# THE CIRCULAR ECONOMY MODEL. CASE OF ROMANIA

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**ABSTRACT**

*Based on the findings of the economic studies on the implications of industrialization in case of the growing economies, the article aims at presenting the economic factors which are at the basis of the development of circular economy. Particularly, the descriptive analysis of these factors outlines a concrete picture of the current circular economy in Romania. Starting with the model of economic growth based on productivity, human capital and circular economy, three statistical hypotheses were validated through a multi-linear regression model analyzed by the Ordinary Least Square (OLS) method with the use of statistical software SPSS 22. The paper highlights that circular economy model is determined by the degree of innovation and labor employed in environmental protection. Investing in innovative assets for the creation of waste collection and recycling infrastructure is essential in the descriptive model presented.*

**KEYWORDS:** *circular economy, ecosystem, environmental program, general equilibrium model, industrialization, regression analysis.*

## 1. INTRODUCTION

We may pay attention to the spectacular evolution in the technical field, which actually translated Jules Verne's novels, which seemed utopian a century ago to the amusement and curiosity of millions of adolescents all over the world.

The Romanian economy, mainly linear, will have to be redefined by consecrating the regenerative model of the circular economy. Added value for the economy is evident through the reintroduction of recycled resources in the production chain. From the perspective of the human factor, the benefits can be quantified by increasing the quality of life, if we are to summarize some examples of green energy or a clean, non-polluting environment. The repair service sector to extend product life is another example of positive externalities generated by the application of the circular economy model to the labor market. In order to achieve these goals, the educational factor is essential for a better knowledge and implementation of the legislation in the field by the business community and civil society as a whole.

Areas of policy action of European Union (EU) in terms of circular economy were identified in the Action Plan launched by the European Commission in 2015, at the time of the adoption of certain proposals of directives on waste, packaging, electrical, electronics and landfills. The legislative package was sent to the European Parliament and the Council of the EU for debate on articles, and after approval, the European directives will be transposed into national law. The EU Forum aims at ambitious targets for the next period in the desire to set minimum quality criteria for recycled materials to be brought back into production. Legislative measures also refer to modifying current fertilizer regulations to encourage the use of organic nutrients with a significant beneficial contribution to the environment and food safety. In the field of wastewater filtration, the European Commission's legislative proposal concerns water reuse. Among the priority areas for innovation,

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set out in the Commission's action plan, attention is drawn to industrial symbiosis and innovative industrial processes. All these legislative measures are aimed at achieving the environmental objectives for the development of circular economies. The Action Plan and the adopted legislative package, once implemented, will contribute to improving the lifestyle and, implicitly, the development of the European Union economy.

Specifically, the European Commission (EU, 2012) supports these initiatives and encourage actions towards meeting these targets, supporting them by means of the European funding programs, achieving the specific objective of the circular economy development. In response to the challenges faced by the governments of the EU Member States, the European Commission provided financial support exceeding € 650 million from Horizon 2020 and € 5.5 billion from the structural funds, providing Member States with guidance for adopting measures to reduce the food waste. At the same time, the Commission will develop quality standards for the secondary raw materials in order to increase operators' confidence in the internal market.

Reports on implementation of environment policy, drafted by the European Commission for each EU Member State, represents, in our view, the mirror of every nation understanding on how to protect their citizens from the harmful effects resulting from industrial processes. The recommendations of these reports will enable national policymakers to take the necessary steps to address the issues raised.

The EU Report for Romania was communicated by the Commission in February 2017. Statistical data were extracted from those presented by Eurostat and based on a set of relevant indicators for circular economy development. According to it, the challenges for our country, in the implementation of circular economy, refers to harmonization of the national law with the EU waste management and urban waste water.

