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Assessment of Causality Relationship between Renewable Energy Consumption and Economic Growth in Lithuania

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The topic of the interrelationship between energy consumption and economic growth is widely discussed in scientific literature. Scientists agree that the reason for the interest in such investigations arises because of increased worldwide concern about the impact of energy and environmental policies on the country's economy. Recently, the investigations of causality interrelationships between energy consumption and economic growth have been performed for many countries, including Indonesia Thailand, Japan, China, other Asian countries, G7 economies, Spain, Albania, Bulgaria, Romania, Central America, OECD and non OECD, Sub-Sahara African countries, for the panel of countries (China, Hong Kong, Indonesia, Korea, India, Malaysia, Philippines, Singapore, Taiwan, and Thailand), and many other countries. The results of these investigations are different, country-specific and depend on the structure of the economy, energy type selected, period analyzed, methodology applied and a variety of other factors.

The main research question of this article is to answer if consumption of renewable energy sources (further in the text RES) might influence Lithuania's real gross domestic product (further in the text real GDP); if so what is real GDP elasticity of RES gross inland consumption in Lithuania. Thus, the causality interrelationship between RES gross inland consumption and real GDP in Lithuania during 1990-2009 is analyzed and elasticity coefficients are calculated.

At the beginning of the article scientific literature regarding the issue of interrelationship between RES consumption and economic growth is reviewed. Later, applied methodology is briefly described. Unit root, co-integration and Granger causality tests are the main methods employed to set an interrelationship between the selected variables.

The results of the analysis show that there is a uni-directional causality running from RES gross inland consumption to real GDP in Lithuania in a short-run. The conclusion that wider utilization and consumption of RES could contribute to Lithuanian real GDP in a short-run is reached. A long-run effect of RES development on real GDP is not identified. Calculated coefficients of real GDP elasticity of RES gross inland consumption are positive and above 1.0, i.e. real GDP is elastic in respect to RES gross inland consumption. This reflects that RES gross inland consumption increases slightly slower than real GDP. However, during economic recession period that was influenced by external factors, the growth of RES gross inland consumption only a little could improve the reduction of real GDP (real GDP elasticity is negative).

Keywords: *renewable energy consumption, economic growth, Granger causality, co-integration, elasticity.*

Introduction

Level of problem exploration. The topic of the interrelationship between energy consumption and economic growth is widely discussed in global scientific literature. After the time Kraft and Kraft (1978) found that there was a uni-directional causality running from energy consumption to gross national income in USA during 1947 – 1974, the number of articles, which deal with this topic, noticeably increased. Recently, the issue of causality relationship between energy consumption and economic growth has been investigated by Adjaye (2000), Yoo (2006), Chen *et al.* (2007), Jinke *et al*. (2008), Lee & Chang (2008), Narayan & Smyth (2008), Chontanawat *et al*. (2008), Apergis & Payne (2009), Akinlo (2009), Ozturk & Acaravci (2010), Menegaki (2011), and others. These scientists agree that the reason for the major interest in these investigations arises because of worldwide increased concern about the impact of energy and environmental policies on the country's economy. The results of performed investigations are controversial; therefore scientists are not of uniform opinion on the impact of energy consumption on the country's economic growth. Several scientists (Narayan & Smyth, 2008; Akinlo, 2009) agree that causality runs from energy consumption to economic growth. They draw a conclusion, that economic growth is dependent on energy consumption, and a decrease in energy consumption, which could be caused by implemented energy conservation policy, may restrain economic growth. This issue is relevant both for economically well developed and developing countries. Others (Yoo, 2006; Chen *et al*., 2007; Jinke *et al*., 2008)

set a reverse relationship, i.e. scientists found that economic growth caused energy consumption. Certainly a bi-directional causality between energy consumption and economic growth was found (Mahadevan & Adjaye, 2007; Paul & Bhattacharya, 2004). This suggested that an increase in energy consumption directly affected economic growth and the latter also stimulated further energy consumption. It is worth noting that neutrality hypothesis was also approved (Ozturk & Acaravci, 2010). It implied that there weren't causality relationships between energy consumption and economic growth.

The problem of the article covers the following question: might the consumption of RES influence on Lithuania's real GDP? If so, what is real GDP elasticity of RES gross inland consumption in Lithuania?

Novelty of the paper. This paper contributes to existing scientific literature in a way it analyses the interrelationship between RES gross inland consumption and real GDP in Lithuania. The authors consider this to be one of the first attempts to assess the causality relationships between the mentioned variables specifically for Lithuania.

Thus, the aim of the article is to assess the causality relationships between RES gross inland consumption and economic growth (real GDP is taken as an indicator) in Lithuania during 1990-2009.

The object of the article is interrelationship between RES and real GDP in Lithuania.

Seeking to implement the aim, the following ***tasks*** are set:

- ❖ to review scientific literature, analyzing relationships between RES consumption and economic growth;
- ❖ to briefly describe the methodology applied in investigation of causality relationships;
- ❖ to overview the tendencies of RES consumption and economic growth in Lithuania;
- ❖ to set the causality interrelationship between RES consumption and real GDP;
- ❖ to assess real GDP elasticity to the RES gross inland consumption.

In order to exercise these tasks the following ***methods*** are applied: the analysis of scientific literature, quantitative analysis of selected statistical data, augmented Dickey-Fuller, Phillip-Perron, Johansen, and Granger causality tests.

