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Causality between economic growth and energy consumption in Croatia*

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Abstract

The main goal of the paper is to investigate relation between economic development and energy consumption in Croatia. This paper examines the casual relationship, using Granger test, between gross domestic products (GDP) and total primary energy consumption in Croatia. Analyzed period is from 1953 to 2005. In the paper vector auto-regression model (VAR), Granger causality test and unit root test are used as tools for analysis. Economic and energetic time series usually have the problem of non stationarity series. Non-stationary time series are trying stationarity with differentiation of variables, using co-integration technique. Applying Granger's causality test in Croatian case, we found that GDP Granger causes total energy consumption not energy consumption Granger causes GDP. The result shows that relationship for Croatia runs from total primary energy consumptions to gross domestic products, not from gross domestic products to primary energy consumption. Conclusion of VAR model is that variable total primary energy consumptions and the constant are not significant in the model and that variable gross domestic products is significant. Base conclusion of the paper is that VAR model evaluation shows that change of GDP of 1% in period t-1 would affect the annual total primary energy consumption for 0,509% in period t.

Key words: *GDP, growth, energy, consumption, Granger causality*

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1. Introduction

Energy and its influence on the economic growth has an important part in defining macroeconomic politics in a country, especially considering volatility of prices

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of energy-generating products in this millennium, after 2002. The importance of energy for the world's economic growth has been acknowledged in the last fifty years because of the increasing lack of energy resources, therefore more quality analyses of relations between energy and the growth of economy began in the outset of the first and the second energy crises in 1973 and 1979. In the last decade major financial institutions like International Monetary Fund (IMF) and World Bank (WB) are making macroeconomic models trying to quantify the influence of increase of oil prices on the growth of world's economy using different economic models.

One of the classical examples of implementing econometric models in the economic-an energy analysis is estimating the relation between two basic variables (Bohi and Zimmerman, 1984):

- Energy demand /consumption, and
- Economic growth of gross domestic product (GDP).

Thus, the opinion that economic growth causes energy demand prevailed until the 1990s, and it was based on elasticity of energy consumption regarding the change of the populations' income, therefore the downfall or the growth of the income causes the downfall or the growth of energy consumption.

Hypothesis of the paper is that economic growth causes energy consumption in Croatia.

2. Literature review

The relationship between energy consumption and economic growth analyzing the direction between these two variables was first researched by Engle and Granger (1987). Many later studies proved that the causal relation runs from economic growth towards increasing of energy consumption, as well as the increasing of energy consumption can lead to economic growth. On the other hand, some authors have proved that casual relationship among these two variables can be bi-directional; that is the direction of the impact from one variable to other is bi-directional, thus economic growth simultaneously effects energy consumption, and vice versa. The positive influence of energy consumption on economic growth can be seen in the positive externalities of energy; that especially electricity has on economic growth. The increase of electricity consumption is related to positive influence on health (e.g. through increasing usage of fridges) and, education (radio, television...) of population contributing to economic growth and increase of the level of development.

Pioneers in that thematic approach were Kraft and Kraft (1978), who analyzed the case of USA using data for the period 1947-1974, concluded that there is a unidirectional relationship from GNP to energy consumption, indicating that the increase of a national income affects the energy consumption. Erol and Yu (1987) analyzed six industrialized countries, and based on tested data found no significant causal relationship between energy consumption and GDP growth and, energy consumption and employment. Yu et. al. (1988), in the case of the USA found no relationship between energy consumption and employment, and between energy consumption and GNP. However, they detected that energy consumption negatively effects employment. Yu and Choi (1985), found causality between energy consumption and GDP in the Philippines, but in the case of the Republic of Korea increase of GNP causes increase of energy consumption. Cheng and Lai (1997), analyzing the case in Taiwan found that increase of GNP causes increase of energy consumption, and also the increase of energy consumption impacts the increase of employment without feedback.

The following tables show the comparative analysis of empiric results of Granger causality test published in various scientific literatures for various countries or groups of countries in the world.