Romania is confronted with a poor rationalization of resources (Busu & Gyorgy, 2016). The efficiency of utilizing the resources, by the rate of resource productivity, was the lowest in the European Union in 2015, with 0.31 EUR / kg compared to the EU average of 2.0 EUR / kg. This is due to the very large consumption of resources, not capitalized through specific processes of reintroduction into the production circuit (e.g. sorting procedures, recycling for plastic, paper and glass packaging, repair and maintenance services to increase the shelf life of purchased home appliances etc.). The inefficient waste management in Romania is also reflected in the largest waste disposal index in the European Union (Eurostat, 2016). Therefore, statistical data reported by Eurostat indicates a poorly developed circular economy in Romania. The transposition of European law into national law is not a sufficient condition for stimulating the circular economy. Investments in waste collection and sorting infrastructure are needed. In this respect, Romanian entrepreneurs have the support measures from the cohesion policy funds. The package adopted by the European Commission in 2015 on the circular economy recommends the transition to a circular economy in which the successive use of residual raw materials reaches almost zero, based on the facilities provided by the eco-innovation funding program.

The report of the European forum notes not only the reduced rate of reusing waste in relation to GDP, but also the lack of effective utilization. This inadequate resource management may create an obstacle to achieving the environmental priority objectives for sustainable development.

We note, based on these statistical reports at national level, the need for sorting and refining waste for reuse. We also note that non-governmental organizations which work in the environmental field, are playing an essential role in stimulating innovation by convincing the policy makers in order to attract investments (Cotae, 2015). These organizations could provide constructive criticism regarding ecological environment, where, through them, would provide an interface between decision makers and end users. As exemplified for the role of these organizations, since 1999, the United Nations Organization -Geneva Network secretariat, in partnership with the Swiss Federal Office for Environment, has actively promoted environmental protection for the sustainable development.

The impact of waste management programs on economic growth was mentioned by many economists in the past decades. Ljunggren Söderman et. al. (2016) analyzed the between economic growth indicator and program management of solid waste in Sweden. Other researchers (Cleary, 2009; Sjöström & Östblom, 2009) concluded that Sweden is one of the countries with the highest level of waste re-use.

The Chinese economists (15, 16) analyzed the circular economy model in China. Indicators used by the Chinese economists could be used as a reference point for evaluating the level of development of the circular economy.

## 2. DESCRIPTIVE ANALYSIS OF ECONOMIC INDICATORS SPECIFIC FOR THE CIRCULAR ECONOMY

In contrast to the linear economy, the circular economy is an economic model that offers resources better use and value. Several economic indicators describing the circular economy and having a direct impact on economic growth were used in this study, and they were proxy variables in the regression model used in the next chapter.

Figures 1-4 give us an idea of the degree of development and use of the circular economy in Romania, compared to the other EU member states.

Thus, Figure 1 gives us an image of the recycling rate of e-products in the EU Member States at the level of 2016.

