THE GDP INFLUENCE ON THE AMOUNT OF RENEWABLE ENERGIES PRODUCTION IN ROMANIA

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Abstract: *Nowadays, energy has become an indispensable part in any human activity. Even so, two billion people i.e., one third of the world population, have no access to modern energy sources. The world's population is being expecting more from the third millennium and the key to a high standard of living is given by the accessibility to sources of clean energy at an affordable price. Energy has an impact on every aspect of modern life as it is in close connection with energy use per capita (which ensures a high level of productivity) and life expectancy. We cannot address phenomena such as economic growth, development and progress and to exclude directly an increase in energy demand. In addition, if we add two current realities of paramount importance, namely air pollution and fossil fuel depletion, then we can say with certainty that the production of renewable energy is the best "clean" and sustainable solution at our disposal. But we know for a fact that it is costly to meet the current level of demand for energy from unconventional sources, and by this we mean the initial investment because later on the maintenance costs are reduced and the resource used is free and inexhaustible. Therefore our work aims to analyze through an econometric model, the impact the Gross Domestic Product has on production of renewable energy. The conclusion we have reached at after developing this model is that there is a direct correlation between renewable energy and Gross Domestic Product. So, we demonstrated using a simple linear regression model that the Gross Domestic Product influence on the amount of renewable energy produced is significant* both in the sample and the total population. *In other words, Gross Domestic Product growth will stimulate the production of energy from non-polluting alternative sources which means less fossil fuel burned.*

Keywords: *renewable energy; GDP; economic growth.*

JEL classification: *O44; Q20; C20.*

1. Pollution - the great challenge of our times

Lately, the terms environment and environmental pollution are interlinked; pollution manifests itself as a continuous aggression against environment integrity. Pollution is actually the price people pay for the benefits of modern technology. What we called now pollution is the end of a process that began with the setting-up of human communities and which, at some point, started to degrade the environment.
Environmental pollution which expanded its threat to the entire planet has reached the peak by carrying out an unleashed attack against human beings and their habitat. By overcoming the nature’s capacity to defend, regenerate and balance itself, all new pollutants are spreading rapidly in air, water and soil, and thus creating,

developing and propagating one of the most serious dangers civilization modern has ever encountered (Marin, Ataman, 1996, p. 141).
Air and water pollution are causing a number of adverse consequences experienced by the population such as: degradation of transportation and transmission systems such as *infrastructure, bridges and power transmission systems which are highly vulnerable to natural disasters;* degradation of constructions' plasters and foundations due to the rising temperature and the increasing pace of natural disasters; increasing demand for water and energy supply; increased frequency of storms and floods whose economic, environmental and social impact is considerable; a decreased agricultural production; increased urban pollution that causes various diseases of the respiratory system; tropical storms and rising temperatures which have led to the disappearance of coral reefs and mangroves; and the negative impact on winter tourism which was also affected due to snow melting in the lower regions (Zhang, 2016).
According to a study conducted by the World Health Organization, increasing levels of atmospheric pollution, with all its disastrous consequences, is responsible for 160,000 human fatalities and unless some clear and concrete measures steps are taken, the projections show that by the end of 2020 the number of casualties will double (Tiwari, Mishra, 2012, p. 457).

2. Renewables - an effective solution

The term "*renewable energy*" means the energy derived from a wide range of resources, all endowed with the ability to renew, for example: water, solar, wind, geothermal and biomass (household, municipal, industrial and agricultural waste) (*Energy Consultancy*)
International Energy Agency defines renewable energy as the "energy derived as a result of natural processes which are fed constantly" (Boaz et all., 2010, pp. 5-10).
In the new law on energy of Japan issued in 1997, renewable energy is called the "new energy" and it was described as an "alternative energy production that replaces oil, coal and natural gas" (Katin, 2010, p. 11).
As against the conventional forms of energy, unconventional energies are based on the very simple idea that within the scope directly accessible to human knowledge there is enough energy that manifests one way or another. It should only be identified, captured and eventually transformed into the desired form of energy. To get down to basics, in the end it comes down to the cost and efficiency of the conversion. Among these renewables a special emphasis is put on the energy potential of geothermal deposits as a viable alternative to fossil fuels; this idea was supported by the fact that, in addition to technical-economic advantages, a number of over 80 countries worldwide have significant geothermal resources.
Instead of conclusion we can state that renewable energy is the energy that is the result of some renewable natural processes. More specifically, by capturing and making use of solar, wind, water and geothermal energy or biological processes though various processes one obtain electricity and/or heat. Among renewables we recall: wind power; solar energy; water power; hydropower; tide energy; geothermal energy; energy derived from biomass: biodiesel, bioethanol and biogas.

