Theoretical and Empirical Researches in Urban Management
Volume 6 Issue 3 / August 2011

OBTAINING ECONOMIC GROWTH FROM ENERGY CONSUMPTION IN URBAN AREAS

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Abstract
This study seeks to determine if, in Romania, a relation in the short and / or long run between economic growth and energy consumption by fuel can be established. To this end, the authors used time series for the period 1965-2007 over which a set of tests were realized: a test to verify the presence of a unit root in the series, cointegration test and causality test. Thus, the Augmented Dickey Fuller test was used to see whether or not the series are stationary, Engle-Granger method to study cointegration (indicating the relationships formed on long term) and Granger test to determine short run relationships and their direction. The results tell us that there is not even a bidirectional relationship between real GDP and energy consumption by fuel in per capita toe values, but that there are one-way causal relationships. Between economic growth and consumption of energy from hydropower, there is a relation established only on long run; this result influences in choosing other renewable energy sources too for consumption, if they can sustain economic growth and the overall energy consumption needs. In the same time, renewable energy may contribute together with sustainable transport to sustainable urban planning. For cities to become along with poles of growth, urban ecosystems, it is necessary to reduce the effects of climate changes. One way to rethink the urban structure and planning is to take into account renewables for these areas hungry for energy.
Keywords: cointegration, economic growth, energy consumption, Granger causality, urban development.

1. INTRODUCTION

In the world in the last 60 years, energy consumption increased unexpectedly long (Wagner, 2010); the world is consuming today by six times more energy than half a century ago. This entails a high consumption of conventional resources, namely a decrease in reserves of oil, natural gas, coal, increases pollution and contributes to global warming. Understanding the danger that affects not only the present but also the future, numerous warning signs were drawn, and the first one was of the Club of Rome in 1972. The document called Limits to Growth, are addressed elements like: population growth, the impact of industrialization, the effects of pollution, food production and natural resource depletion trends (National Centre for Sustainable Development, 2008). Five years later in the report Our Common Future by World Commission on Environment and Development, appears the first definition of sustainable development. Since then, all policies, strategies, conventions began to be built upon sustainable development in order to achieve sustainable living.

Given that multiple social, health and environmental problems are related to urban areas, it is absolutely necessary to act in order to obtain quality of life in these poles of growth which are cities. Nowadays, 2% of the Earth's surface is covered by cities which embed half of the world's population. European Environment Agency (2010) states that in Europe, 75% of the population lives in cities and the tendency is to grow to 80% by the year 2020. It also specifies that cities are those that are responsible for 69% of the total energy use, determining this way the release of large amounts of greenhouse gases.

Therefore, a first opinion about cities has been expressed: even though cities are poles of growth with influence on all kinds of activities in our lives, they are poles for energy use, water utilization, overall consumption and waste generation.

A second opinion suggests that cities offer important opportunities for sustainable living. The explanation lies on the effect of population's density, meaning shorter time to get to work, better utilization of transportation means and smaller houses that need less lighting and heating. This opinion leads the impression that, the energy consumption will be smaller and that the demand for energy could decrease. Totally wrong, because the energy consumption had an increasingly tendency for the last half of century and shows no signs of decline.

As demand for energy will not diminish but will likely increase further, everyone looks for solutions that ensure a sustainable future in this field. One of the five interrelated goals set out in a Communication of the European Commission (2010): An European Strategy for smart, ecological growth and favorable to inclusion, refers to "reducing emissions of greenhouse gases by at least 20% below the levels in 1990(...); increase to 20% the share of renewables in final energy consumption and increase energy efficiency by 20%. "

Romania is taking into account these objectives, trying to increase usage of renewable energy from 17.8% in 2005 to 24% in 2020, to reduce greenhouse gases emissions by 21% and use 10% biofuels by 2020.