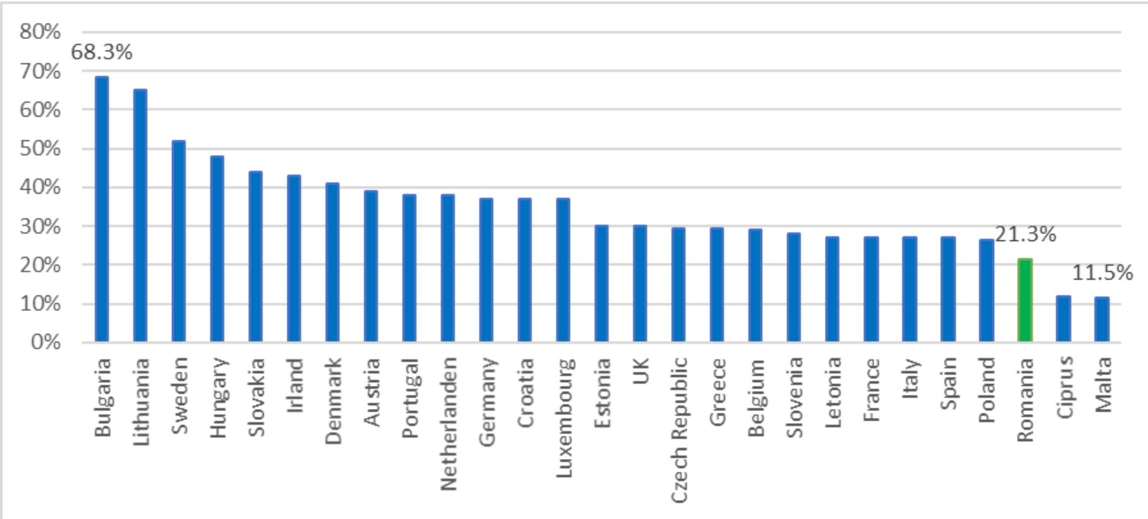


**Figure 1. Recycling rate of the electronic products**

*Source:* based on processed data provided by Eurostat, 2015

From this graph, we can see that the country with the highest recycling rate of the electronic product is even the neighboring country of Romania, Bulgaria, with 68% in the reference year 2015, according to Eurostat, and the country with the lowest recycling rate is Malta with 11.5%. At the level of 2015, Romania is one of the last places, with an electronic recycling rate of 21.3%.

Figure 2 shows us the degree of renewable energy use in the EU states at the level of 2015.

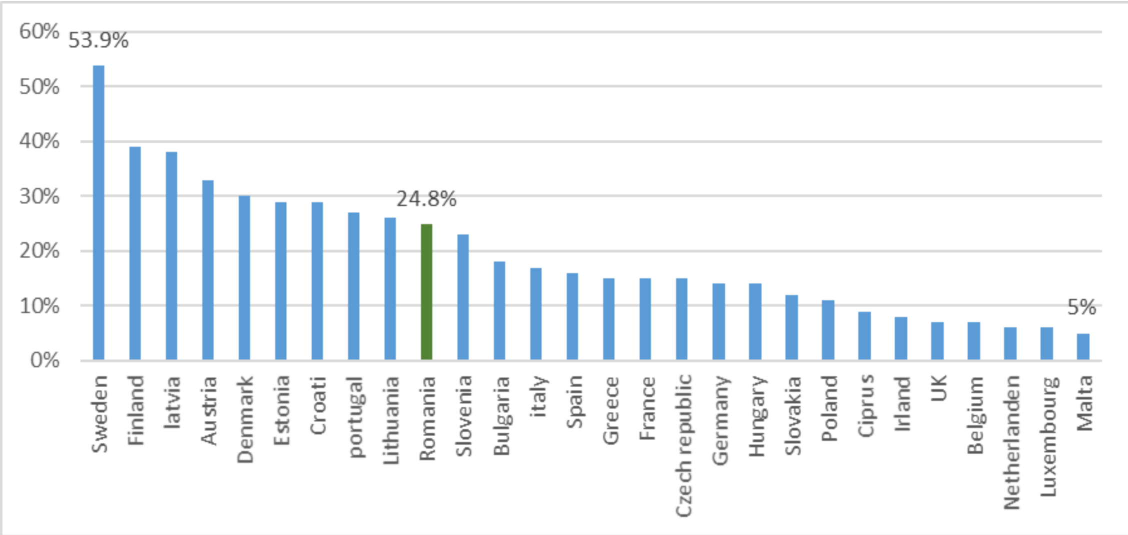


**Figure 2. Use of green energy, percentage of total energy consumption**

*Source:* based on processed data provided by Eurostat, 2015

From this graph we can see that the countries with the highest green energy use are the Nordic states, namely Sweden (53.9%), Finland (39.3%) and Latvia (37.6%) respectively. On the opposite side are the Netherlands (5.8%), Luxembourg (5%) and Malta (5%). In this ranking, calculated at the level of 2015, Romania ranks 10th out of 28 EU member states, with a 24.8% green energy use percentage. This high green energy use is largely due to massive green energy investments in early 2010, notably through the construction of wind farms in the Dobrogea area.

Figure 3 shows the share of innovative enterprises that brought new, value-added and environmental benefits to the EU Member States in the year 2015.