Table 1: Comparison of empirical results from causality test

Authors	Analyzed countries and period of included data	Casual relation
Yu and Choi (1985)	South Korea, Philippines (1954-76)	GDP→ Energy
Masih and Masih (1996)	Malaysia, Singapore, Philippines, India, Indonesia, Pakistan (1955-90)	Mixed
Glasure and Lee (1997)	South Korea, Singapore (1961-90)	Energy ↔ GDP
Masih and Masih (1998)	Sri Lanka, Thailand (1955-91)	Energy → GDP
Asafy-Adjaye (2000)	India, Indonesia, Turkey (1973-95); Thailand, Philippines (1973-95)	Energy → GDP Energy ↔ GDP
Yang (2000)	Taiwan (1954-97)	Energy ↔ GDP
Soytas and Sari (2003)	Argentina, South Korea, Turkey, Indonesia, Poland (1950-92)	Mixed
Fetai et al. (2004)	India, Indonesia (1960-99), Thailand, Philippines (1960-99)	Energy → GDP Energy ↔ GDP
Jumbe (2004)	Malawi (1970-99)	GDP → Energy
Morimoto and Hope (2004)	Sri Lanka (1960-98)	Energy ↔ GDP
Oh and Lee (2004)	South Korea (1970-99)	Energy ↔ GDP
Paul and Bhattacharya (2004)	India (1950-96)	Energy ↔ GDP
Lee (2005)	18 countries (1975 – 2001)	Energy → GDP
Ambapour and Massamba (2005)	Congo (1960-99)	GDP → Energy
Keppler (2006)	China (1971-2002) India (1971-2002)	Energy → GDP GDP → Energy
Keppler (2007)	Argentina, Brazil, Chile, China, Egypt, India, Indonesia, Kenya, South Africa, Thailand (1960/71-2002)	Mixed

Source: Lee, C. (2005), Keppler, J. H. (2007)

This research has been conducted on various samples of countries. The previous table shows that there is no unambiguous conclusion about energy and economic growth. Energy can impact on economic growth, but also economic growth can cause the increase of energy consumption, as well as the existence of reciprocal influence, so the final results of these studies are diverse. Moreover, in the case of the Republic of Korea, different results can be seen depending on the period of study, which indicates the changes in the relationship between two variables during time.

3. Methodology

Granger causality (Granger, 1969) analyses to what extent the change of past values of one variable accounts for later variation of other variables. Therefore, Granger causality exists between variables y_t and x_t, if by using the past values of variable y_t, the variable x_t can be predicted with a better accuracy, and relating to a case when past values of variables y_t are not being used, with an assumption that other variables stay unchanged. Granger causality test usually analyses two variables together, testing their interaction. All of the possible permutations of the two variables are:

- Unidirectional Granger causality from variables y_t to variables x_t,
- Unidirectional Granger causality from variables x_t to variables y_t,
- Bi-directional casualty,
- No causality.

In all possible cases, a common assumption is that the data are stationary. Stationarity in a Random Process implies that its statistical characteristics do not change with time. If not the Granger causality on non-stationary time data can lead to false casual relation (Cheng, 1996). Economic and energetic time series usually have the problem of non stationarity series. The reason most often lies in constant change of legal and technical regulations and rules, and is making changes in the economic relations, which influences the change of time series. The change of regulations can affect the stationary time series, but in that case the relation between variables before and after the changes is stable. Non-stationary time series are trying stationarity with certain mathematic procedures, for example differentiation of variables.

Granger test of causality analyzes if the equation

$$y_t = \alpha_0 + \sum_{i=1}^{T} \alpha_{1i} y_{t-1} + \sum_{j=1}^{T} \alpha_{2j} x_{t-1} + \varepsilon_t$$

where is

$$0 \leq i, j \leq T$$

Gives better results than equation:

$$y_t = \beta_0 + \sum_{i=1}^{T} \beta_{1i} y_{t-1} + \varepsilon_t$$

where is

$\sum_{j=1}^{T} a_{2j} x_{t-1} = 0$ (the null hypothesis, H_0).

If the hypothesis H_0 is rejected where $\alpha_{21} = \alpha_{22} = ... = \alpha_{2T} = 0$, than it can be implied that according to Granger causality x_t causes variable y_t. The statement which implies that x according to Granger does not cause y, is gained if the current value if x better explains the current value y, and the past values of x and y, than just past values of y. Granger causality test explains which variable is dependent and which is independent in the equation, and in the energy economics most often the long term relation is formed between energy consumption and income of a country, and it is expressed through the gross domestic product.

To get valid results along with the Granger test the analysis of the stationarity of the original variables and then test cointegration between them. According to Granger (1986), the test is valid if the variables are not cointegrated. Second important element is the analysis of lag length. The studies have shown that the result of Granger causality test is very sensitive to the selection of lag length. If the chosen lag length is less than the true lag length, the omission of relevant lags can cause bias. If the chosen lag length is more the true lag length, the irrelevant lags in the equation cause the estimates to be inefficient and does not give expected results.

Two or more variables are said to be cointegrated if they share common trends i.e. they have long run equilibrium relationships. The technique of cointegration involves three steps. The first step requires a determination of the order of integration of the variables of interest.