In the same time, our country has been "allowed to increase GHG emissions by 19% for sectors of small polluters", GHG meaning Greenhouse Gases (Leca & Muşatescu, 2010). We can appreciate that this statement is wrong or not related to that mentioned in the target. However, it is quite true, and an

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idea that comes to support the statement, is the following: high energy consumption can be a stimulus for economic growth in developing countries; these countries may therefore be allowed to pollute more than developed countries (Amirat & Bouri, 2008).

It was also shown to be valid also the inverse relationship, meaning it was found that economic growth can lead to increased energy consumption. For some countries, unidirectional links have been revealed, for others, bidirectional links. For example, according to a study in which were used as indicators: the energy consumption and GDP, it appeared that in Argentina a bidirectional causal relationship has been discovered; in Italy and Korea, the relationship starts from GDP to energy consumption, but not vice versa, and in Turkey, France, Germany and Japan, causality is based on energy consumption to GDP, but not vice versa (Soytas & Sari, 2003).

It has been proven also the case that cannot establish any causal relationship, for example in India (Omotor, 2008). These results certainly depend on the period of study taken into account; if this period is increased, changes in data used, due to economic and political circumstances, appear. Similar approaches have been made by other authors in different areas (Cicea et al, 2007).

It has been concluded that we can distinguish four directions of the causal relationship between energy consumption and economic growth, based on four hypotheses (Acaravci, 2010):

1. Growth hypothesis, implies a causal relationship in the direction: energy consumption → economic growth;

2. Conservation hypothesis, implies a causal relationship in the direction: economic growth → energy consumption;

3. Feedback hypothesis, involves a bidirectional causal relationship: economic growth ↔ energy consumption;

4. Neutrality hypothesis, assumes the absence of any type of causal relationship between economic growth and energy consumption.

2. DATA AND METHODOLOGY

To analyze the causal relationship in the short and long run between economic growth and energy consumption in Romania, were used data sets for the period 1965-2007 (British Petroleum, 2010). On time series regarding energy consumption, changes were made to obtain values per capita. Thus, the data series used in the analysis are:

- Tones per capita energy consumption, energy derived from oil resource;
- Tones oil equivalent per capita energy consumption, energy derived from natural gas resource;
- Toe per capita energy consumption, energy coming from coal resource;
- Toe per capita energy consumption, energy with hydropower origin;
- Real Gross Domestic Product per capita in constant prices.

The authors worked with the Eviews 7 software, where the data series have been named after the source of the energy, for instance COAL, OIL, GAS and HYDRO and for the indicator representing economic growth, GDP. Energy consumption from nuclear source, was not taken into account, since there are no data from 1965, given that Romania has started to produce nuclear energy in 1996 (CNE Cernavodă, 2004). The evolution of variables in the considered period is presented in Figure 1.

Most of this kind of analysis are carried out in three steps (Aqeel & Butt, 2001), which will be discussed below. Many of these end up by finding an econometric model to explain variation of a factor on behalf of independent variables; this aspect will probably make the subject for a separate study.

The first step is to test if the data series are stationary through Augmented Dickey Fuller test - ADF. A series is stationary when it is constant on average, variance and covariance. Mostly, we encounter non-stationary series; what makes a series non-stationary? The main sources for non-stationary series are trend and breaks in the series.

It is necessary that a series to be stationary whereas, economically, if there is a shock to the series, it will absorb itself over time, will be temporary and not permanent, as in the case of a non-stationary series. (Codirlaşu, 2007)

ADF test has the null hypothesis the existence of nonstationarity or of a unit root; the alternative hypothesis says that the series are stationary (Quantitative Micro Software, 2009b). How do we decide whether to reject or not the null hypothesis? After applying the test in EViews, values for confidence levels 1%, 5% and 10% are returned. If the test value is less than the values returned, then the null hypothesis can be rejected. The test can be done at first for level (meaning the values as they are) and if it appears that we have non-stationary series, we apply the test to the first-level differences, meaning on ΔY, calculated by:

$\Delta Y = Y_t - Y_{t+1}$

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If the series are still non-stationary, we use the differences of second level. Therefore we will eventually have to deal with time series integrated of order (p) if we had to do p differentiation to obtain stationary series.