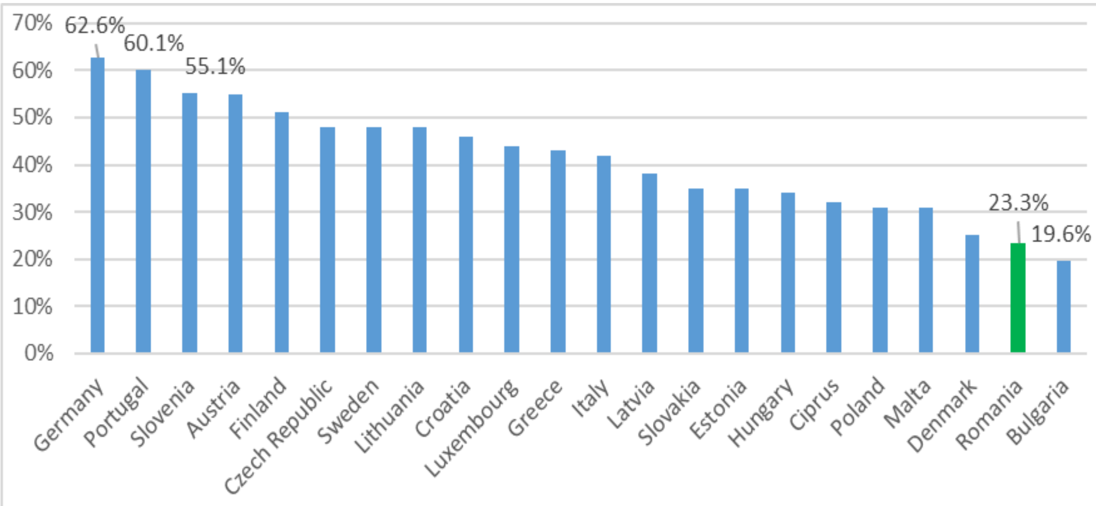


**Figure 3. The share of enterprises that have brought to market innovative new products with environmental benefits**

*Source:* based on processed data provided by Eurostat, 2015

From this graph it can be seen that, at the end of 2015, Romania was positioned on the second last level in the EU, with a share of 23.3% of companies which brought innovative new products with environmental benefits on the market, followed by Bulgaria (19.6%). Germany ranks first (62.6%), followed by Portugal (62.6%) and Slovenia (55.1%).

An important indicator of the circular economy is given by the workforce engaged in services and production of environmental goods. This indicator, at the level of the EU member states in 2015, can be seen in Figure 4.