Review of literature about interrelationship between RES consumption, economic growth, and efficiency

Scientific literature is well-off publications in which the relationship between energy consumption and economic growth is investigated. However, there are only few articles, which deal with the relationship between RES and economic growth, and renewable energy and efficiency. In this context valuable research was performed by Chien & Hu (2007; 2008). Chien & Hu (2007) set that the consumption of RES improved economy's technical efficiency, whereas the consumption of other type of energy decreased technical efficiency. Seeking to improve technical efficiency it is not necessary to increase energy consumption. Controversially, technical efficiency might be improved when traditional energy is substituted by RES. The findings of the research suggested that the government of the country should adopt comprehensive strategies to promote consumption of RES. A year later Chien & Hu (2008) analyzed the channels through which the effect of RES might pass GDP in 116 economies during 2003. The results of the investigation told that RES have a significant and positive impact on capital formation. Similar results were received by Bobinaite *et al.* (2011). Scientists set that Lithuanian GDP (calculated at previous year prices) was sensitive over the consumption of indigenous resources, including RES. Development of indigenous resources might explain 92.9% of GDP development in the country. Besides, an increase of indigenous resources by 1 ktoe might improve GDP by 82.6 million LTL. The positive influence of indigenous resources passed Lithuania's GDP through this variable positive effect on gross capital formation. It was also set that households' consumption expenditure was dependent on the volume of indigenous resources, i.e. the consumption of indigenous resources increased households' consumption expenditure.

A valid contribution to the topic of the relationship between renewable energy consumption and real GDP was done by Apergis & Payne (2010a; 2010b; 2011) too. Scientists had analyzed the statistical data of various groups of countries those level of economic development was very different. They used heterogeneous panel co-integration and Granger causality tests to reveal the relationship between renewable energy consumption and real GDP in short- and long-run. The results of the tests for different groups of countries were very similar. The results of the heterogeneous panel co-integration test showed that a long-run equilibrium relationship between renewable energy consumption and real GDP existed in 20 OECD countries during 1985-2005 (Apergis & Payne, 2010a), 15 Eurasia (including Lithuania) countries during 1992-2007 (Apergis & Payne, 2010b), 6 Central America countries during 1980-2006 (Apergis & Payne, 2011). However, the elasticity coefficients for renewable energy consumption with respect to real GDP were different. It was calculated that a 1% increase in renewable energy consumption increased real GDP in OECD countries by 0.76%, in Central America countries by 0.244%, in Eurasia countries by 0.195% when Russia is included in the analysis and only by 0.074% when Russia is excluded. The results of Granger causality test supplemented the results of performed heterogeneous panel co-integration test in two ways. Firstly, Granger-causality test affirmed that bi-directional causality between two variables existed both in short- and long-run. Secondly, the results indicated that renewable energy consumption might affect real GDP through its positive impact on real gross fixed capital formation. Later Apergis *et al.* (2010c) expanded the scope of research in a way they investigated the causality relationships between four variables, i.e. between CO_2 emissions, nuclear energy and renewable energy consumption, and economic growth in 19 developed and developing countries during 1984-2007. A long-run relationship between the selected variables was set. Besides a bi-directional causality relationship between renewable energy consumption and economic growth was found. Moreover, some additional calculations were performed and conclusions done. The results of these

calculations showed that a 1% increase in nuclear energy consumption reduced CO_2 emissions by 0.477%, whereas renewable energy consumption so far didn't reach a level at which it could contribute to this reduction.

Methodology for the assessment of causality relationship

Data analysis. The analysis of the relationship between renewable energy consumption and economic growth will be started after the tendencies of selected variables are presented. Time series of Lithuanian real GDP and RES gross inland consumption will be analyzed in this paper. Agreeably to Yoo & Ku (2009) real GDP in national currency Litas (LTL) instead of GNP as a measure for economic growth was chosen. The decision to select GDP instead of GNP was influenced by the fact that energy consumption of the specific country is related to goods and services produced within the country but not outside it. Chontanawat *et al*. (2008) recommended including final energy consumption (consumption of industry, construction, agriculture, transport, fishing, commercial and public services, as well households) into the investigation. Narayan & Prasad (2008) investigated the causality running from electricity consumption to real GDP in 30 OECD counties and used only industrial electricity consumption. RES (wind, hydro, geothermal, biomass, biofuel) gross inland consumption will be analyzed in this paper. The examined data are of the year 1990-2009.

Unit root, co-integration and Granger causality tests. Properties of selected time series will be analyzed. For this purpose unit root test will be performed. The aim of this test is to ascertain the stationarity of time series. At the same time this test allows to find the order of the integration "d", which is relevant in taking a decision to perform a co-integration test and to determine a long-run equilibrium among the selected series.

The scientific literature proposes various types of tests for stationarity of selected series testing. Yoo & Ku (2009) and Odhiambo (2010) applied Phillip-Perron (*further in the text PP*) test, since this test is familiar to be robust for a variety of serial correlations and time-dependent heteroscedasticities. Chontanawat *et al*. (2008) and Jinke *et al*. (2008), Pilinkus & Boguslauskas (2009) used the augmented Dickey-Fuller (*further in the text ADF*) test. Since the ADF test might be specious for testing stationarity when presence of structural breaks of variables is taken into account, therefore Zhang & Cheng (2009) employed Zivot and Andrews unit root test. Yuan *et al*. (2008), Soytas & Sari (2009) applied five different unit root tests, i.e. augmented Dickey–Fuller, Elliot–Rothenberg–Stock Dickey–Fuller GLS detrended, Phillips–Perron, Kwiatkowski–Phillips–Schmidt–Shin, and Ng–Perron MZα. These tests produced contradictory results. With reference to performed analysis of scientific literature, ADF and PP tests will be employed in this paper.