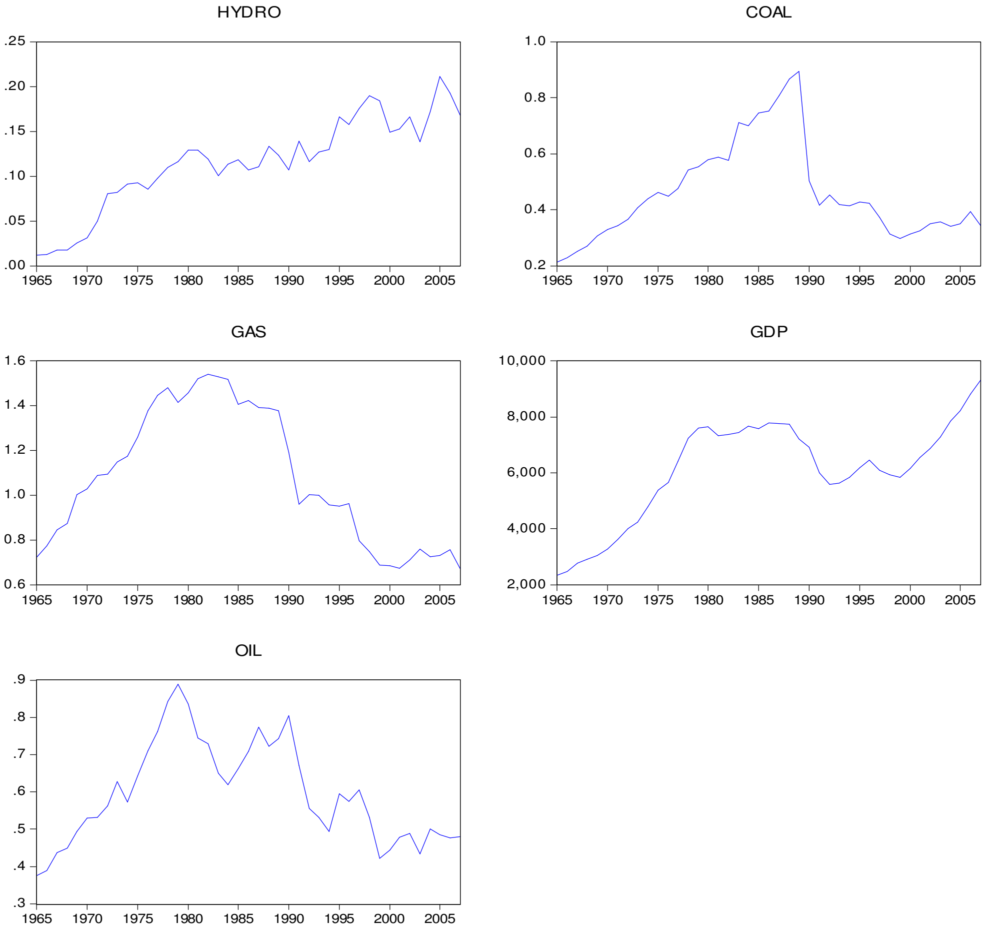

FIGURE 1 - THE EVOLUTION OF VARIABLES IN THE PERIOD CONSIDERED
Source: Authors

The second step consists of testing cointegration, with the Engle Granger method (Mata, 2003). In general, it is said that two or more variables are cointegrated if they have a common trend. Usually, between these variables, long-term equilibrium relationship occurs, relationships that may not be valid in the short run.

Using the method of ordinary least squares, parameters of a regression equation are estimated; the equation is formed always with GDP, as dependent variable and one by one, the variables for energy consumption per capita, from different sources, only if the test for stationary proved that the series are integrated of the same order. So we can build equation only if the series used are integrated of the same order.