For this purpose two popular tests are used: namely Dickey – Fuller (DF) and Augmented Dickey Fuller (ADF) test based on expanded Dickey – Fuller test; Perron (Perron 1988), Philips and Perron (1988) made a PP test, which is considered more useful for aggregates data; Kwiatkowski et al. (Kwiatkowski at al., 1992) – KPSS test; Perron (Perron 1989) with PB test which is considered more useful when there structural breaks time series data with PB test, which is considered better than other tests, if there are structural breaks in time series data.

Combining these tests, there are four different results to be considered:

1. Rejection with ADF and PP tests and the acceptance with KPPS test offer firm proof stationary of the analyzed data

2. The acceptance of ADF and PP tests and the rejection of KPPS test offers firm indication I(1);
3. Acceptance of all the tests indicates that the data with insufficiently long series of data is not representative enough.
4. Rejection of all the tests indicates that series of data is not I(1) nor I(0).

In literature, Dickey – Fuller (DF) test and Augmented Dickey Fuller (ADF) test (Dickey and Fuller 1979, 1981) are commonly used based on H_0:X_t is not I(0), which are given by the following equations:

$$\text{(DF) } \Delta X_t = a + bX_{t-1} + \varepsilon_t$$

where X_t denotes the variables GDP, energy consumption (total energy consumption or energy consumption of specific for, of energy like electricity, oil, gas,...). All the variables are real and in log form. Δ is the difference operator, a and b are parameters to be estimated.

ADF test:

$$\text{(ADF) } \Delta X_t = a + bX_{t-1} + \sum_{i=1}^{\gamma} c\Delta X_{t-1} + \varepsilon_t$$

a, b, and *c* are the parameters to be estimated, *y* is element t.

The tests are based on the null hypothesis (H_0): X_t is not I(0), If the calculated DF and ADF statistics are less than their critical values from Fuller's table, then the null hypothesis (H_0) is rejected and the series are stationary or integrated.

In the second step co-integration between variables is estimated using variables:
– Engle and Granger technique (Engle and Granger 1987), or
– Johansen maximum likelihood approach (Johansen 1988; Johansen and Juselius 1990, 1992)

The co-integration equation estimated by the OLS method is given as:

$$Y_t = a_0 + a_1 X_{ti} + Z_t$$

Where Y_t and X_t are the income and energy consumption.

In the third step residuals (Z_t) from the cointegration regression are subjected to the stationarity test based on the following equations:

$$\text{(DF) } \Delta Z_t = \alpha + \beta_0 Z_{t-1} + V_t$$

$$\text{(ADF) } \Delta Zt = \alpha + \beta_0 Z_{t-1} + \sum_{i=1}^{k} \beta_1 \Delta Z_{t-1} + V_t$$

where, Z_t is the residual from equation gained by OLS method. If b is negative and the calculated DF or ADF statistics is less than the critical value from Fuller's table, the null hypothesis of non-stationarity is rejected. On the other hand, if the null hypothesis of non-stationarity is rejected and the variables are not cointegrated then the standard Granger causality test is appropriate.

In the third step vector error-correction modelling and exogenous variables test are used.

Engle and Granger introduced a new method for the analysis of time series in 1987.

The assumption for their modelling is that they are stationary. Time series is a stationary, if its arithmetic mean does not depend on time, and if its variance does not change systematically through time. That implicates that the value of variance is a definite number. Therefore, time series return to the middle of the series and fluctuate around it, around its constant range. In practice, that mostly is not the case. Time series can be transformed, but working with such series leads to cases where it is difficult or almost impossible to interpret gained results.

By overcoming such circumstances, Engle and Granger have proven that if the independent series is integrated by the sequence I(d), and if the residual linear regression are among these variables integrated by the same order, I(d-b), then the series are coinegrated sequences d,b, CI(d,b).

In order to detect integration, it is necessary to note the order of the integration of variables x and y. Non-stationary series are causing problems when unit rooted, which equals them, being integrated to the first order. Such series are series of random walk, according to which the future value equals the past value increased by error. Random walk series are difficult for predicting future. Therefore, it is necessary for them to be tested for unit roots, and it is necessary to discover the order of integration. Causality in econometric relates to the possibility of one variable, predicting (and therefore causing) the rest of the variables.

Relation between these variables can be described by the VAR models. In this case is possible that variable x_t influences y_t, that y_t influences x_t, as well as there exists mutual influence of these variables, or that these variables are non dependent of each other.

Granger causality test comes down to the estimation of following VAR model:

$$y_t = a_1 + \sum_{i=1}^{n} \beta_i x_{t-i} + \sum_{j=1}^{m} \gamma_j y_{t-j} + e_{1t}$$

$$x_t = a_2 + \sum_{i=1}^{n} \theta_i x_{t-i} + \sum_{j=1}^{m} \delta_j y_{t-j} + e_{2t}$$

with the assumption of being correlated and producing white noise[2]. All the variables, used in analysis have unit roots, approximately of 5% of significance. Non-stationary has been removed by differentiation.