The ADF test takes several forms. Two cases will be analyzed in this paper. They are the following:

$$\Delta y_t = \alpha_0 + \beta y_{t-1} + \delta_1 \Delta y_{t-1} + \\ + \delta_2 \Delta y_{t-2} + ... + \delta_p \Delta y_{t-p} + \varepsilon_t \quad (1)$$

$$\Delta y_t = \alpha_0 + \beta y_{t-1} + \gamma t + \delta_1 \Delta y_{t-1} + \\ + \delta_2 \Delta y_{t-2} + ... + \delta_p \Delta y_{t-p} + \varepsilon_t \quad (2)$$

Here: Δy_t – 1st differenced value of y;
α_0 – intercept;
y_{t-1} – the 1st lagged value of y;
y – variable to be tested;
p – augmenting lags;
ε_t – error term;
t – time trend;
β, δ_p – the parameters to be estimated.

The (1) equation represents time series, which is flat and slow-turning around a non zero value. This equation has an intercept term, but no time trend; whereas the (2) equation describes time series, which has a trend (down or up) and is potentially slow-turning around a trend line. The equation (1) and (2) represents that the results of the unit root tests depends on lag lengths, therefore appropriate lag length should be selected. Scientific literature suggests employing Akaike Information Criterion or Schwarz Information Criterion (*further in the text SIC*). SIC will be used in this paper.

In parallel with ADF test, the PP test will be employed. This test is appropriate since it make a correction to the t-statistics. Unlike the ADF test, there are no lagged differences terms in PP test. Thus, the PP test is described by the equation (3):

$$\Delta y_t = \mu + \rho y_{t-1} + \varepsilon_t \quad (3)$$

Both tests refer to the hypotheses that the series is:
H_0: Non-stationary
H_A: Stationary

Seeking to reject the H_0 it is essential to compare t-statistics of ADF and PP tests to critical values at 1%, 5% and 10% significance level. With reference to You & Ku (2009), the probability value of 0.10 is reasonable level of significance for small sample sizes.

In the case H_0 is accepted, the unit root exists and time series is non-stationary. Thus, it is necessary to difference it. Differencing commonly converts series from non-stationarity to stationarity. If time series is stationary then it is determined as integrated and is noted as I(d), where "d" is the order of integration. If both series are found to be I(1) (stationary after the first difference) or one I(1) and the other I(2) (stationary after the second difference), or both I(2) then co-integration test is performed (Chontanawat *at el*., 2008).

The co-integration test will be performed in order to reveal the existence of a long-run equilibrium. If two series are co-integrated then a long-run effect exists. This prevents the two series drifting away from each other and will force the series to converge into a long-run equilibrium (Kadir & Jusoff, 2010). In contrary, when co-integration doesn't exist, then a linear combination is not stationary. The Johansen procedure will be applied seeking to disclose a long-run equilibrium.

Causality relationship between series will be tested using Granger causality test. It is pointed out that series x_t Granger causes y_t, if y_t can be predicted with better

accuracy by using past values of series x_t. Other factors are kept constant. Granger causality model is described by formula (4):

$$y_t = \mu_t + \sum_{i=1}^{p} \alpha_i y_{t-i} + \sum_{j=1}^{q} \beta_i x_{t-i} + \varepsilon_t \quad (4)$$

Here: μ_t – deterministic component;

ε_t – white noise;

β_i, α_i – the parameters to be estimated.

H_0 will be tested using F-test. When p-value is significant, then H_0 is rejected. This implies that the first series Granger causes the second series and vice versa.

Elasticity coefficient will be calculated to show, how much y will change if x will increase by 1%. The elasticity coefficients will be calculated by the formula (5):

$$E = \frac{\Delta y_{\%}}{\Delta x_{\%}} \quad (5)$$

Here: E – y elasticity of x;

$\Delta y_{\%}$ – percentage change of y;

$\Delta x_{\%}$ – percentage change of x.

Based on the methodology described above, tendencies of economic growth and RES consumption will be overviewed, tests will be performed and calculations will be done. The main results are presented in the next sections of the paper.

Tendencies of economic growth and RES consumption in Lithuania

Lithuania's economy was developing inconsistently during 1990-2009. Montvilaite (2009) segregated six stages of Lithuanian economy development during this period. With reference to this segregation, tendencies of GDP and its drivers will be shortly presented in this section of the paper. In more details drivers of economic growth were also elaborated by Seckute & Tvaronavicius (2007), Lapinskiene & Peleckis (2009), Lapinskiene & Tvaronaviciene (2009), Lakstutiene (2009), Snieska & Simkunaite (2009), Karazijiene (2009), Zilinske (2010), Kilijoniene *et al.* (2010).

After the recovery of independence in 1990 the country met a deep recession, which was influenced by economic, social and political transformations. The economic slump was comparatively large in Lithuania. At the end of 1994, Lithuanian GDP dropped to 56.1% of the 1990 level (Figure 1).

The "recovery" period (1995-1998) brought the country economic stability and growth. Real GDP grew by approximately 6.8% a year. Mistakes of domestic economic policy and Russian crisis influenced on economic recession in Lithuania in 1999, when real GDP decreased by 1.1%. The year 2000 was a turning point for the national economy. Since this year the national economy was growing very fast. During 2000-2003 real GDP was growing by 7.9% a year.