Cointegration definition says that two variables integrated of order I(d) are called cointegrated if there is a linear combination of them which is integrated of order I(c) with c < d. Each time the residuals series derived from linear regression is kept so an ADF test could be performed on errors. In what purpose to do all this? The two series are cointegrated if residuals are also stationary at a level lower than the series (Golinelli, 2005).

Cointegration results show a causal relationship between the variables chosen, but it doesn't show the direction of causal relationship, therefore, the next step should be performed.

The third step is to test causality using Granger test (Quantitative Micro Software, 2009a). This test assumes that between two variables x and y can be a causal relationship as follows: the values of x series can be influenced by its past values, but also by past values of y series; at the same time, the question arises as namely, the current values of y can be explained on account of its past values, but also on account of past values of x. The theory is therefore focused on the relevance of past values; the test made in EViews needs to specify the number of lags, representing the time after which a series may be useful in predicting the other. Working with annual time series, we need a lag of one. Null hypothesis test is a double one, formulated as follows:

X does not Granger Y- which means that there is no causality - and Y does not Granger X.

Alternative hypothesis is obviously the opposite that X Granger causes Y and Y Granger causes X. The decision rule is as follows: null hypothesis is rejected if probability associated to F-statistic is ≤ 0.05 and the null hypothesis is accepted if the associated probability of F statistic is > 0.05 (Akan et al, 2010).

3. RESULTS

After applying the three steps, we obtained the following:

Testing for stationarity

ADF test was conducted on the GDP, COAL, GAS, HYDRO AND OIL data series. In all cases, trend and intercept were included in the equation of the test; the maximum number of lags was 9, the program being allowed to automatically choose the appropriate number of lags according to Akaike information criterion. The maximum length of 9 was determined by calculating after the method suggested in 1989 by Schwert mentioned in Zivot (2005):

$$maxLagLength = [12 * (T/100)^{1/4}]$$

where T is the number of observations. [m] denotes the integer part of m.

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TABLE 1 - VALUES OF ADF TEST

	LEVEL	FIRST Difference	Second difference
GDP	-2.048511	-2.703705	-7.599545
COAL	-1.608917	-5.491007	
GAS	-2.183013	-4.877838	
HYDRO	-2.854980	-2.224402	-5.354869
OIL	-2.382645	-5.410000	

Source: authors' calculations in Eviews

A part of the ADF test results, is contained in Table 1. It may be noted that for some time series the second level of differences has been calculated. Only so the values obtained after performing the test allowed the rejection of the null hypothesis (of a unit root or non-stationary series) and accepting the hypothesis of stationary series, namely of integration order I(2). The values obtained in the level calculations were higher than the values returned for three levels of confidence 1%, 5% and 10%; therefore the null hypothesis could not be rejected and could not be proved that the series are stationary and integrated of order I(0). Besides GDP and HYDRO, which are integrated of order I(2), series COAL, GAS and OIL are integrated of order I(1).

Testing cointegration

After testing for stationary series, the order of integration for GDP is I(2), as well as for HYDRO. So the regression equation was formed only for GDP and energy consumption from hydro source; the regression includes also the intercept and has the following expression:

GDP = 2984.38796566 + 27169.1253086*HIDRO

The residual series was kept and the ADF test was applied on it. In test's equation performed on this series, neither trend nor intercept were included, whereas the errors must have mean equal to zero.

As this time, the ADF test is applied to residuals, the null hypothesis of non/stationary could become the null hypothesis of non-cointegration. The value obtained for the test is less than the returned values for the three levels of confidence, therefore we can reject the null hypothesis and conclude that errors are integrated of order I (0). The order of integration of residuals is I(0), lower than that of variables in the regression, namely I(2); this means that the condition from cointegration definition is met. Also, the same results tell us that there is a long term relationship between GDP and HYDRO variables.