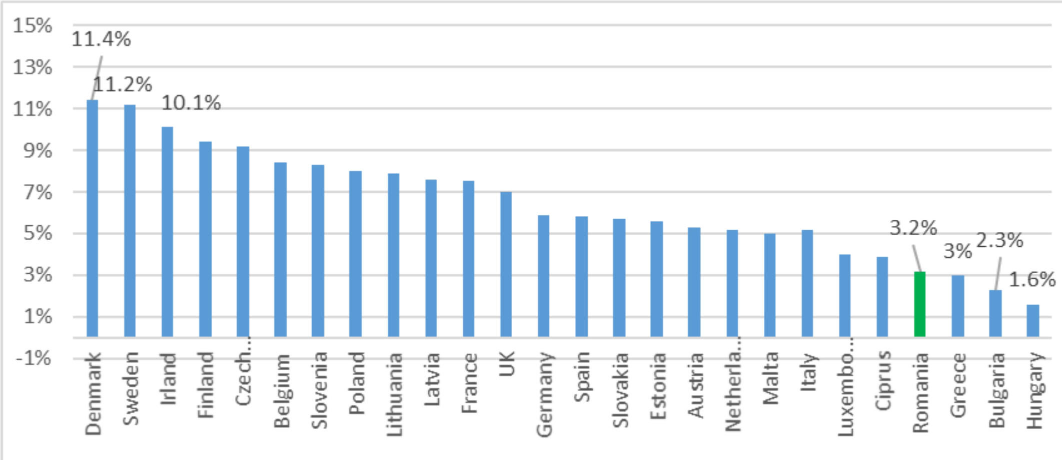


**Figure 4. The labor force employed in the service and production of goods for environmental protection**

*Source:* based on processed data provided by Eurostat, 2015

Thus, we could note that the EU countries with the highest percentage of employees in the field of services and production of environmental goods, of the total active population, are Denmark (11.4%), Sweden (11.2%) and Ireland (10.1%), while the countries with the lowest percentage of employees in this area are Bulgaria (2.3%), Hungary (1.6%) and Portugal (1.2%). In this ranking, the indicator for Romania stands at 3.2%.
Another very important indicator of the circular economy is the "resource productivity". This is defined as the ratio of a country's GDP to the domestic consumption of materials and shows us the economy's efficiency in the 28 EU Member States to use materials to produce well-being. Figure 5 shows the value of this indicator, calculated in euro/kg, at the level of EU member states.

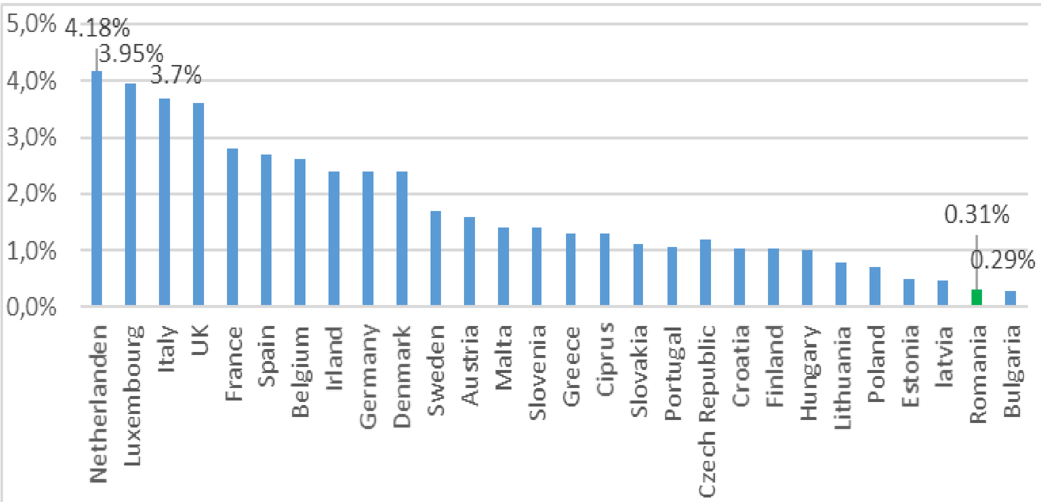


**Figure 5. Productivity of the resources**

*Source:* based on processed data provided by Eurostat, 2015

This chart shows that the most efficient EU Member State in terms of material use are the Netherlands (EUR 4.18 / kg), Luxembourg (3.95 EUR / kg) and Italy (3.69 EUR / kg), while the last places are Latvia (EUR 0.48 / kg), Romania (EUR 0.31 / kg) and Bulgaria (EUR 0.29 / kg).

In conclusion, the descriptive analysis of the circular economy indicates that Romania, although it has heavily invested in renewable energy in the last years, being in the first half of the renewable energy countries (Figure 2), it has important steps to take in terms of the circular economy through investments in infrastructure and environmental protection, increasing recycling of electronic products.

## 3. RESEARCH METHODOLOGY. QUANTITATIVE ANALYSIS OF THE MODEL

### 3.1 Estimating an economic growth model based on productivity, human capital and circular economy

At the EU level there are 28 Member States that joined the EU at different times. In our analysis we will take as a basis the year 2007, which corresponds to the accession of Romania to the European Union.

The relationship between economic growth and the circular economy has been analyzed in a number of research articles. It was demonstrated that there is a close link between the use of cyclical economy and economic growth (Geng et al., 2012; George et al., 2015). Other authors (Grossman & Krueger, 1995; Brock & Taylor, 2005; Lyasnikov et al., 2014) concluded that human capital and innovation for environmental benefits have a positive impact on economic growth.