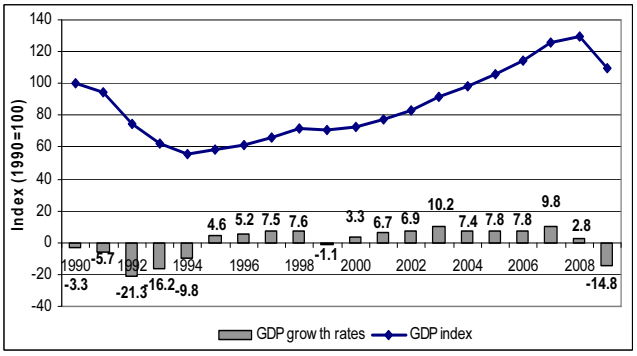

Figure 1. Changes of real GDP annual growth rates and index (Lithuanian Statistics Department)

Growth of export volume by 12.5%, increase of household expenditures and expenditures for gross capital formation respectively by 7.3% and 13.0% a year were the main factors influencing on changes of GDP. The highest growth rate of real GDP (10.2%) was recorded for the year 2003. It is argued that thereinafter (2004-2007) national economy was highly influenced by both internal and external factors those impacts on economic development were controversial. On the one hand, economic development was restricted by increasing fuel prices in global markets, migration of labor force and growth of labor costs. On the other hand, economic development was positively influenced by received support from EU Structural funds, low interest rates, which increased consumption and borrowing of households and private sector (Montvilaite, 2009). As a result of these factors, real GDP grew by 7.8% a year. The global economic crisis affected Lithuanian real GDP already in 2008. Reduction of internal consumption and significant decrease in export of goods were very important factors that caused dramatic decline of GDP in 2009. Thus, this short overview of Lithuanian GDP development and its drivers also shows that the role of energy is not always taken into account, when GDP development is analyzed. This paper will fill this gap by analyzing the possibility of RES to contribute to the country's economic growth.

After the recovery of independence the consumption of RES was very low in Lithuania (Figure 2).

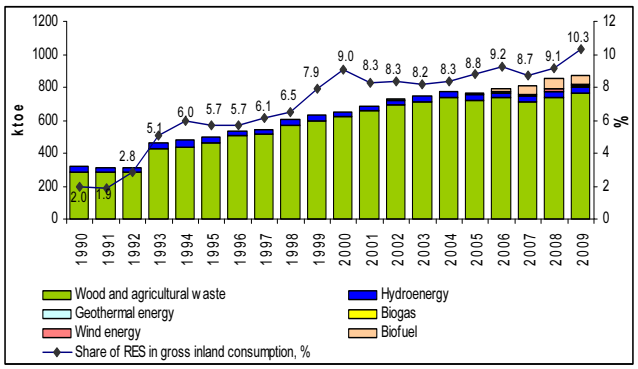

Figure 2. RES gross inland consumption during 1990-2009 (Lithuanian Statistics Department)

It amounted only to 320.3 thousand tones of oil equivalent (*further in the text ktoe*) and made only 2% of gross inland energy consumption in 1990. Due to the reasons, which were analyzed by Konstantinavicute *et al.*

(2010), Bobinaite & Konstantinaviciute (2010), RES gross inland consumption was increasing by 5.4% a year. In 2009, RES gross inland consumption amounted to 874.3 ktoe (10.3% of gross inland energy consumption); this is 25.2 ktoe more than in 2008.

Figure 2 showed that wood and wood waste dominated in the structure of RES. In 2009, wood and wood waste covered about 93.4%, hydro energy – 4.5%, biofuels – 6.4%, wind energy – 1.7%, biogas and geothermal energy – 0.6% each, and agricultural waste – 0.4% of total RES consumption. 35.2% of these RES were transformed in power and heat plants in 2009. It is worth noting that the amount of RES transformed in these plants was increasing by 15.6% a year during 2001-2009. Development of final RES consumption in sectors of national economy is presented in Figure 3.

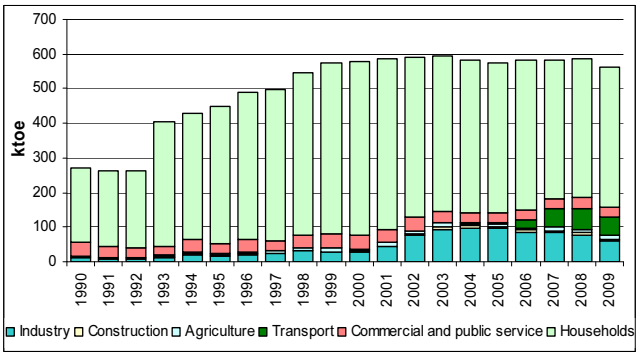

Figure 3. RES consumption in the sectors of the national economy during 1990-2009 (Lithuanian Statistics Department)

Figure 3 showed that households were the main consumers of RES. However, during Lithuanian rapid economic development period households were tended to reduce RES consumption by 3.3% a year. This reduction might be covered by the consumption of natural gas and electricity. During the period of national economy slowdown the common structure of fuel consumed in household sector changed. Again, households increased consumption of wood and wood waste. In 2009, 71.9% of RES have been consumed in households, 11.2% – in industry, 9.2% – in transport, 5.2% – in trade and service, 1.9% – in agriculture, 0.5% – in construction.

It is worth noting that Lithuania was a net exporter of RES during 2001-2009, except in 2007 when imports exceeded exports by 0.8 ktoe. With reference to statistical data 163 ktoe of wood and agricultural waste, biogas and biofuel were exported and 78.5 ktoe were imported in 2009. RES export volume increased from 51.3 ktoe (2007) till 163 ktoe (2009).

Based on the data presented above a unit root, Johansen co-integration, Granger causality tests are performed and elasticity coefficients calculated. Results are presented in the next sections of this paper.

