THE ANALYSIS OF THE THEORIES ABOUT THE CONNECTION BETWEEN ECONOMIC GROWTH AND POLLUTION. ECONOMETRIC TESTING OF KUZNETS CURVE FOR ROMANIA

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Abstract

In the course of recent history three theories pointed out about the connection between development and pollution. The first theory is that of Camelia Cămoşoiu, who believes that the problem is either cultural or of mentality, or both. Another theory is supported by William Nordhaus, who builds a comparative study on global carbon emissions as well as their implications. And the third theory is provided by Kuznets, who presents a graphic demonstration of its called Kuznets curve. In this paper we desire to analyze the extent to which these theories are demonstrated for Romania, highlighting their weaknesses and strengths and in the last part to theoretically analyze the link between Kuznets' theory with that of the Australian Colin Clark the Frenchman Jean Fourastie.

Key words: economic growth, Kuznets curve, pollution

JEL Code: O44, Q53

Introduction

Much has been written over the years about the connection between the level of pollution and economic growth in order to try and find a link between them. In the course of recent history three theories remarked themselves in respect to the link between the level of development and the degree of pollution. In the following article we want to present the main theories written on this issues and we want to indentify the one that is closest to nowadays reality.

1 The analysis of the theories regarding the connection between economic growth and environmental pollution

In the course of history three theories remarked themselves regarding the connection between the level of development and pollution. The first theory is that of Carmelia Cămoşoiu, who believes that the problem is either cultural, or of mentality, or both. The author explains her theory in a comparative example between a citizen of a developing country, whose wage is low and a citizen from a developed country with a high wage. At a first analysis the author believes that the citizen from the country in development lacks culture and the specific education for a citizen, or love of beauty, because a clean unpolluted nature produces the same joy for a citizen from a developing country as for the one in a developed country. On the other hand, the author considers that an individual who is concerned for its daily existence and for insuring the necessary financial resources to satisfy needs, the beauty problem and that of decontamination is placed on an inferior position in his list of priorities. (Cămoşoiu, 2004)

Considering all these, statistics show with irrefutable data that poor countries carry the lowest pressure on the planet.

Tab. 1: The analysis of CO_2/capita emanation in different countries

Continent / Country	Carbon dioxide damage	Continent / Country	Carbon dioxide damage
China	1.11	*Romania*	0.5
Luxembourg	0.24	Czech Republic	0.57
Spain	0.19	Germany	0.18
Kenya	0.3	Niger	0, 1 July

Source: World Bank, available on-line http://worldbank.org/all?qterm=CO2 accessed on 23. 04.2012

We know that Luxembourg is the country with the highest GDP per capita of the European continent and Africa is where, despite the global food supply exceeds demand, a part of its population suffer from malnutrition or die due to lack of food.

Another theory is supported by William Nordhaus who made a comparative study on global carbon emissions as well as their implications. He starts from the information according to which in 2006 global carbon emanations were of 7.5 billion tons (27.5 billion tons of CO_2=3.67 tons CO_2). In order to a better understanding of this astronomical number, Nordhaus calculated emissions at individual level as follows: he assumes that an individual in a year he rides 10.000

miles in a car that uses one gallon at every 28 miles. In this case, the vehicle will emit one ton of carbon that is equivalent to approximately 4 tons of CO_2. (Nordhaus, 2008)

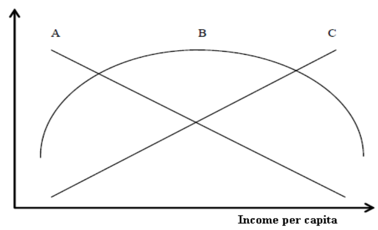
For heating the residence the individual will consume 10,000 kWh per year (which is the average kWh consumption per capita in U.S.A./year). If this energy is generated by burning coal, carbon emanations would be of 3 tons (about 11 tons of CO_2) per year. Overall, the United States emanations are 1.6 billion tons of carbon (6 billion tons of CO_2), which is 5 tons carbon (18.35 tons of CO_2) per capita, than the world average which is 1.25 tons (4.58 tons of CO_2).

The example given by William Nordhaus and the presented statistical data reinforce some theories according to which pollution (calculated emissions of CO_2) increases directly proportional with economic growth. In a world where economic growth is the most important indicator of a country and also its goal every year comes up the relevant question: What will happen to the environment and inhabitants of this planet?