Given the Granger test interpretation rule stated above, we see that we can reject the null hypotheses 2, 4 and 7 and accept all others. Thus, there is a causal relationship in the short term, which starts from

COAL to GDP, from GDP to GAS and another one from OIL to GDP. In other words, the energy consumption from coal and oil sources affect short-term gross domestic product and economic growth can lead to a short-term energy consumption derived from natural gas.

TABLE 2 - RESULTS OF ADF TEST ON RESIDUES SERIES

	LEVEL	FIRST Difference	Second difference
Residuals series	-3.557230		
Test critical values	1% level: -2.632688 5% level: -1.950687 10% level: -1.611059		

Source: authors' calculations in Eviews

Testing causality

TABLE 3 - RESULTS AFTER APPLYING GRANGER TEST

Nr crt	Null Hypothesis	F-Statistic	Probability
1	GDP does not Granger Cause COAL	0.07835	0.7810
2	COAL does not Granger Cause GDP	6.26269	0.0166
3	GAS does not Granger Cause GDP	1.04679	0.3126
4	GDP does not Granger Cause GAS	9.03485	0.0046
5	HYDRO does not Granger Cause GDP	0.42191	0.5198
6	GDP does not Granger Cause HYDRO	0.60849	0.4401
7	OIL does not Granger Cause GDP	5.20422	0.0281
8	GDP does not Granger Cause OIL	0.31569	0.5774

Source: authors' calculations in Eviews

As we cannot reject any other hypothesis, even though a long term relationship between energy consumption from hydro sources and economic growth resulted in the previous step, in the short term the relationship is no longer valid.

4. CONCLUSIONS

In the literature are found several studies for different countries, industrialized or developing countries, studies that call into question the causal relationship between energy consumption and economic growth. Through this paper, we tried to outline this type of relationship, for Romania; thus we used time series for the period 1965-2007, with the per capita values. The methodology used included three steps, through which were obtained causal relationships in the short and long run, between real GDP per capita and energy consumption by fuel toe per capita.

Thereby, after testing for the degree of cointegration, the results showed that a long run causal relationship appears only between GDP and energy consumption that comes from hydropower. Because the relationship is not valid in the short term, therefore we cannot know the direction of the relationship. Instead, energy consumption with coal source, namely oil, does not affect long-term GDP, but only short term, having an important role in growth and development. Inverse relationship, for instance GDP energy consumption with coal source, or GDP energy consumption from oil resource, are not valid. Relationship that will start from GDP and influence one type of energy is valid only in the situation of energy consumption from natural gas resource. This tells us that Romania is not dependent on energy derived from natural gas to achieve economic growth. Furthermore, growth can lead to greater consumption of energy. Not even one bidirectional relationship was found.

Further research on the relationship between energy and economic growth can bring additional elements related to the impact of one over the other; they can be taken into account in developing effective and reliable energy system, in approving investment projects in the energy sector. Meanwhile, energy policy should be designed so that energy conservation measures do not adversely affect economic growth. As demand for energy is increasing, and the only renewable source of study established a long term relationship with GDP, leads to the conclusion that other renewable sources should be used too, increasingly more.

Taking into account that other policies, like urban development policy, reconsider the importance of the energy, the analysis made, should help in decision making when it comes to obtaining urban communities' welfare and economic growth. Has been a long time since the urban planning no longer considers just the spatial planning but also the social component, trade, services, environment, education, culture, science and research. From an administrative point of view, the city becomes a major player in the national economic scene, with its own rights, political importance and ability to ally with other actors to promote economic growth. Knowing that energy consumption and economic growth establish a connection, either on short or long term, the key is to decide what technology of energy efficiency to use, what renewable resource to exploit, how to decrease greenhouse gases emissions, how to enhance a green architecture by consuming less of those finite resources and more of renewable ones.

ACKNOWLEDGMENTS

This work was cofinanced from the European Social Fund through Sectoral Operational Programme Human Resources Development 2007-2013, project number POSDRU/107/1.5/S/77213„ Ph.D. for a career in interdisciplinary economic research at the European standards" (DOCCENT).

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