Results of unit root, Johansen co-integration and Granger causality tests

The stationarity of RES gross inland consumption and real GDP was tested using ADF and PP tests. These tests helped to determine the existence of unit root. The results of unit root tests for stationarity at levels are presented in Table 1.

Table 1

Unit root for stationarity at level

Variables	ADF (Intercept)	ADF (Intercept and Trend)	PP (Intercept)	PP (Intercept and Trend)
RGDP	-1.807014 (-3.020686)	-2.825493 (-3.673616)	-1.894559 (-3.020686)	-1.718097 (-3.658446)
RES	-0.682074 (-3.020686)	-2.498144 (-3.658446)	-1.086097 (-3.020686)	-2.498144 (-3.658446)

Significance at 5% level. Number in the angle brackets indicates the critical value. The lag length was selected using Schwarz's information criterion.

Results, presented in Table 1, show that the H_0 is accepted. Thus, real GDP and RES gross inland consumption are not stationary in levels, when 5% significance level is considered. These series have to be differenced. The results are presented in Table 2.

Table 2

Unit root for stationarity at first difference

Variables	ADF (Intercept)	ADF (Intercept and Trend)	PP (Intercept)	PP (Intercept and Trend)
RGDP	-3.341076 (-3.029970)	-3.633466 (-3.673616)*	-3.270051 (-3.029970)	-3.618883 (-3.673616)
RES	-5.459973 (-3.029970)	-5.511985 (-3.673616)	-5.864342 (-3.029970)	-8.704202 (-3.673616)

*Significance at 5% level. Number in the angle brackets indicates the critical value. * represents the rejection of H_0 of non-stationarity at 10% level of significance. The lag length was selected using Schwarz's information criterion.*

Data presented in Table 2 show that none-stationarity can be rejected for first difference of real GDP and RES gross inland consumption series at 5% level of significance. However, a remark has to be done considering the results of ADF test when intercept and trend is included in real GDP series. In this specific case the stationarity can be affirmed at 10% level of significance. The results tell that both series become stationary after the first differencing. This implies that series are integrated in order one, i.e. I(1). Since series are found to be I(1), the co-integration test is performed. The results of the test are presented in Table 3.

Table 3

Results of the Johansen co-integration test

Hypothesized No. of cointegration equations	Trace statistics	5% critical value	Probability	Max-Eigen Statistics	5% critical value	Probability
None	13.02225	15.49471	0.1140	11.37955	14.26460	0.1362
At most 1	1.642697	3.841466	0.2000	1.642697	3.841466	0.2000

With reference to the results of the Johansen co-integration test, it could be stated that there is no co-integration between series at 5% level of significance. This implies that the long-run relationship does not exist between real GDP and RES gross inland consumption. However, Johansen co-integration test was based on the assumption that level data y_t have linear trends, but co-integrating equations have only intercepts.

In order to identify the causality relationships between selected series, the Granger causality test was performed. The results of the test are presented in Table 4.

Table 4

Results of Granger causality test

H_0	Number of lags	Number of observations	F-statistics	Probability	Conclusion
RES does not Granger cause RGDP	1	20	3.67430	0.0722	Rejected
RGDP does not Granger cause RES			0.04886	0.8277	Accepted
RES does not Granger cause RGDP	2	19	8.14986	0.0045	Rejected
RGDP does not Granger cause RES			0.36934	0.6977	Accepted
RES does not Granger cause RGDP	3	18	3.97736	0.0382	Rejected
RGDP does not Granger cause RES			1.05604	0.4068	Accepted
RES does not Granger cause RGDP	4	17	6.80133	0.0109	Rejected
RGDP does not Granger cause RES			1.36656	0.3268	Accepted

As it is indicated in Table 4, the results of Granger causality test are lag sensitive. The results tell that RES gross inland consumption Granger causes real GDP at 10% level of significance when 1 lag is considered and at 5% level of significance when 2, 3 and 4 lags are included. The Granger causality test indicated that there was one-way causality running from RES gross inland consumption to real GDP during 1990-2009. However, the received results contradict the results received by Menegaki (2011) who investigated the causal relationship between economic growth and renewable energy in EU-27 during 1997-2007. The empirical results didn't confirm causality between renewable energy consumption and GDP, therefore a "neutrality" hypothesis was approved by the scientist.

Real GDP elasticity of RES gross inland consumption

Real GDP elasticity to RES gross inland consumption was calculated. The results are presented in Figure 4.

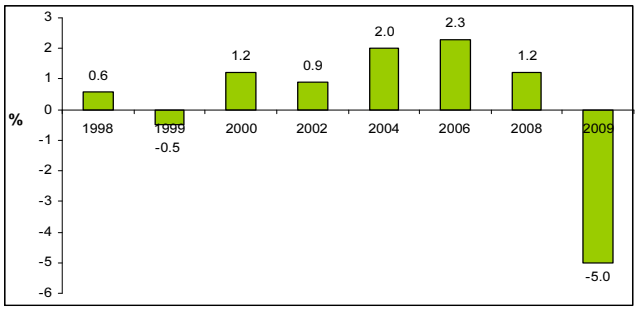

Figure 4. Real GDP elasticity of RES gross inland consumption during 1998-2009 (own calculations)

Figure 4 shows that real GDP is elastic to RES gross inland consumption and RES consumption grows slower than real GDP. For example, a 1% increase in RES gross inland consumption could increase real GDP by 1.2% in 2000. It should be noted that this would be the case if RES gross inland consumption was the only factor influencing on real GDP.

