<td>0.530896</td>
<td>7.58423</td>
<td>93.4562</td>
</tr>
<tr>
<td>5</td>
<td>0.372439</td>
<td>5.32056</td>
<td>98.7768</td>
</tr>
<tr>
<td>6</td>
<td>0.064669</td>
<td>0.92384</td>
<td>99.7006</td>
</tr>
<tr>
<td>7</td>
<td>0.020956</td>
<td>0.29937</td>
<td>100.0000</td>
</tr>
</tbody>
</table>

Data source: EUROSTAT database, processed by author with Statistica software

According to the methodology used in this study, the role of PCA is to illustrate the relationship between variables (economic and educational indicators), groups of individuals (countries) and corresponding developments. As a result, we analyze Table 2.2, which shows the factor coordinates referred to as “factor loadings”. This further implies that the factor coordinates of a variable are the correlations between the variable and the factor axes. There is a strong negative correlation between the first factor and PEE and EEAL variables, i.e. the first factor is a linear combination of these two variables that are most correlated with it. Similar, the second is a linear combination between TEA and PEAL variables.
Factor-variable correlations

Table 2.2.

Factor-variable correlations (factor loadings)
Active and Supplementary variables *Supplementary variable Include condition: Cod_1=1

<table>
<thead>
<tr>
<th></th>
<th>Factor 1</th>
<th>Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>-0.800131</td>
<td>-0.099922</td>
</tr>
<tr>
<td>PEE</td>
<td>-0.737424</td>
<td>-0.597408</td>
</tr>
<tr>
<td>USEA</td>
<td>-0.159949</td>
<td>0.023473</td>
</tr>
<tr>
<td>TEA</td>
<td>-0.713525</td>
<td>0.609765</td>
</tr>
<tr>
<td>ERRG</td>
<td>-0.155623</td>
<td>0.659506</td>
</tr>
<tr>
<td>EEAL</td>
<td>-0.734255</td>
<td>-0.629764</td>
</tr>
<tr>
<td>PEAL</td>
<td>-0.752644</td>
<td>0.586524</td>
</tr>
<tr>
<td>*GDP</td>
<td>-0.742212</td>
<td>-0.528789</td>
</tr>
</tbody>
</table>

Data source: EUROSTAT database, processed by author with Statistica software

Projection of the variables on the factor plane

Graph 2.1

The variable representation onto factor plane is made in Graph 2.1. According to the neighborhoods system between the two variables, the strongly correlated variables are very close to each other and determine, essentially, two factors. Approaching GDP by PEE and EEAL suggests that GDP is strongly influenced by PEE and EEAL, so we resort to multiple regression.
Projection of the cases on the factor plane. Cases with sum of cosine square>=0.5

For the quality of representation, Graph 2.2 shows the dynamics of the EU member states or individuals which, in 2001, formed an angle that was less than 45 degrees on the factor plane (i.e. cosine square is greater than 0.5), namely: Romania, Hungary, Slovakia, Italy, Poland, Germany, France, Great Britain, Sweden, Belgium, Netherlands, Denmark, Ireland, Lithuania, Cyprus, Latvia, Malta, and Luxembourg.

The graph 2.2. shows that countries in the second and third quadrants have the highest GDP, PEE, EEAL, TEA, and PEAL values, i.e. countries with high quality education, such as Denmark, Sweden, Netherlands, Belgium, and Great Britain. Countries in the first and fourth quadrants, such as Romania, Bulgaria Slovakia, Hungary, Greece, Cyprus or Malta, ranked low.

Data source: EUROSTAT database, graphical representation by author
Dynamics of EU member states during 2001-2015

Graph 2.3 illustrates a special case, i.e. the projection of a few EU member states observed during 2001-2015 and active variables in 2001, which form an angle that is less than 45 degrees on the factor plane.

**Projection of the cases on the factor plane**

![Graph 2.3](image)

Data source: EUROSTAT database, graphical representation by author

One can easily notice that countries in the second and third quadrants have the highest PEE, EEAL, PEA and TEA values, namely the EU, Great Britain, Sweden, Germany, and France. Although it is placed on the third quadrant, Italy is an outlier, and therefore, its position should be explained. To perform a comprehensive analysis and a better visibility of individuals clouds, I will focus on the situation in EU member states with opposite GDP, and, respectively, educational values. As a result, I will perform a separate analysis for each case, including, of course, Romania, and its neighbors Hungary and Bulgaria.

Given the current international context, European resources and work force strongly depend on political stability and the ability to identify...
solutions to cope with challenges in today’s world, i.e. Brexit, terrorism, and widespread conflicts. One thing is clear: there are major gaps between industrialized, Western countries, and the former Communist states located in Eastern Europe. As for Romania, our country should strongly promote its Western orientation, i.e. strengthen cooperation with EU member states and increase its role in ensuring security and peace at the international and the European levels.