Hypothesis for Granger casualty test are:

$$H_0 \ldots \sum_{i=1}^{n} \beta_i = 0, x_t \text{ does not influence } y_t$$

$$H_1 \ldots \sum_{i=1}^{n} \beta_i \neq 0, x_t \quad \text{influences } y_t$$

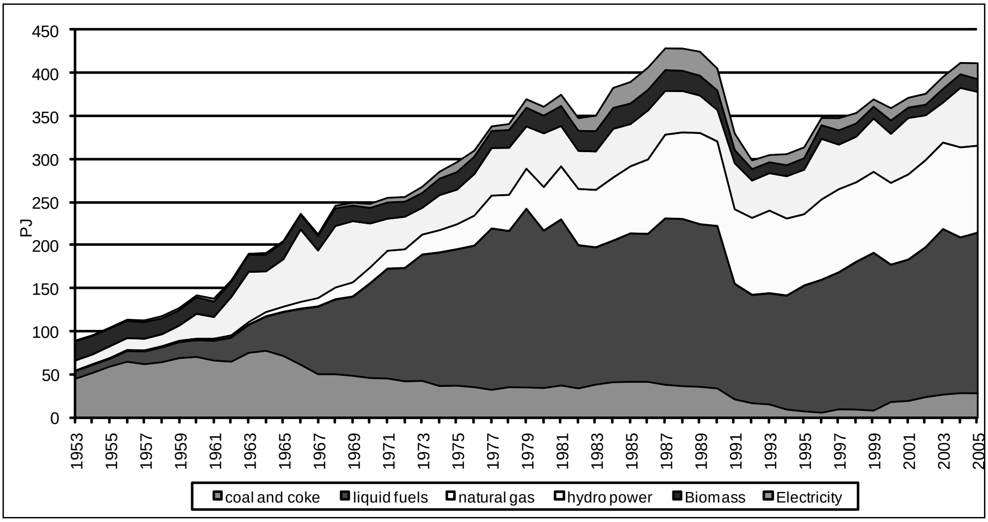
4. Data used

Total primary energy consumption (TPEC) and the fluctuation of economic activity (GDP) are connected variables. Total primary energy consumption is the result of cumulative consumption of particular forms of primary energy (coal and coke, liquid fuels, natural gas, hydro power, biomass, electricity, waste and renewable). In the longer time period major changes occur in the structure of energy consumption. The share of one energy forms falls while another energy forms rises.

On the following diagram are shown the total primary energy consumption according to different forms of energy. The analyzed period of total primary energy consumption and its structure is from 1953 to 2005, the period of 53 years.

[2] It is the process of the independent, equally distributed casual variables with constant expectation, for which it is usually assumed, that it equals zero and with constant variance.

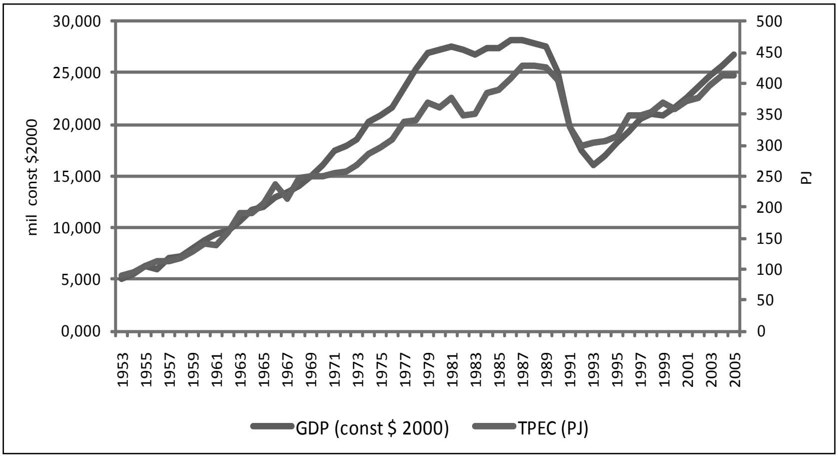
Diagram 1: Total energy consumption according to different forms of energy



Source: Energy balances 1945-2005, Energy Institute *Hrvoje Požar*

The total consumption of primary energy in the period over 50 years has increased approximately 4,6 times. If the period from 1945 was looked at, than the total consumption would be increased approximately 7,7 per year. From 1949 to 1953, there was no significant difference in the change of energy consumption. Energy consumption by 1990 has grown by the average year rate of 4%. As it can be seen from the previous diagram in the years 1991 and 1992, because of the aggression on Croatia, and war destruction, but also because of the transition of Croatian economy, major fall of energy consumption occurs. After 1991 the average rate of primary energy consumption growth is between 2 and 2.5% per year. In addition the structure of energy consumption has significantly changed. Until 1965 the dominant energy-generating product is coal and coke. After that the hydro power and liquid fuels become important. The consumption of hydro power has not got major deviation, while consumption of liquid fuels grows. The consumption of liquid fuels grows more significantly in 1980s and that trend still continues. The consumption of biomass and waste falls. The consumption of electricity only shows imported electricity, where after 1991 there are no major oscillations. The other analyzed forms of energy are input for energy transformation to electricity. Circulation of energy consumption and gross domestic product for the period of 1953 to 2005 is shown in the following diagram.