Figure 4 also represents that a negative interrelationship between RES gross inland consumption and real GDP existed in 1999 and 2009, i.e. an increase of RES was associated with the decrease of real GDP. Such situation can be explained by the fact that real GDP was negatively and highly influenced by external factors (by economic recession in global markets) but not RES consumption. Certainly, due to increasing RES export volume in 2008-2009, the slump of real GDP in 2009 could be slightly mitigated.

Conclusions

RES are an important constituent part of energy sector and national economy. The analysis of the relationship between RES gross inland consumption and real GDP showed that RES gross inland consumption could be a factor influencing on real GDP in a short-run in Lithuania. There was found a uni-directional causality running from RES gross inland consumption to real GDP during 1990-2009 (the assumption that level data y_t have linear trends, but co-integrating equations have only intercepts was taken into account). With reference to the results, it could be argued that wider utilization and consumption of RES could contribute to Lithuanian real GDP in a short-run. Positive interrelationship between the selected variables was found during economic growth periods. In the case of

economic recession the amount of RES consumed could only mitigate a slump of real GDP. This reflects that this sector is too small to highly influence on economic growth. As a result a long-run effect of RES consumption on real GDP was not identified. Nonetheless, increasing export volume of wood, biogas and biofuels could be a channel through which very small, but positive impact of RES passed Lithuanian real GDP in a short-run. As well it was set that indigenous resources (including RES) passes Lithuania's GDP through their positive effect on gross capital formation and the consumption of indigenous resources increases households' consumption expenditure (Bobinaite *et al.*, 2011). Calculated coefficient of real GDP elasticity to RES gross inland consumption showed that real GDP is elastic to RES gross inland consumption and RES consumption grows slower than real GDP.

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Atsinaujinančios energijos vartojimo ir ekonomikos augimo priežastinių ryšių vertinimas Lietuvoje

Santrauka

Problemos ištyrimo lygis. Energijos vartojimo ir ekonomikos augimo tema mokslininkai nemažai diskutuoja. Šia tema susidomėta po to, kai Kraft & Kraft (1978) paskelbė straipsnį, kuriame nagrinėjo JAV energijos vartojimo ir bendrųjų nacionalinių pajamų priežastinius ryšius 1947–1974 m. Mokslininkai nustatė, kad egzistuoja vienpusis priežastinis ryšys tarp šių kintamųjų, t. y. energijos vartojimas lemia bendrųjų nacionalinių pajamų dydį. Nustačius šį ryšį sustiprėjo atsakomybė tų asmenų, kurie priima sprendimus, įgyvendinant energetikos ir aplinkosaugos politiką. Šiuo metu mokslininkai nesutaria, ar yra priežastiniai ryšiai (ir kokie, jei yra) tarp energijos vartojimo ir ekonomikos augimo. Vieni mokslininkai (Narayan & Smyth, 2008; Akinlo, 2009) teigia, kad energijos vartojimas lemia ekonomikos augimo tempus, t. y. mažėjant energijos suvartojimui, šalies ekonomikos augimo tempai lėtėja. Šie mokslininkai, remdamiesi gautų tyrimų rezultatais, priėjo prie išvados, kad suvartotas energijos kiekis yra ekonomikos augimo veiksnys. Vadinasi, įvairiose pasaulio šalyse įgyvendinama energijos taupymo politika gali lėtinti ekonomikos augimo tempus. Kiti mokslininkai (Yoo, 2006; Chen et al., 2007; Jinke et al., 2008) nustatė atvirkštinį ryšį, t. y. energijos vartojimas yra ekonomikos augimo pasekmė. Suprantama, tarp energijos vartojimo ir ekonomikos augimo gali būti nustatytas dvipusis priežastingumo ryšys (Mahadevan & Adjaye, 2007; Paul & Bhattacharya, 2004). Šiuo atveju, didėjant vartojamam energijos kiekiui, auga ekonomika; jai augant, toliau suvartojama daugiau energijos. Kita vertus, mokslinėje literatūroje yra tokių tyrimų, kurių rezultatai byloja, kad tarp minėtų kintamųjų nėra jokių priežastinių ryšių.

Mokslinės literatūros apžvalga. Nors yra pakankamai įvairių straipsnių, kuriuose keliama energijos vartojimo ir ekonomikos augimo tarpusavio ryšio problema įvairiais aspektais (konkrečios šalies, taikomų metodų, analizei pasirinkto laikotarpio ir kitais požiūriais), tačiau pastebima, kad nėra daug publikacijų, kuriose gvildenamos atsinaujinančių energijos išteklių (toliau AEI) ir ekonomikos augimo, AEI suvartojimo ir efektyvumo problemos. Prie šios grupės galima priskirti Chien & Hu (2007; 2008), Apergis & Payne (2010a; 2010b; 2011), Menegaki (2011) ir Bobinaite et al. (2011) darbus. Chien