Starting from these empirical studies mentioned above, we will focus our study on the research question: "*What is the impact of the circular economy on economic growth at the European Union level?*". In addition to what is known in this area, we will try to estimate which of the three independent factors impacting on the circular economy, namely: the work force engaged in services and production of environmental goods, the degree of use of renewable energy and share their innovative to enterprises that have brought to market new, innovative products with environmental benefits, to the dependent variable regression model. These will be the proxies used in the model.

In order to carry out this impact analysis, three statistical assumptions were formulated in Table no. 1:

**Table 1. Hypothesis of the research study**

| | |
|---|---|
| Hypothesis 1 | Countries from EU with a higher number of employees in the field of services and production of goods for environmental protection have higher economic growth. |
| Hypothesis 2 | EU Member States using more renewable energy have higher economic growth. |
| Hypothesis 3 | EU countries with a higher degree of innovation have a higher economic growth. |

*Source:* authors

To test the three statistical hypotheses mentioned above, we will build an econometric model starting with the Mankiw-Romer-Weil production function, which will be described in the next chapter.

With this function, we will create a multilinear regression model in which the dependent variable will be economic growth and the independent variables will be the number of employees in environmental protection activities, the degree of use of renewable energy and the degree of innovation used for benefits environment.

An econometric model that has economic growth as an endogenous variable should use both control variables and predictive variables as exogenous variables (Mankiw et al., 1992). The model has a simple parametric structure but can be used for a wide range of applications, on average estimation, covariance, and constraints on equation parameters. Taking into account that in 2007 the EU had 27 Member States, the statistical survey will include a panel-based analysis. Thus, the exogenous variables used in this model were divided into control variables (GDP / capita and human capital

increase in environmental activities) and in prediction variables (the number of employees involved in environmental protection activities, the degree of energy use renewable and the degree of innovation used for environmental benefits).
The regression analysis will use panel data. The results obtained by panel and sampling analysis are consistent (Cappa et. al., 2016; Gopal et. al., 2013). Thus, we can say that the sample used in the regression analysis is large enough.
In conclusion, the regression model is as follows:

$$\text{Economic growth} = \beta_0 + \beta_1 \text{ (GDP/capita)} + \beta_2 \text{ (Human Capital)} + \beta_3 \text{ (Degree of renewable energy)} + \beta_4 \text{ (Degree of environment innovation)} \quad (1)$$

in which:

- Economic growth - the dependent variable - is calculated as the percentage increase in GDP / capita;
- GDP / capita was introduced into the model to describe the convergence effect (Barro, 2013) between EU Member States
- Human capital is defined as the number of employees in environmental protection activities. This explains the economic growth due to capital increases as they are considered to be factors of production. We expect this variable to have a positive coefficient in the regression model;
- The degree of renewable energy is calculated as a percentage of the total energy use. In this case we expect the value of the coefficient in the regression model to be positive;
- The degree of innovation is calculated as a percentage of innovative enterprises that have introduced innovations for environmental benefits.

Data collected for these variables was based on EUROSTAT reporting.

### 3.2 Estimation of the results

The regression equation used to test the three statistical assumptions was accomplished using the Smallest Pattern Method. We used this method to calculate performance-based economic growth and the use of circular economy.
The overall conclusion is that the regression model is a significant one, with a value of Test F of 7.113 and an adjusted R-squared of 0.658. Additionally, the Durbin-Watson Test indicates that there are no collinearity issues between the independent variables in the model. Also, the exogenous variables are significant and explain about 70.9% of the economic growth of the 28 Member States. The positive coefficient $\beta 1$ confirms our expectations regarding the convergence between countries with low income to high-income. Capital growth per capita is, as expected, significant and positive. Coefficients of prediction variables are also significant and positive, which means that the proxies used for the circular economy have a positive and significant impact on economic growth.
The regression equation resulted from the econometric analysis, using the statistics software SPSS 22, led to the following equation:

$$Y=-2.013+1.517 X_1+1.043X_2+0.369X_3+0.420X_4 \quad (2)$$

where:

- $Y$ = economic growth
- $X_1$ = labor productivity
- $X_2$ = labor force engaged in services and production of environmental goods
- $X_3$ = use of renewable energy
- $X_4$ = the share of innovative enterprises that have brought innovative new products to the market with environmental benefits

Thus, according to the statistical analysis results, all three statistical assumptions were valid (Table 2).