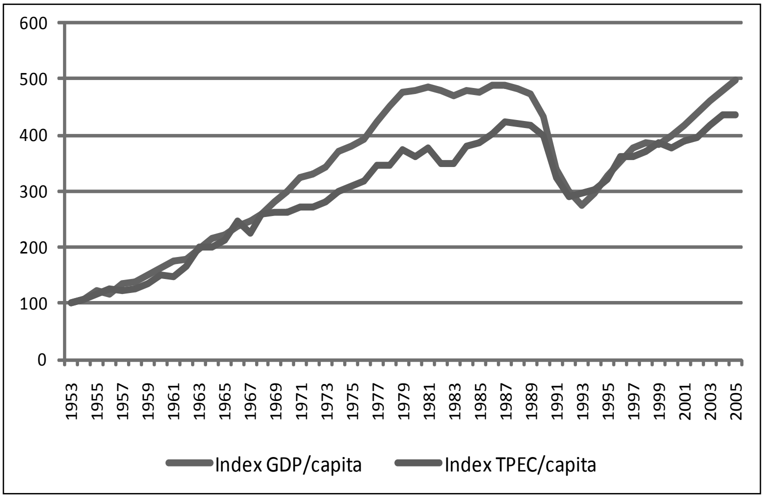
Diagram 2: Circulation of GDP and energy consumption



Source: authors' calculation (source: Energy balances 1945-2005, Energy Institute *Hrvoje Požar*; Druzic, I., Tica, J. (2002))

On the left side of diagram, the development of the GDP is shown in millions of American dollars and in the constant prices from 2000. On the right side circulation, primary energy consumption is shown in petajoulima (PJ). GDP grows until 1980, then it stagnates until 1990, and after that it falls primary because of the war, but also because of the downfall of planned economy. The fall of energy consumption occurs after the second oil crisis in 1980, as shown on the diagram. That same year the GDP has decreased. In the time of the first oil shock 1974, there is no slowing of the growth of energy consumption, and no increase of GDP. GDP has increased from 1953 to 2005 around 5,2 per year, and energy consumption around 4,6. The variable of population is included in the analysis, to exclude the influence of circulation of population on other two variables. GDP and energy consumption are divided with number of people per year, to get the GDP variable per capita and energy consumption per capita. On the next diagram, circulation of the index of GDP per habitant and energy consumption per capita is shown. The year 1953 is shown with index 100.

Diagram 3: Circulation of index GDP per habitant and consumption per capita (1953=100)



Source: authors' calculation (source: Energy balances 1945-2005, Energy Institute *Hrvoje Požar*; Druzic, I., Tica, J. (2002))

Until 1968 the growth of GDP and consumption of the energy per capita has been increasing by simultaneous rates. By the end of 60s and the beginning of the 70s, the increase of energy consumption per capita is slowing down, while after 1972 it starts increasing again until the second oil shock in 1979. Consumption per habitant has been constant until 1983 when sudden fall occurs; it is followed by the period of growth until 1989. At the same time GDP per capita, is increasing until 1979, afterwards stagnates for ten years, until 1989. Sudden fall occurs in 1991 and 1992, and then it is equalised until 1999.

Rates of growth of consumption per capita has been slowing down, while the growth rate of GDP per capita continue to circulate on the same level, except for the negative growth rate in 1998. One of the most important determinants, which influence the energy consumption, is the price of the energy. The price, which directly or indirectly influences all other energy prices, is the price of the oil. The nominal price has until 1974 been between 1and 2 USD/barrel. It is followed by the first oil shock and the price growth over 10 USD/barrel. The mild growth of nominal prices continues until 1979 and 1980, when the second oil shock occurs and the price grows over 35 USD it is followed by a decrease until 1986, when oil barrel equals 15 USD. By 1999 it has fluctuated between 15 and 20 USD per barrel. It is followed by the growth of the oil prices, and by the 2005 it around 55 USD per barrel. Circulation of the real prices has the same direction as one of the nominal ones, but there are enormous price differences. Oil price by 1981 reached the level of around 90 USD/barrel in dollars from 2006. By the 80s it has been around 30 USD per barrel and it has continued to decrease until 1998, when it was less than 20 USD (BP Statistical Review of World Energy, 2007).