3. The relationship between renewable energy and GDP – literature review

In his works, Roegen describes the link between economic growth and resource depletion. Starting from the idea that fossil fuels (he addressed the coal) participate in a single process of production as by burning it results energy, pollution and waste; thus he concludes that humanity has a limited stock of energy (and of fossil fuels implicitly) which, incidentally, is responsible for current anthropogenic degradation of the environment.

A few centuries ago, mankind was on the verge to face a big problem, namely a food supply crisis due to a massive increase of population; currently a great challenge faced by humanity is the exhaustion of conventional energy resources. Bretschger (Wang, Zhang, 2011, p. 322) complements the above theory by explaining that technological innovation (Loukil, 2016) and discoveries are those factors who once contributed to meet food demand and will be those which, through non-exhaustible resources, will contribute to meeting energy demand, which inevitably will be reflected in our macroeconomic indicators.

Our analysis starts from this truth of our lives, namely: energy is now an engine of growth and economic development. Until recently, the population was content with the fact that the demand for energy was met but, at present, the problem is not meeting the energy demand but how the energy is generated. This is an issue because, on one hand, resources used to produce energy are exhaustible in a not too distant future, which will make them more expensive, and on the other hand because producing energy is one of the biggest roots of increased levels of air pollution. As we explained in the first part of this paper, a possible solution (and we believe that is the single one so far) in order to meet the growing demand for energy without degrading the environment is the alternative energy.

Following the above reasoning for choosing this topic, our paper aims to analyze the relationship between the amount of renewable energy produced and the macroeconomic indicators, to be more accurate: Romania's GDP. The connection between the two parts of the equation was analyzed by Apergis and Payne in 2010; they used data from 20 OECD member states and other 13 countries of Eurasia. Following their analysis, they concluded that there is a direct connection between the real GDP and the amount of alternative energy produced. Specifically, an increase of 0.76% of GDP increases by 1% the amount of energy from renewable sources produced and consumed (Information Resources Management Association, 2017, 1306).

On the other hand, Fang (Information Resources Management Association, 2017:1306) shows in the case of China that the relationship between the two variables is mutual, i.e. a 1% increase in the amount of energy alternative produced increases the real GDP by 0.12% and the GDP/capita by 0.162%.

4. Estimation results and discussions regarding the relationship between GDP and renewable energy

To identify the impact that the Gross Domestic Product (GDP_t) has on the Renewable Energy (RE_t) in Romania, we will use a simple regression. The research is based on the data available on the Eurostat database during the period 1990 – 2015. Given the exponential evolution of the variables considered, the numerical values were transformed by logarithm and the influence of seasonal factors was eliminated using

Tramo-Seats method. The new variables were further symbolized: Renewable Energy - Log_RE and the Gross Domestic Product - Log_GDP.
Specifying an econometric model assumes choosing a mathematical function (*f(x)*) with the help of which the connection between the two variables can be described. In the case of a single factor model, the most common used method is the graphical representation of the two strings of values with the help of the scatter plot. Thus, in order to identify the relation between the mentioned variables, we have created a graphic representation of the pair of points which include the values of the variables, the Renewable Energy and the GDP. Based on the data provided by Eurostat and using the Eviews software, we have obtained the following results:

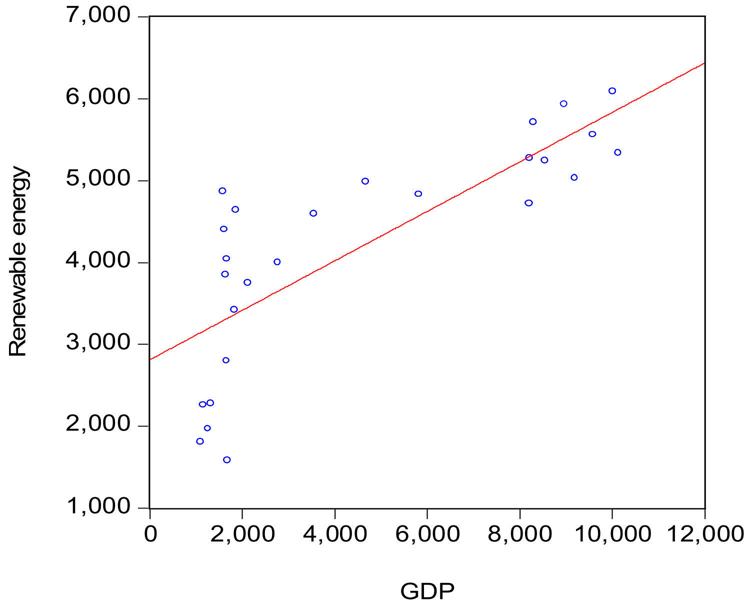

Figure 1: The relationship between Renewable energy and GDP
Source: created by the author

Since the points lie within a well-defined area we may say that there is a direct link between the dependent variable i.e. Renewable Energy and the independent variable i.e. GDP. In order to identify the connection between the variables and the intensity of the relationship between them, we shall assume that there is a form of linear link between variables. Thus the model of simple linear regression proposed in the study of the evolution of Renewable Energy (Yt), according to GDP (Xt) has the following formula:

$$Log\_RE=c(1) +c(2) *Log\_GDP + \varepsilon_t \quad (1)$$

The main problem of any regression model is how to determine model parameters. To determine the model parameters we shall make use of generalized least squares (GLS) technique. To test the validity of the assumptions underlying the classical model we will use various statistical tests. In order to estimate the parameters of model (1) we used the software Eviews by which we obtained the following results at sample level:

Table 1: The estimation of regression equation

Dependent Variable: LOG(RENEWABLE ENERGY)
Method: Least Squares
Sample: 1990 2015
Included observations: 26
LOG(RENEWABLE ENERGY)=C(1)+C(2)*LOG(GDP)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	5.330396	0.493642	10.79811	0.0000
C(2)	0.363560	0.060611	5.998251	0.0000

R-squared	0.599860	Mean dependent var	8.276379
Adjusted R-squared	0.583188	S.D. dependent var	0.391993
S.E. of regression	0.253075	Akaike info criterion	0.163539
Sum squared resid	1.537122	Schwarz criterion	0.260315
Log likelihood	-0.126001	Hannan-Quinn criter.	0.191407
F-statistic	35.97901	Durbin-Watson stat	0.312898
Prob(F-statistic)	0.000003		

Source: authors' estimates using Eviews based on the data provided by Eurostat

Values of coefficients estimated at sample level are: c(1) = 5.330396 and c(2) = 0.363560. The coefficient c(2) shows the increase level in Renewable Energy when GDP increases by one unit, while the coefficient c(1) shows what would be the value of Renewable Energy if GDP was zero. Also, given the positive nature of the coefficient c(2) and starting from the two coefficients we may state that there is a direct correlation between the two variables since the sign of the estimated coefficient c(2) is positive. To determine GDP's influence on the dependent variable Renewable Energy in the total population starting from the simple linear regression model, we generalize the results of two coefficients estimated by applying Student Test. Based on the data in the table above one may notice that the parameter c(1) is significantly different from zero, with a significance level α = 0.05, as t_{calc}=10.79811 > t_{tab}=2.05, which means that the null hypothesis is rejected. This can be seen by the probability associated with the parameter c(1) which is equal to p = 0.000, which confirms that the parameter is significant in the total population. Also, in the case of the parameter c(2), it is noted that t_{calc} = 5.998251 > t_{tab} = 2.05, and the probability associated with the parameter c(2) is zero. This confirms that the parameter is significant and hence the null hypothesis H_0 is rejected.
Therefore, the results obtained by using Eviews software shows that two parameters are significantly different from zero, meaning that the model was correctly specified, identified and evaluated, and that one may continuing the econometrics based arguing.
We determine the R-square value in order to measure the intensity of the correlation between endogenous variable and its determinants. As to what the Adjusted R-square is concerned, this is equal to 0.599860 at sample level, which suggests a