& Hu (2007) atliktų tyrimų rezultatai rodo, kad daugiau suvartojus AEI, gali padidėti šalies ekonomikos techninis efektyvumas, o daugiau suvartojus tradicinės energijos, techninis efektyvumas gali sumažėti. Pasirodo, techninį efektyvumą galima padidinti vietoj tradicinių energijos išteklių vartojant AEI. Chien & Hu (2008) taip pat tyrė, kokiais kanalais AEI vartojimo poveikis gali būti perduodamas ekonomikai. Mokslininkai, apibendrinę 116 šalių patirtį, nustatė, kad AEI vartojimo nauda perduodama vienam iš BVP elementų, t. y. AEI daro tiesioginę įtaką bendrojo kapitalo formavimui. Panašius tyrimų rezultatus pateikė Bobinaite et al. (2011). Pritaikiusios daugialypės tiesinės regresijos modelį, autorės nustatė, kad vietinių energijos išteklių (tarp jų ir AEI) vartojimo įtaka Lietuvos BVP yra dvejopa. Viena vertus, AEI plėtra daro teigiamą įtaką bendrojo kapitalo formavimui. Kita vertus, vartojant vietinius energijos išteklius didėja namų ūkių vartojimo išlaidos. Nustatyta, kad vietinių energijos išteklių vartojimo apimtims padidėjus 1 ktne (kilotona naftos ekvivalentu), BVP padidėja 82,6 mln. Lt. Verta paminėti Apergis & Payne (2010a; 2010b; 2011) atliktų tyrimų rezultatus. Šie mokslininkai, atlikę Grangerio priežastingumo testą, nustatė, kad tirtose šalyse ilguoju ir trumpuoju laikotarpiais, tarp AEI suvartojimo ir BVP egzistavo dvipusis ryšys. Pasirodė, kad AEI vartojimas darė tiesioginę įtaką bendrojo vidaus produkto, apskaičiuoto išlaidų būdu, investicijų komponentei. Vėliau Apergis & Payne (2010) išplėtė tyrimų sritį į nagrinėjamų veiksnių sąrašą įtraukdami CO_2 emisijas. Mokslininkai apskaičiavo, kad branduolinei energijai vartojimo padidėjus 1 proc. CO_2 emisijos sumažėja 0,477 proc. Tenka pripažinti, kad AEI sektorius kol kas dar nepasiekė tokio lygio, kad galėtų sumažėti CO_2 emisijos.

Šio straipsnio problema formuluojama klausimu: ar atsinaujinančios energijos vartojimas gali turėti įtakos Lietuvos realiajam BVP? Jei taip, tai koks yra realiojo BVP elastingumas suvartotos atsinaujinančios energijos atžvilgiu?

Darbo tikslas – įvertinti priežastinius ryšius tarp atsinaujinančių energijos išteklių bendrojo suvartojimo ir ekonomikos augimo (jį nusako Lietuvos realusis BVP, apskaičiuotas praeitų metų kainomis) 1990–2009 m.

Darbo objektas – ryšys tarp bendrojo AEI suvartojimo ir realiojo BVP.

Siekiant įgyvendinti užsibrėžtą tikslą, iškelti šie *darbo uždaviniai*:

- atlikti mokslinės literatūros apžvalgą;
- trumpai aprašyti taikomą metodologiją;
- apžvelgti AEI suvartojimo ir ekonomikos augimo tendencijas Lietuvoje;
- nustatyti AEI suvartojimo ir realiojo BVP priežastinius ryšius;
- apskaičiuoti realiojo BVP elastingumą AEI atžvilgiu.

Darbe taikyti šie *metodai*: mokslinės literatūros analizė, statistinių duomenų kiekybinė analizė, ADF, Phillipo ir Perrono, Johansono ir Grangerio priežastingumo testai.

Taikyta metodologija. Pasirinktų kintamųjų priežastiniai ryšiai buvo analizuoti taikant šiuos metodinius etapus:

- pirminis duomenų analizės etapas: atlikta realiojo BVP ir AEI kitimo tendencijų bei struktūros analizė;
- vienetinės šaknies, kointegravimo ir Grangerio priežastingumo testų tikrinimo etapas: ištirtos realiojo BVP ir AEI laiko eilučių savybės, apžvelgti taikomų metodų ypatumai ir priimtos prielaidos;
- elastingumo įvertinimo etapas: pagal pateiktą formulę atlikti realiojo BVP elastingumo skaičiavimai AEI atžvilgiu.