And the third theory is provided by Kuznets, who presents a graphic demonstration which he calls Kuznets curve. This curve starts on the assumption that trade liberalization has positive effects on the environment. In the early stages of the environmental movement some scientists have asked "how big is the availability of natural resources and to which extent can they provide sustainable growth?" To this question the neo-classics responded that economic growth is not prevented by natural resources. Then they continued a series of debates between the so-called pessimists who argued that natural resources are depleting and intensive economic growth would lead to the extinction of the human species and of other species, while on the opposite side of the debate were the optimistic, among which the neo-classics. While debates continued over the years it has been proven eventually few decades ago that the pessimists were not able to foresee technical progress. But the optimists had not been completely right either, because today's reality in which pollution implicitly global warming causes a series of negative effects on the economy, on ecosystems and on the human species. Thus, around the 1980's aspects regarding the thinning of the ozone layer, global warming, the loss of biodiversity began to be intensely debated.

In the 1990s the specialized literature on the relationship between the economy and the environment has proliferated. To this category also belongs Kuznets's theory that argues that in the beginning stages of economic development the environmental degradation will increase at high speed to a certain level of income (to the point of turning). This relationship between the income per capita and the level of pollution is presented as a form of inverted U curve. (Gallagher, 2008)

Fig. 1: The analysis of the link between environmental degradation and the income per capita - Kuznets curve



Source: Gallagher, 2008, p. 51

In what follows we will try an analysis of this theory, highlighting its weaknesses but also its strengths. Through this curve Kuznets wants to highlight the relationship between the two analyzed sizes namely the pollution degree and the economic development, that take a primary route, then a second and finally a third. In the first phase (quadrant A) the economy is dominated by the primary sector, which as defined by the Australian Colin Clark and Frenchman Jean Fourastie, represented by agriculture and mining. This phase corresponds to the economic start in which the attraction of resources and their accumulation take place, and when the economy has registered a certain level (of 1000-1200 $ / person) (Pohoaţă, 2010) of income environmental degradation becomes a major problem. In quadrant B a maximum point of pollution is reached (around an increase of $ 3,000 / person), and this quadrant corresponds to the period in which the second sector dominates, that is the period in which the manufacturing industries are predominant, when the pressure on the lands, forests and on the environment is maximum. Then takes place the shift to the tertiary sector (when the GDP / capita reaches values of approx. $ 10,000) when the accumulation of wastes and massive pollution determines public awareness regarding the implications resulting from pollution which leads to large amounts of money from the state budget to be allocated in the implementation of measures designed to protect the environment. In addition, legal action will be taken against pollution and polluters causing thus the orientation towards those industries that are efficient and clean.

In this case, the environment is regarded as a normal good. In other words, according to the income elasticity of demand is greater than zero, maybe even more from which it can be deduced that as the income increases (in general the one calculated per capita) the care for the environment will increase as well, perhaps even more than directly proportional. In addition, rich countries are more capable in fulfilling the imposed criteria for having a healthy environment due to the ability to purchase cleaner technologies.

2 Data and methodology

The dependence between the economic variables can take many forms. In the book Handbook on Trade and the Environment the author starts with the study of the link between CO_2 and GDP / capita form the hypothesis that between the two variables there is a parabolic connection. Thus we will try to see whether in the case of Romania that form of the connection is suitable to determine the relationship between the mentioned variables, that is we will try to determine whether the Kuznets curve is checked or not having as starting point the statistical data between 1990 and 2010. (Gallagher, 2008)

In the multiple regression analysis first of all are taken into consideration the aspects linked to the identification of the explanatory variables. We will use data regarding the amount of carbon dioxide ($CO2_t$), and on GDP per capita during 1990 - 2010.

The parabolic regression model proposed in the study on the evolution of carbon dioxide (CO2) according to the GDP / capita is (Stern, 2004):

$$CO2_t = c(1) * PIB_t + c(2) * PIB_t^2 + c(3) + \varepsilon_t \qquad (1)$$

2.1 The testing the validity of the model

After testing the collinearity with the help of the correlation matrix we can conclude that the presence of collinearity at the level of this regression model is missing. Next we turn to estimate the parameters of the parabolic regression model.

In the cases of the multifactorial model the parameters can be estimated by several methods. To determine the parameters of the model we will use the generalized method of the least squares. In order to test the validity of the hypothesis that is based on the classical model will use various statistical tests.