5. Results

To be able to realize the connection between the energy and GDP, the first Granger test has been conducted, that applies to relation of the total primary energy consumption, and gross domestic product. The analysis has been done in the Program package Eviews 5.1. The analyzed period is between 1953 and 2005. Variables used in the modal are logarithmic, and defined:

– lgtpec – Logarithm of the total primary energy consumption
– lggdp – Logarithm gross domestic product

By using logarithms, the analysis of the changes in the percentage is conducted, that is the influence of change of one variable on the other variable is displayed in percentage.

The aim of econometric testing is to determine which of the following relations is valid for the mentioned two variables:

– whether the growth of total primary energy consumption affects the growth of gross domestic product,
– whether the growth of gross domestic product affects the growth of total primary energy consumption
– whether there is the mutual influence of gross domestic product and the growth of total primary energy consumption
– whether the growth of variables is independent of each other

Firstly, the model of analysis has been estimated, and later the Granger causality test has been taken.

VAR Model is:

$$\lg gdp_t = a_1 + \sum_{i=1}^{n} \beta_i \lg tpec_{t-i} + \sum_{j=1}^{m} \gamma_j \lg gdp_{t-j} + e_{1t}$$

$$\lg tpec_t = a_2 + \sum_{i=1}^{n} \theta_i \lg tpec_{t-i} + \sum_{j=1}^{m} \delta_j \lg gdp_{t-j} + e_{2t}$$

Hypothesis for the Granger causality test are:

$$H_0 ... \sum_{i=}^{n} \beta_i = 0, lg\ gdp_t \text{ does not influences } lg\ tpec_t$$

$$H_1 ... \sum_{i=1}^{n} \beta_i \neq 0, lg\ gdp_t \text{ influences on } lg\ tpec_t$$

Variable GDP is logarithmic, and since the original GDP series had unit roots lggdp has been differentiated and transformed into lggdpdif. Total primary energy consumption variable is as well logarithmic, lgtpec, and since it had unit roots it as well differentiated, lgtpecsdif was gained. In the following tables are the results of econometric analysis for mentioned tests. The results of analysis for the unit root test lgtpec, are displayed in the Appendix, Table 2 Test of the unit root without the differentiation for the total primary energy consumption.

The results show that the p-value is 5% higher, which leads to conclusion, that we are accepting the null hypotheses about the existence of a unit root, for the variable lgtpec.

For the abstraction of a unit root the differentiation of lgtpec is conducted, as shown in the Appendix, Table 3 Test of a unit root with differentiation.

Differentiated series has no unit root. P-value is 0.000, which is less than 5%, which leads to rejections of null hypothesis about the existence of the unit root. Also, the analysis for the unit root test has been conducted for lggdp. Considering that, lggdp had a unit root the variable has been differentiated and the unit root test has been repeated; and the results are displayed in the Appendix, Table 4 Unit root test with the differention for the logarithm of GDP.

The analysis has shown that the p-value is less than 5%, which excludes the assumption that the series has a unit root.

The next step in defining relations between the analyzed variables is defining the optimal length. Test about the adequacy of the model are shown in the Appendix, Table 5 Defying of the optimal lag length in variable in a model.

Value k has been defined by minimizing the information criteria, while simultaneously trying to decrease the autocorrelation of residual deviations. Based on the conducted tests about the model adequacy with various lag values, value k has been gained according to the information criterion gained in the previous table, where it can be seen that according to criterion the optimal lag 1 value (according to Schwarz and HQ-Hannan-Quinn information criterion), AIC-Akakike and FPE- Final prediction error), while according to LR- sequential modified LR test statistic the optimal lag value is 9. In the proceeding of the analysis, the optimal lag value, chosen according to most of the information criterion is used. In this case lag value 1 is used. Granger causality test, which is order of the variables proceeds in a model.

According to Granger causality test (Appendix, Granger causality test for logarithm of total primary energy consumption and GDP) with usual level of significant of 5%, we reject the assumption that the change of GDP does not affect of total primary energy consumption.

The theoretical F proportion is 4,04 which is less than 9,78 which leads to conclusion that we are rejecting the hypotheses that the change of GDP, does not cause the change of total primary energy consumption, and at same time it accepts the hypothesis that the total primary energy consumption does not cause the change of GDP.

VAR model has been evaluated in the first differentiation, and ratings are displayed in the Appendix, Table 7 Results of VAR model evaluation.