The EU
Graph 2.4 shows that the European Union faced an upward trend during 2001-2015, see the third quadrant, with the highest PEE and EEAL values. We can draw two conclusions: the direction of GDP growth, by increasing total public expenditure on education and the employment by tertiary education, is indicated by the major economic powers of the continent. Although the EU member states have been trying to follow this example, despite their efforts, the gap still remains and will most likely remain on the short term.

**Projection of the European Union, during 2001-2015, on the factor plane**

*Graph 2.4*

---

*Data source: EUROSTAT database, graphical representation by author*
Italy

Italy, is an outlier, since despite its low PEE as a proportion of GDP and a high tertiary education leavers rate, as well as its difficulties in entering the labour market for highly-skilled people, which confirm the conclusion drawn by EC in its report on *Education and training 2015*, it is nevertheless placed on the third quadrant. However, following the recent withdrawal of Great Britain from the EU, Italy will most likely become the third economic power in Europe, as recent negotiations aimed at reshaping the EU, carried out after Brexit by the German Chancellor, the French President, and Italian Prime Minister, do show.

**Projection of Italy during 2001- 2015, on the factor plane**

*Graph 2.5.*

Data source: EUROSTAT database, graphical representation by author

Hungary and Bulgaria

Although our neighbors, Bulgaria and Hungary, have a parallel trajectory following the EU model, Hungary has higher PEE and EEAL as compared to Bulgaria. While in Bulgaria stands a little relevance of tertiary education to the labor market and low levels of PEE, in Hungary, higher technical education recorded numerous leavers and PEE remains at one of the lowest levels in the EU. Nevertheless, Hungary experiences high school
dropout rates, and its spending on education is among the lowest in the EU. This finding confirms the conclusion drawn by EC in its report on Education and training 2015.

Projection of Hungary and Bulgaria, during 2001-2015, on the factor plane

Graph 2.6

Data source: EUROSTAT database, graphical representation by author

Sweden, Great Britain, France and Germany

Graph 2.7 shows the projection of Germany and Sweden, which have quite a parallel trajectory, being placed in the second and third quadrants. Although it has high PEE, France stagnates and faces major challenges, i.e. migrants from the former French colonies. As for Great Britain, the graph shows a major decline in PEE, which explains the discontent of the British at the work force migration within the EU that has led to Brexit. Germany is the only European power which ranks highest.
Projection of Sweden, Great Britain, France and Germany, during 2001-2015, on the factor plane

Graph 2.7

Data source: EUROSTAT database, graphical representation by author

Romania

Graph 2.8 shows Romania has a pronounced convergence trajectory to the origin of axes (the centroid of data cloud) during 2001 until 2004, and, respectively, to approach the countries with average values during 2005-2009, and, subsequently, to growing faster and evolve on a parallel trajectory. Romania has high TEA, EEAL and PEE, which have triggered GDP growth. The upward trend is experienced by European powers, such as Germany, France, and Great Britain.
Projection of Romania, during 2001-2015, on the factor plane

Graph 2.8.

Data source: EUROSTAT database, graphical representation by author

Correlations

Table 2.3

Correlations (Date UE) Marked correlations are significant at \( p < .05 \)

<table>
<thead>
<tr>
<th></th>
<th>GDP</th>
<th>SE</th>
<th>PEE</th>
<th>USEA</th>
<th>TEA</th>
<th>ERRG</th>
<th>EEAL</th>
<th>PEAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>1.00</td>
<td>0.33</td>
<td>0.99</td>
<td>-0.18</td>
<td>0.12</td>
<td>-0.08</td>
<td>0.94</td>
<td>0.14</td>
</tr>
<tr>
<td>SE</td>
<td>0.33</td>
<td>1.00</td>
<td>0.38</td>
<td>0.02</td>
<td>0.35</td>
<td>-0.01</td>
<td>0.38</td>
<td>0.34</td>
</tr>
<tr>
<td>PEE</td>
<td>0.99</td>
<td>0.38</td>
<td>1.00</td>
<td>-0.15</td>
<td>0.13</td>
<td>-0.12</td>
<td>0.96</td>
<td>0.14</td>
</tr>
<tr>
<td>USEA</td>
<td>-0.18</td>
<td>0.02</td>
<td>-0.15</td>
<td>1.00</td>
<td>0.09</td>
<td>-0.15</td>
<td>-0.08</td>
<td>0.12</td>
</tr>
<tr>
<td>TEA</td>
<td>0.12</td>
<td>0.35</td>
<td>0.13</td>
<td>0.09</td>
<td>1.00</td>
<td>0.11</td>
<td>0.14</td>
<td>0.95</td>
</tr>
<tr>
<td>ERRG</td>
<td>-0.08</td>
<td>-0.01</td>
<td>-0.12</td>
<td>-0.15</td>
<td>0.11</td>
<td>1.00</td>
<td>-0.19</td>
<td>0.12</td>
</tr>
<tr>
<td>EEAL</td>
<td>0.94</td>
<td>0.38</td>
<td>0.96</td>
<td>-0.08</td>
<td>0.14</td>
<td>-0.19</td>
<td>1.00</td>
<td>0.17</td>
</tr>
<tr>
<td>PEAL</td>
<td>0.14</td>
<td>0.34</td>
<td>0.14</td>
<td>0.12</td>
<td>0.95</td>
<td>0.12</td>
<td>0.17</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Data source: EUROSTAT database, processed by author with Statistica software
Correlations between variables, histograms, scatterplots