**Table 2. Validation of the Statistical Hypotheses**

| Hypothesis | Validated (Yes/No) |
|---|---|
| Hypothesis 1 | Yes |
| Hypothesis 2 | Yes |
| Hypothesis 3 | Yes |

*Source:* authors

A description of the regression model can be observed in the below table.

**Table 3. Statistical description of variables in the model**

| Variable | Mean | Standard deviation | N |
|---|---|---|---|
| Y | 0.1310 | 0.02509 | 27 |
| $X_1$ | 9.8580 | 3.21432 | 27 |
| $X_2$ | 0.1481 | 0.03843 | 27 |
| $X_3$ | 0.5741 | .086762 | 27 |
| $X_4$ | 0.8889 | 0.06979 | 27 |

*Source:* Data analysis was performed by the authors harnessing SPSS 22

**3.3 Results and discussions**

In this chapter we discuss the factor analysis resulting in least squares (LSM). This method was used by the authors to calculate the performance and impact of circular economy in growth.

The relationship between economic growth and use of circular economy has received attention in recent economic literature. Simple linear regression model parameters used in this study was estimated by Ordinal Least Square (OLS), and the analysis software used was SPSS 22 software.

Analyzing the evolution economic growth in the 27 EU Member States in 2007-2015 through independent variables (GDP / capita, the number of employees in activities for environmental protection, utilization of renewable energy and the degree of innovation used for benefits to the environment), the following results were obtained through the analysis of multifactorial regression (table 4): $Y = -2.013 + 1.517\ x1 + 1.043X2 + 0.369X3 + 0.420X4$, with standard error coefficients (1.430), (1.320), (1.009) and (0.870).

**Table 4. Estimation of the regression coefficients**

| Coefficients[a] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Model | | Unstandardized Coefficients B | Unstandardized Coefficients Std. Error | Standardized Coefficients Beta | t | Sig. | Collinearity Statistics Tolerance | Collinearity Statistics VIF |
| 1 | (Constant) | -2.013 | 1.920 | | 2.662 | .515 | | |
| | X1 | 1.517 | 1.430 | 1.141 | 1.602 | .043 | .815 | 1.228 |
| | X2 | 1.043 | 1.320 | 1.073 | 1.326 | .028 | .875 | 1.142 |
| | X3 | 0.369 | 1.009 | 1.004 | 1.019 | .025 | .984 | 1.017 |
| | X4 | 0.420 | 0.870 | -0.114 | -1.457 | .032 | .721 | 1.387 |

a. Dependent Variable: Y.

*Source:* Data analysis was performed by the authors harnessing SPSS 22

As it can be seen from the table above, all of the call model statistically significant at a significance level of 95% for all four independent variables in the model. Simple linear regression model assumptions are verified for the same level of significance, with the exception of error autocorrelation hypothesis tested using the Durbin-Watson test (table no. 5). The value of statistical test is DW = 2.087, very close to 2, which leads to the conclusion that no autocorrelation of errors. Next, SPSS 22 software was used to calculate the Test VIF (Variance Inflection factor) for each independent variable in the model (table no. 4). All four values (1.228, 1.142, 1.017 and 1.387) are lower than 3 which leads to the conclusion that the independent variables are not correlated with each other. This complements the results in the table below. 6, the Pearson correlation coefficients between the independent variables are very small. The intensity of the relationship between variables in the model is given by the multiple correlation coefficient $R_{y / x1, x2, x3, x4}$ with a value of 0.842 (table no. 5), which means that the variation is the direct bond and intense. Also, the independent variables included in the multiple linear regression model explained 70.9% of the variation in the EU growth factors (table no. 5, R_square = 0.709), the difference of 29.1% is explained by other factors. Correlation is the model valid. The results of our analysis are consistent with the work of Puigcerver-Peñalver (2007) who developed a regression model for economic growth is partly explained by environmental factors and circular economy.