Based on the results of above evaluated equation of the influence of GDP change on total primary energy consumption change (first system equation) can be written down as:

$$\Delta \lg tpec_t = 0{,}017403 - 0{,}166440 \Delta \lg tpec_{t-1} + 0{,}509019 \Delta \lg gdp_{t-1}$$

The theoretical t proportion for n-1 freedom level and 5% significance is $t_{0.025}(50) = 2.009$.That leads to conclusion that $lgtpec_{t-1}$ and the constant are not significant in the model and that variable lggdp(t-1) is significant.

Economic interpretation of significant variables of evaluated equation is:

Change of GDP of 1% in period t-1 would affect the annual total primary energy consumption for 0,509% in period t.

The significance of gained results can be seen in the fact that GDP is the cause of change of total primary energy consumption and not that primary energy consumption is the cause of change in GDP.

6. Conclusions

In the paper we confirm our hypothesis that economic growth causes energy consumption in Croatia. The result of the Granger causality tests and cointegration analysis shows that relationship for Croatia runs from primary energy consumptions to gross domestic products, not from gross domestic products to primary energy consumption.

Conclusion of VAR model is that variable $lgtpec_{t-1}$ and the constant are not significant in the model and that variable $lggdp_{t-1}$ is significant. Results of VAR model evaluation shows that change of GDP of 1% in period t-1 would affect the annual total primary energy consumption for 0,509% in period t. This result shows how to predict future energy needs based on economic growth.

The mentioned results should be taken with a restriction considering that gross domestic product time series are evaluated from 1953 to 1990.

Future research will examine the casual relationship between gross domestic products and oil consumption or (other form of energy like electricity, coal, gas,…) in Croatia in the same period. Model will include oil prices as important determinant of oil consumption.

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Kauzalnost između ekonomskog rasta i potrošnje energije u Hrvatskoj

Tomislav Gelo[1]

Sažetak

Glavni cilj rada je istražiti vezu između gospodarskog razvoja i potrošnje energije u Hrvatskoj. Ovaj rad istražuje kauzalni odnos između bruto domaćeg proizvoda (BDP) i ukupne potrošnje primarne energije u Hrvatskoj. Analizirano razdoblje je od 1953. do 2005. godine. U radu su korišteni Grangerov test kauzalnosti, VAR model i unit root test. Vremenske serije ekonomskih i energetskih varijabli često imaju problem nestacionarnosti koje se kontegracijom pretvaraju u stacionarne. Koristeći navedene modele i testove u radu je pokazano da bruto domaći proizvod utječe na potrošnju primarne energije a ne da potrošnja primarne energije utječe na bruto domaći proizvod odnosno da porast BDP-a utječe na porast primarne potrošnje energije a ne da porast primarne potrošnje energije utječe na rast BDP-a. Zaključak dobivenog VAR modela je da su primarna potrošnja i konstanta nesignifikantne varijable a da je bruto domaći proizvod signifikantna varijabla. Osnovni zaključak VAR modela je da rast GDP-a od 1% u razdoblju t-1 utječe na rast primarne potrošnje od 0,509% u razdoblju t.

Ključne riječi: *BDP, rast, energija, potrošnja, Grangerova kauzalnost*

JEL klasifikacija: *C32*

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Appendices

Table 2: Test of the unit root without the differentiation for the total primary energy consumption

Null Hypothesis: lgtpec has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.769518	*0.7051*
Test critical values:	1% level	-4.144584	
	5% level	-3.498692	
	10% level	-3.178578	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(lgtpec)
Method: Least Squares
Date: 06/03/08 Time: 20:24
Sample (adjusted): 1954 2005
Included observations: 52 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
lgtpec(-1)	-0.067323	0.038046	-1.769518	0.0830
C	0.307992	0.136671	2.253532	0.0287
@TREND(1953)	0.000250	0.001125	0.222311	0.8250

R-squared	0.165754	Mean dependent var	0.029281
Adjusted R-squared	0.131703	S.D. dependent var	0.066221
S.E. of regression	0.061706	Akaike info criterion	-2.676909
Sum squared resid	0.186574	Schwarz criterion	-2.564337
Log likelihood	72.59964	F-statistic	4.867827
Durbin-Watson stat	1.974513	Prob(F-statistic)	0.011795

Table 3: Test of a unit root with differentiation

Null Hypothesis: D(lgtpec) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.874882	*0.0000*
Test critical values:	1% level	-4.148465	
	5% level	-3.500495	
	10% level	-3.179617	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(lgtpec,2)
Method: Least Squares
Date: 06/03/08 Time: 20:26
Sample (adjusted): 1955 2005
Included observations: 51 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(lgtpec(-1))	-0.992413	0.144353	-6.874882	0.0000
C	0.067548	0.021346	3.164384	0.0027
@TREND(1953)	-0.001453	0.000648	-2.242220	0.0296