medium to strong correlation between the model variables. In order to study the size of Adjusted R-square for the entire population, we used the Fisher test. Since F_{calc} = 35.97 > F_{tab} = 3.15, it results that the null hypothesis is rejected therefore the exogenous variable influence on the endogenous variable is significant. The largest the difference between F_{calc} and F_{tab} is, the stronger the relationship between variables in the total population is.

Testing the basic hypotheses regarding the random variable ε
The first hypothesis we are going to put to test is the *independence of the residual variable ε_i values*. For this study we shall make use of the Durbin-Watson test. Starting from the following equation (Stancu, 2011, p.48):

$$\varepsilon_t = \rho \cdot \varepsilon_{t-1} + \omega_t \tag{2}$$

We start from the following assumptions:

H_0: $\rho = 0$, with the alternative
H_1: $\rho \neq 0$

The above ρ is the first-order autocorrelation coefficient of the errors. To choose the correct hypothesis, we determine the calculation DW_{calc}=0.31. By working with a significance level α = 5%, the number of exogenous variables is *k* = 1, and the number of observations is T = 26, in the Durbin-Watson Significance Table we address the values d_1 = 1.30 and d_2 = 1.46. Since 0 < DW_{calc}=0.31 < d_1 = 1.30, errors have a positive autocorrelation, and the hypothesis H_0 is rejected, therefore the errors independence hypothesis is not confirmed.
In order to eliminate the autocorrelation phenomenon we shall estimate the parameter ρ using the Cochrane-Orcutt estimation procedure (Andrei, Bourbonnais, 2008, p.126). After the calculations, we obtained the value of the parameter below:

$$\rho = 1 - \frac{DW_{calc}}{2} = 0.74 \tag{4}$$

Thus the residues can be calculated according to the following formula:

$$\varepsilon_t = 0.74 \cdot \varepsilon_{t-1} + \omega_t \tag{5}$$

From the multiple linear regression model

$$Log\_RE_t = c(1) + c(2) * Log\_GDP_t + \varepsilon_t \tag{6}$$

and

$$Log\_RE_{t-1} = c(1) + c(2) * Log\_GDP_{t-1} + \varepsilon_t \tag{7}$$

By substituting in equation (5) one obtains the following formula:

$$Log\_RE_t - (0.74 * Log\_RE_{t-1}) = C(1)*(1-0.74) + C(2)*(Log\_GDP_t - 0.74*Log\_GDP_{t-1}) + \omega_t \quad (8)$$

Estimation of the new regression model

We check the features of the new regression model by repeating the same steps as in the case of the previous model. In order to evaluate the parameters of the new regression model we have also used the Least Square Method. The results are presented in the table below.

Table 2: The estimation of new regression equation

Dependent Variable: Log(renewable energy) - (0.74 * (Log(renewable energy(-1))))
Method: Least Squares
Sample (adjusted): 1991 2015
Included observations: 25 after adjustments
Log(renewable energy)-(0.74*(Log(renewable energy(-1))))=c(1)*(1-0.74)+c(2) *(Log(GDP)-0.74*(Log(GDP(-1))))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	6.851289	0.698119	9.813934	0.0000
C(2)	0.193716	0.083285	2.325928	0.0292

R-squared	0.190424	Mean dependent var	2.200425
Adjusted R-squared	0.155225	S.D. dependent var	0.119261
S.E. of regression	0.109614	Akaike info criterion	-1.507077
Sum squared resid	0.276352	Schwarz criterion	-1.409567
Log likelihood	20.83847	Hannan-Quinn criter.	-1.480032
F-statistic	5.409940	Durbin-Watson stat	1.760032
Prob(F-statistic)	0.029196		

Source: Source: authors' estimates using Eviews based on the data provided by Eurostat

Resulted regarding the two parameters of the new regression model show that Student statistics parameters are higher in absolute terms than the tabular value equal to 1.96 for a significance level of 5%. Also, the probability that the null hypothesis is true is smaller than 5% (p=0.0000 for c(1) and p=0.0292 for c(2)), so it can be stated that the null hypothesis is rejected and the only accepted true hypothesis is the alternative H_1 (c(1) ≠ 0, and c(2) ≠ 0).