Graph 2.9.

PCA clearly shows that GDP is influenced by education expenditure and EEAL.

The same offers us, the figure 2.9, where on one hand we see, from examining the histograms, that the normality or close to it have only variables PEE, EEAL and GDP. On the other hand, considering the variable GDP on OY and PEE respectively EEAL, on OX is noted that these are the only Scatterplots showing a linear regression.

Regression analysis can be performed based on the above-mentioned conclusions, i.e. calculating regression coefficients and defining the quality of the model.

Thus, we get the standardized Ridge regression equation:

\[
\ln(GDP) = 0.646684 \ln(PEE) + 0.288343 \ln(EEAL) 
\] (2.9)
To see how independent variables contribute to the GDP prediction we analyze the following non-standardized or standardized coefficients:

**Ridge regression summary**

*Table 2.4*

<table>
<thead>
<tr>
<th>Beta</th>
<th>Std.Err. - of Beta</th>
<th>B</th>
<th>Std.Err. - of B</th>
<th>t(271)</th>
<th>p-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercep</td>
<td></td>
<td>3.427957</td>
<td>0.173833</td>
<td>19.71986</td>
<td>0.000000</td>
</tr>
<tr>
<td>PEE</td>
<td>0.646684</td>
<td>0.035710</td>
<td>0.696523</td>
<td>0.038462</td>
<td>18.10923</td>
</tr>
<tr>
<td>EEAL</td>
<td>0.288343</td>
<td>0.035710</td>
<td>0.329859</td>
<td>0.040852</td>
<td>8.07452</td>
</tr>
</tbody>
</table>

Data source: EUROSTAT database, processed by author with Statistica software

**Adjusted quality indicators**

*Table 2.5*

| Summary Statistics; DV: GDP (Date UE) Exclude condition: Cod > 100 |
|----------------------|------------------|
| Value                |
| Multiple R           | 0.954            |
| Multiple R²          | 0.910            |
| Adjusted R²          | 0.909            |
| F(2,271)             | 1364.255         |
| p                    | 0.000            |
| Std.Err. of Estimate | 0.508            |

Data source: EUROSTAT database, processed by author with Statistica software

High R squared value (0.95) – where R is the coefficient of multiple correlation, shows the strong correlation between PEE and GDP, on the one hand, and EEAL and GDP on the other hand, i.e. they have a strong influence on GDP. Multiple shows that PEE and EEAL influence economic growth, i.e. 91%, and the rest of 9% - other factors. Thus, we can further elaborate and predict GDP values.

**5. CONCLUSIONS**

To perform a comprehensive analysis, I took into consideration an exploratory approach, i.e. factor analysis, that is viewed as a data-reduction technique as it reduces the number of selected educational indicators which are strongly correlated, in order to conduct multiple regression. The exploratory analysis and inferential statistical methods used in this study have shown us that GDP is strongly influenced by education expenditure and EEAL, and that is one of the main conclusions of my research.
Also, the review on the dynamics of the EU member states during 2001-2015 has led to clear findings shortly presented below. Despite major gaps within the EU, European countries face the same challenges and have to cope with them in order to ensure prosperity and comply with democratic standards. It seems that there is only one solution, i.e. to perform an accurate assessment of the situation, apply coherent reforms, and strengthen cooperation, based on mutual benefits.

Romania should increase its role within the EU, and capitalize upon its resources, encouraging sustainable development, improving its situation, and reducing its vulnerabilities. To that end, a key role is played by quality education and training in order to assert traditional values and make our dream come true.

Acknowledgement

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21. *** EUROSTAT database

22. *** Statistica software