**Table 5. The estimation of the econometric model**

| **Model Summary[b]** | | | | | |
|---|---|---|---|---|---|
| **Model** | **R** | **R Square** | **Adjusted R Square** | **Std. Error of the Estimate** | **Durbin-Watson** |
| 1 | .842[a] | .709 | .658 | .2700 | 2.087 |

a. Predictors: (Constant), X4, X3, X2, X1

b. Dependent Variable: Y

*Source:* Own evaluation based on SPSS 22

**Table 6. Matrix of correlation**

| **Correlations** | | | | | | |
|---|---|---|---|---|---|---|
| | | **Y** | **$X_1$** | **$X_2$** | **$X_3$** | **X4** |
| **Pearson Correlation** | Y | 1 | -.097 | .039 | .016 | .032 |
| | X1 | -.097 | 1 | .028 | .034 | .409 |
| | X2 | .039 | .028 | 1 | .052 | .332 |
| | X3 | .016 | .034 | .052 | 1 | .098 |
| | X4 | .032 | .409 | .332 | .098 | 1 |

*Source:* Data analysis was performed by the authors harnessing SPSS 22

Multiple linear regression model accuracy is calculated using Fisher test. From Table. 7 we can see that the value of the test is (Sig. F = 0.027) lower than 0.05, which leads to the conclusion that the regression model is valid at a significance level of 95%. We also believe that the independent variables included in the model have a significant impact on the dependent variable variation, contributing to economic growth annual average of EU member states. Thus, the main conclusion is that the regression model the factors of economic performance and finance circular explains a significant share of 70.9% of growth in the Member States.

**Table 7. ANOVA Table**

| ANOVA[a] | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 31.892 | 4 | 7.973 | 7.113 | .027[b] |
| | Residual | 24.662 | 22 | 1.121 | | |
| | Total | 56.554 | 26 | | | |

a. Dependent Variable: Y

b. Predictors: (Constant), X4, X3, X2, X1

*Source:* Own evaluation based on SPSS 22

In conclusion, from this analysis we can conclude that the model is valid and correctly specified, and that environmental factors and the circular economy are significant for economic growth in the 28 EU Member States, because there have been significant values for the coefficients estimate that are significantly different from zero and that the model explains most of the variation in economic growth at EU level. This paper adds to the recent studies of impact assessment of circular economy on economic growth (Ghisellini et. al., 2016; Preston, 2012; Su et. al., 2013).

## 4. CONCLUSIONS AND RECOMMENDATIONS

European Commission Report on environmental policy indicate some reuse of resources in Romania. Implementation of circular economy model requires significant investments in the environmental infrastructure in order for Romania to develop smoothly towards meeting its environmental objectives.

Shortcomings are observed in the productivity of resources and labor employed in the field of environmental protection. Beyond inventory of the current situation of the Romanian circular economy, the paper presents the advantages of using the conceptual model in terms of sustainable economic growth based on the efficient and responsible consumption of the resources.

The studies on the developed economies showed multiple benefits based on education of the civil society in environmental protection, while making investments in infrastructure for collection, sorting and recycling. The positive effects of circular economy model are commensurately increasing the level of municipal revenues, labor employed and the profit earned by entrepreneurs providing environmental infrastructure.

Probably the most important benefit of using circular economy is felt individually. Making an analogy between the life of products through reuse or extending the products life and the human life, one can observe how environmental factors are propagated on the quality of our daily life.

Econometric analysis carried out reveals the impact indicators exogenous determinants of circular economy in growth. At the same time, the impact on the dependent variable control is much higher predictive variables than in control variables. This means that the degree of innovation in the environment and the use of renewable energy play a greater role in terms of economic growth impact rate compared to the impact of GDP / capita and increasing human capital involved in renewable energy.

Since the calculation of macroeconomic indicators used in the regression analysis covered a period of nine years, the main limitation of this research is related to the time database used for the factor analysis. Such future research will be conducted for longer periods of time which may provide a more accurate picture of the model created by Mankiw, applied for the Romanian macroeconomic indicators.

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