After the calculations, the Student statistical value associated to the free coefficient c(3) indicates that they do not have a significant influence on the endogenous variable, because the calculated measures are smaller in absolute value than in the tabular measure, this think suggesting us that the multiple regression model estimated above is not valid. For this reason we will eliminate the free ratio model. Thus the regression model becomes

$$CO2_t = c(1) * PIB_t + c(2) * PIB_t^2 + \varepsilon_t \qquad (2)$$

The obtained results indicate the fact that the new model is valid because the Student statistical values calculated for the two parameters are larger in absolute value than the tabular value equal to 1.96 for a significance threshold of 5%. Thus we can conclude that the null hypothesis H_0 for all the parameters of the regression equation is rejected, these being significantly different to zero, thus we can state that the exogenous variables are significant as well as at the total population level. Also we can assert that due to the negative value of the c(2) coefficient the Kuznets curve is checked (the peak is up).

As for the intensity of the connection we can say that based on the obtained results at sample level between the endogenous variable and the exogenous variables there exist a very strong connection, the value of $R^2 = 0.7$, being very close to one.

To study the size of the total population, we will use the Fisher test. Since $F_{calc} = 42.02 > F_{tab} = 3.10$ results that the null hypothesis is rejected, so the influence of the exogenous variables on endogenous variable is significant.

2.2 Testing the fundamental hypotheses regarding the random variable ε

The hypothesis of the independent values of the residual variable $\varepsilon_{i.}$ This hypothesis requires the verification of the relationship:

$$\text{cov}(\varepsilon_t, \varepsilon_k) = E(\varepsilon_t, \varepsilon_k) = 0 \; (\forall) \; t,k=\overline{1,20}$$

In order to detect the autocorrelation the residual variables are used a series of statistical tests. For this study we will use the Durbin-Watson test. Starting from the relationship:

$$\varepsilon_t = \rho\varepsilon_{t-1} + u_t \qquad (3)$$

This ρ is the autocorrelation coefficient of errors. In order to choose the correct, it is determined the statistics DW_{calc}=0,43.

Working with a threshold of significance level α = 0.01, the number of the exogenous variables is k = 2, and the number of observations T = 20, the Durbin-Watson distribution table the values are read $d_1 = 0.86$ and $d_2 = 1.27$. Since $0 < DW_{calc} = 0.43 < d_1 = 0.86$, the errors are positive autocorrelated, the hypothesis H_0 is the one that is rejected, so the hypothesis of independent errors is not checked.

In order to eliminate the autocorrelation phenomenon we will estimate parameter ρ with the help of the Cochrane-Orcutt method (Andrei & Régis, 2008). After calculations, we obtained the parameter

$$\rho = 1 - \frac{DW_{calc}}{2} = 0.785 \qquad (4)$$

Thus the series of residues can be written like this:

$$\varepsilon_t = 0,785 \cdot \varepsilon_{t-1} + u_t \qquad (5)$$

From the parabolic type of the linear regression model:

$$CO2_t = c(1) * PIB_t + c(2) * PIB_t^2 + \varepsilon_t \qquad (6)$$

and

$$CO2_{t-1} = c(1) * PIB_{t-1} + c(2) * PIB_{t-1}^2 + \varepsilon_{t-1} \qquad (7)$$

Substituting in the relationship (1) we obtain:

$$\mathrm{CO2}_t\text{-}(0.785 * \mathrm{CO2}_{t-1}) = \mathrm{c(1)*(PIB}_t\text{-}0.785\mathrm{*PIB}_{t-1}) + \mathrm{c(2)*(PIB}_t^2\text{-}0.785\mathrm{*PIB}_{t-1}^2) + u_t \qquad (8)$$

In the next step we will check the qualities of the new model repeating the same steps as for the previous model.

The estimation of the parameters of the new model of parabolic regression we used the method of the least squares. The results related to the two parameters of the new model show that values of the Student statistics calculated for the two parameters are larger in absolute value than the tabular value equal to 1.96 for a significance threshold of 5%. Thus we can conclude that the null hypothesis H_0 is rejected for all the parameters of the regression equation, these being significantly different from zero, the exogenous variables are significant and the total population.