Tyrimų rezultatai. Lietuvos ekonomika 1990–2009 m. plėtojosi netolygiai. Montvilaitė (2009) išskiria 6 Lietuvos ekonomikos plėtros etapus. Pasinaudojus šios autorės pateiktu ekonomikos plėtros skaidymu laike, buvo atlikta Lietuvos BVP ir jo veiksnių analizė. 1990 m. atkūrus Lietuvos nepriklausomybę, šalį ištiko gilus nuosmukis. Jį lėmė vykstančios ekonominės, socialinės ir politinės transformacijos. Nuosmukis buvo didelis–1994 m. Lietuvos BVP sudarė tik 56,1 proc. 1990 m. BVP lygio (1 pav.). „Atsigavimo“ laikotarpiu (1995–1998 m.) realusis BVP didėjo po 6,8 proc. kasmet. Vidaus klaidos ir Rusijos krizė pakoregavo Lietuvos ekonomikos raidą. 1999 m. šalies realusis BVP sumažėjo 1,1 proc. 2000 m. yra vadinami lūžio metais. Nuo šių metų šalies ekonomikos plėtra vyko ypač sparčiai. 2000–2003 m. realusis BVP augo po 7,9 proc. kasmet. Tokiems BVP tempams įtaką darė didėjančios eksporto apimtys (vidutiniškai po 12,5 proc. kasmet), didėjantys pagrindinio kapitalo formavimo tempai (vidutiniškai po 13,0 proc. kasmet), ir didėjantis namų ūkių vartojimas (vidutiniškai po 7,9 proc. kasmet). Vėlesniais metais ekonomikos plėtrą lėmė tiek vidiniai, tiek išoriniai veiksniai, kurių poveikis ekonomikai buvo skirtingas. Viena vertus, ekonomikos augimą stabdė didėjančios kuro kainos, darbo jėgos migracija. Kita vertus, ekonomikos plėtrą teigiamai veikė ES parama, mažos palūkanų normos. Pasaulinė ekonominė krizė pakoregavo Lietuvos realųjį BVP. 2009 m. mažėjo vidaus vartojimo ir eksporto apimtys. 1990–2009 m. AEI vartojimui buvo būdinga augimo tendencija. AEI suvartojimo apimtys po Lietuvos nepriklausomybės atgavimo buvo nedidelės (2 pav.). 1990 m. jos sudarė tik 2 proc. bendrojo energijos suvartojimo šalyje. Dėl priežasčių, kurios išsamiai buvo nagrinėtos Konstantinavičiūtės et al. (2010), Bobinaitės, Konstantinavičiūtės (2010) darbuose, 1990-2009 m. AEI suvartojimo apimtys šalyje didėjo po 5,4 proc. kasmet. 2009 m. Lietuvoje buvo suvartota 874,3 ktne AEI (tai sudarė 10,3 proc. bendrojo energijos suvartojimo). AEI struktūroje dominavo malkos ir medienos atliekos. AEI struktūroje malkos ir medienos atliekos 2009 m. sudarė 93,4 proc., hidro energija – 4,5 proc., biodegalai – 6,4 proc., vėjo energija – 1,7 proc., biodujos ir geoterminė energija – po 0,6 proc. ir žemės ūkio atliekos – 0,4 proc. 3 pav. matyti, kad namų ūkiai yra pagrindiniai AEI vartotojai Lietuvoje. Vis dėlto sparčiai augant ekonomikai namų ūkiai buvo linkę mažinti AEI vartojimą kasmet po 3,3 proc. Toks mažėjimas buvo dengiamas daugiau naudojant gamtinių dujų ir elektros energijos. Ekonomikos nuosmukio laikotarpiu kuro struktūra namų ūkiuose keitėsi – namų ūkiai padidino malkų ir medienos atliekų naudojimą. Verta pastebėti, kad 2001 - 2009 m. (išskyrus 2007 m.) Lietuva buvo grynoji AEI eksportuotoja. AEI eksporto apimtys padidėjo nuo 51,3 ktne (2007 m.) iki 163 ktne (2009).

Atlikus laiko eilučių analizę, toliau darbe atliekami vienetinės šaknies, Johanseno kointegravimo, Grangerio priežastingumo testai. AEI ir realiojo BVP laiko eilučių stacionarumas nustatomas pritaikius papildytą Dickey ir Fullerio (ADF), ir Phillipo ir Perron (PP) testus. Šie testai padeda nuspręsti, ar yra vienetinė šaknis. Vienetinės šaknies testų rezultatai pateikti 1 ir 2 lentelėse. 1 lentelėje pateikti rezultatai rodo, kad H_0 hipotezė yra priimama, vienetinė šaknis egzistuoja, todėl realiojo BVP ir AEI laiko eilutės nėra stacionarios lygyje, esant 5 proc. reikšmingumui. Todėl būtina nagrinėti pirmos eilės skirtumus. 2 lentelės duomenys rodo, kad pirmos eilės skirtumų realiojo BVP ir AEI laiko eilutės yra stacionarios. Tai rodo, kad laiko eilutės yra integruotos pirma eile. Kadangi abi eilutės yra I(1), todėl atliekamas kointegravimo testas, kurio rezultatai leidžia daryti išvadas apie ilgalaikio ryšio egzistavimą. 3 lentelėje pateikti kointegravimo testo rezultatai. Remiantis 3 lentelės duomenimis, daroma išvada, kad nėra ilgalaikio ryšio tarp realiojo BVP ir AEI bendrojo suvartojimo. Priežastiniai kintamųjų ryšiai nustatyti, atlikus Grangerio priežastingumo testą. Rezultatai pateikti 4 lentelėje, kuri rodo, kad AEI bendrasis suvartojimas daro įtaką realiajam BVP. Atlikto testo rezultatai rodo, kad egzistuoja vienpusis ryšys tarp AEI suvartojimo ir realiojo BVP, t. y. AEI lemia realųjį BVP. Apskaičiavus realiojo BVP elastingumą AEI suvartojimo atžvilgiu, nustatytas santykinis elastingumas – AEI didėja lėčiau nei realusis BVP. Pavyzdžiui, 2000 m. AEI bendrojo suvartojimo apimtims padidėjus 1 proc. realusis BVP padidėjo 1,2 proc. Neigiamas ryšys tarp AEI ir realiojo BVP egzistavo 1999 m. ir 2009 m. Tokios situacijos susidarymą lėmė išoriniai veiksniai. Žinoma, augant AEI eksporto apimtims, realiojo BVP apimties kritimas 2009 m. galėjo būti pristabdytas.

Išvados. AEI yra svarbi Lietuvos energetikos sektoriaus ir šalies ekonomikos sudedamoji dalis. Atliktų tyrimų rezultatai rodo, kad AEI vartojimas yra realiajam BVP darantis įtaką veiksnys trumpuoju laikotarpiu. Tai įrodo, kad platesnis AEI panaudojimas galėtų prisidėti prie BVP apimties didėjimo. Teigiamas ryšys tarp nagrinėtų kintamųjų pastebėtas tik ekonomikai augant. Ekonomikai smunkant, didesnis AEI naudojimas gali pristabdyti BVP apimčių mažėjimą.

Raktažodžiai*: atsinaujinančios energijos vartojimas, ekonomikos augimas, Grangerio priežastingumas, kointegravimas, elastingumas.*

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