R-squared	0.496142	Mean dependent var	-0.001333
Adjusted R-squared	0.475147	S.D. dependent var	0.088761
S.E. of regression	0.064305	Akaike info criterion	-2.593344
Sum squared resid	0.198485	Schwarz criterion	-2.479707
Log likelihood	69.13027	F-statistic	23.63242
Durbin-Watson stat	1.997785	Prob(F-statistic)	0.000000

Table 4: Unit root test with the differentiation for the logarithm of GDP

Null Hypothesis: lggdpdif has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic based on SIC, MAXLAG=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.360299	0.0056
Test critical values:	1% level	-4.148465	
	5% level	-3.500495	
	10% level	-3.179617	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(lggdpdif)
Method: Least Squares
Date: 06/03/08 Time: 21:49
Sample (adjusted): 1955 2005
Included observations: 51 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
lggdpdif(-1)	-0.575132	0.131902	-4.360299	0.0001
C	0.041839	0.019303	2.167460	0.0352
@TREND(1953)	-0.000900	0.000577	-1.560870	0.1251

R-squared	0.284255	Mean dependent var	-0.000661
Adjusted R-squared	0.254432	S.D. dependent var	0.064169
S.E. of regression	0.055408	Akaike info criterion	-2.891179
Sum squared resid	0.147360	Schwarz criterion	-2.777542
Log likelihood	76.72506	F-statistic	9.531482
Durbin-Watson stat	2.169057	Prob(F-statistic)	0.000327

Table 5: Defying of the optimal lag length in variable in a model

VAR Lag Order Selection Criteria
Endogenous variables: lggdpdif lgtpecdif
Exogenous variables: C
Date: 06/03/08 Time: 20:30
Sample: 1953 2005
Included observations: 40

Lag	LogL	LR	FPE	AIC	SC	HQ
0	120.5411	NA	9.14e-06	-5.927056	-5.842612	-5.896524
1	139.4223	34.93015	4.35e-06*	-6.671114*	-6.417782*	-6.579518*
2	141.4508	3.549960	4.81e-06	-6.572542	-6.150322	-6.419880
3	144.9780	5.819746	4.94e-06	-6.548898	-5.957790	-6.335172
4	146.1853	1.871442	5.73e-06	-6.409267	-5.649271	-6.134476
5	149.2256	4.408422	6.10e-06	-6.361281	-5.432398	-6.025426
6	150.0124	1.062096	7.30e-06	-6.200618	-5.102847	-5.803699
7	152.7641	3.439689	7.99e-06	-6.138206	-4.871546	-5.680222
8	154.2933	1.758541	9.40e-06	-6.014664	-4.579117	-5.495615
9	163.7722	9.952883*	7.52e-06	-6.288611	-4.684175	-5.708498
10	164.9110	1.081803	9.27e-06	-6.145548	-4.372225	-5.504370
11	167.9661	2.596904	1.06e-05	-6.098307	-4.156096	-5.396065
12	174.1141	4.610946	1.07e-05	-6.205703	-4.094604	-5.442396

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 6: Granger causality test for logarithm of total primary energy consumption and GDP (order of variables in a model)

Pairwise Granger Causality Tests
Date: 06/03/08 Time: 20:32
Sample: 1953 2005
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
lgtpec does not Granger Cause lggdpdif	51	2.97239	0.09092
lggdpdif does not Granger Cause lgtpecdif		9.78514	0.00299

Table 7: Results of VAR model evaluation (first differential of variables)

Vector Autoregression Estimates
Date: 06/03/08 Time: 20:40
Sample (adjusted): 1955 2005
Included observations: 51 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	lgtpecdif	lggdpdif
lgtpecdif(-1)	-0.166440	0.369714
	(0.15843)	(0.13598)
	[-1.05054]	[2.71890]
lggdpdif(-1)	0.509019	0.293083
	(0.16272)	(0.13966)
	[3.12812]	[2.09851]
C	0.017403	0.010667
	(0.00978)	(0.00840)
	[1.77896]	[1.27050]
R-squared	0.180241	0.359194
Sum sq. residue	0.182143	0.134175
S.E. equation	0.061601	0.052871
F-statistic	5.276889	13.45283
Log likelihood	71.32123	79.11520
Akaike AIC	-2.679264	-2.984910
Schwarz SC	-2.565627	-2.871273
Mean dependent	0.028541	0.030988
S.D. dependent	0.066662	0.064712
Determinant residue covariance (dof adj.)		7.39E-06
Determinant residue covariance		6.55E-06
Log likelihood		159.6511
Akaike information criterion		-6.025535
Schwarz criterion		-5.798261