For measuring the intensity of the dependence of the endogenous variable regression factors, it is determined the coefficient of determination. At sample level between the endogenous and exogenous variable exists a medium intensity relationship, because R-squared = 0.39888 in order to determine if this intensity is maintained at the total population level, we will use the Fisher test. Because $F_{cal} = 10.94 > F_{tab} = 3.10$ means that the null hypothesis is rejected according to which between the variables would not exist a relationship, so the influence of the exogenous variables on the endogenous variable is significant.

2.3 Testing the fundamental hypotheses according to which the random u_t

The independence hypothesis of the residual variable u_t values. In order to detect the autocorrelation of the residual variables we will use the Durbin-Watson test (Meşter, 2012). This time we will start from the relationship:

$$u_t = \rho u_{t-1} + \omega_t \qquad (9)$$

In this case the Durbin Watson statistic is equal to 1.387262, so $d_2 = 1.27 < DW_{calc} = 1.387262 < 4 - d_2 = 2.73$, so we can conclude that the errors are independent, the hypothesis of independence of errors is checked.

The hypothesis of homoscedasticity of the residual variable u_t. In order to verify the hypothesis of homoscedasticity we will use the White test. Starting from the relationship:

$$u_t^2 = \alpha_0 + \alpha_1 PIB_t + \alpha_2 PIB_t^2 + \alpha_3 PIB_{t-1} + \alpha_4 PIB_{t-1}^2 + \omega_t \qquad (10)$$

it is intended to study if there exists or not a relationship between the variables.

It is determined this time too the measure calculated of the Fisher test. Since $F_{calc} = 0.26$ and $F_{tab} = 3.10$ the hypothesis H_0 hypothesis is accepted, which means the model is homoscedastic. The H_0 hypothesis cannot be rejected; this thing guaranteeing a 90% probability.

Testing the normality of the random variable u_t distribution. Due to the importance of the normal distribution in modeling various statistics, were constructed different special tests of concordance to check the normality different distributions. One way to verify the normality hypothesis of errors is through the Jarque - Berra test, which is an asymptotically test that is valid for a large sample, which follows a chi-square distribution with 2 degrees of freedom.

Since $JB_{calc} = 1.74 < \chi^2_{tab(\alpha;5)} = 5.99$; from this results the normality of errors hypothesis cannot be rejected at the total population level, the errors are normally distributed. Because all three hypotheses about the random variable were checked, results that the model is valid, so it can be used for making predictions.

Since we are interested in the GDP, which is the OX axis (as it is an independent variable), is sufficient to find out the ratio of value –c(1)/2*c(2) because the value is in the OX axis. Thus we will have the GDP / capita at the top of the parabola equal to:

$$\frac{-c(1)}{2*c(2)} = \frac{-0,001294}{2*(-9,03E-08)} = 4902 \quad (11)$$

This theory is criticized by today's reality. It is true that rich countries are those that have the ability to invest in new technology that has the ability to protect to some extent the environment, but let us not forget that an economic growth means more products made, and more used resources which implies more emitted pollutants. (Stern, 2004) Another criticism of this model is given by the fact that pollution is calculated per capita fact that determines that in most cases of some countries with a numerous population (as China) this theory cannot be demonstrated. (Madisson, 2007)

An overlooked aspect by most theories is given by the fact that rich countries do not have an air so polluted because they have developed their industries in other countries in order to keep for them cleaner air. One of the supporters of this idea is the American monetarist Milton Friedman who recommends the opening of polluting enterprises in poor countries, because in this manner the "United States will breathe fresh air" (Florea, 2008). These countries that allow the development of highly polluting industries on the territory of their country are also called "pollution havens". (Carson, 2004)

Conclusion

In conclusion we can say that for Romania during 1990 and 2010 Kuznets curve is demonstrated. More specifically we can say that the threshold of \$ 4,902 per capita (which is peak of the parabola was achieved in 2005-2006) Romania is characterized by a directly proportional relationship between economic growth and the level of pollution because since 2006 the relationship between the two variables has become an indirectly proportional. But if add that starting with 1995 the services sector has begun to develop, leading Romania to pass among developed countries according to the classification made by Colin Clark and Jean Fourastie, we can believe that Kuznets's theory is correct. Another argument leading to the veracity is the fact that during 2004-2008 Romania has experienced a boom period which together with the EU Sustainable Development Strategy can be responsible to some extent for the reduction of the pollution.

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