To measure the intensity of the relationship between the two variables we set the determination coefficient. At the level of the sample between the two variables considered there is link of average intensity. To determine whether this intensity is maintained at the level of total population or not, we used Fisher's exact test. Since $F_{calc} = 5.409940 > F_{tab} = 3.15$ it results that the it is rejected the null hypothesis according to which there is no correlation between variables, so the influence of exogenous variable GDP on endogenous variable Renewable Energy is significant.

Table 3: Testing the basic hypotheses regarding the random variable ω_t

Dependent Variable: LOG(RENEWABLE ENERGY)-(0.74*(LOG(RENEWABLE ENERGY(-1)))) *Method: Least Squares* *Included observation: 25 after adjustments* LOG(RENEWABLE ENERGY)-(0.74*(LOG(RENEWABLE ENERGY(-1)))) = C(1)*(1-0.74)+C(2)*(LOG(GDP)-0.74*(LOG(GDP(-1))))		
1. Independence of errors (Durbin Watson Test)		
	DW_{calc}	1.760032*
2. Homoscedasticity of errors (White Test)		
	F_{calc}	2.256610 (Prob=0.1284)
3. Normality of errors (Jarque Bera Test)		
	JB_{calc}	0.241124 (Prob=0.886422)

* Working with a significance level of α= 0.05, the number of exogenous variables is k=1, and the number of observations is T=25, from the Durbin-Watson distribution table we find the following values: d1 = 1.28 and d2 = 1.45.
Source: authors' estimates using Eviews

As to what the testing of the fundamental hypothesis referring to the random ω_t variable is concerned for the new model, we have reached the following conclusions:
-*the independence hypothesis* of the values of the residual variable ω_t is confirmed this time, because the Durbin-Watson statistic is equal to 1.760032, so that $d_2 = 1.45 < DW_{calc} = 1.760032 < 4\text{-}d_2 = 2.55$, meaning the errors of the model are independent;
-*the homoscedasticity hypothesis* of the residual variable ω_t is confirmed, because, as the data from Table 3 shows, the probability related to the Fisher exact test is higher than 5%, which determines the acceptance of the H_0 hypothesis as being true.
-*the normality hypothesis* of the random variable ω_t is confirmed. One way to check the normality of errors hypothesis is the Jarque-Berra test, which is an asymptotic test, usable in the case of a large volume sample, which follows a chi-squared distribution with two degrees of freedom (Meșter, 2012: p.150). Because the related probability of accepting the null hypothesis as being true (Prob=0.886422) is higher than 5%, we can state that the normality of errors hypothesis cannot be rejected for the level of the entire population, the errors being normally distributed.

5. Conclusions

In conclusion, we wish to emphasize that currently it is neither the terrorism, nor hunger, not even the infernal race for economic and military supremacy the major problem of the mankind, but the survival of humanity and the possibility of future generations to meet their needs and to maintaining earth's ecosystem and preserving its biodiversity which are endangered by environmental pollution. Therefore, an evidenced based and actually implemented approach on sustainable development in all fields of human activity is or should be a top priority nowadays.

Moreover as we have shown in this paper, increasing the amount of alternative energy leads to an increase in GDP as in some cases i.e. China, but we strongly believe that the link between the GDP level and the amount of green energy produced is a mutual and dependant relationship.
In this paper we intended to analyze this relation in the case of Romania. Through an econometric model we demonstrated that the GDP influence on the amount of renewable energy produced is significant. In other words, GDP growth will stimulate the production of energy from non-polluting alternative sources which means less fossil fuel burned.

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