Energy consumption and Economic Growth Nexus in the Baltic Countries: Causality Approach

Gitana Dudzevičiūtė[1], Rima Tamošiūnienė[2]

Abstract. **The relationship between energy consumption and economic growth has been a hot issue in academic research. The results of the investigations have been varied due to quite different national economic development and diversity of research methods as well. This paper investigates the causal relationship between energy consumption and economic growth in the Baltic countries, such as Lithuania, Latvia and Estonia in the period of year between 1995 and 2012. To that end, Granger causality test is applied in order to suggest which variable in the model has significant impact on the future value of other variable in the system. Based on the causal relationship, regression model has been employed for the estimation of interrelationship between energy consumption and economic growth. The empirical results could be summarized as following: 1) in terms of correlation analysis between energy consumption and economic growth, there is a weak and insignificant relationship for Lithuania, strong and significant for Latvia and moderate one for Estonia; 2) in terms of causality running from GDP to energy consumption, the causal relationship exists for Estonia. The main implication of this finding is that the energy conservation policies will not have impact on economic growth; moreover, the results of the research highlight the absence of Granger causality between variables observed in the case of Lithuania and Latvia. In this light, national energy policies will not have impact on economic growth as well as economic growth will not has influence on energy consumption.**

Index Terms: **energy consumption, economic growth, Granger causality, regression analysis.**

JEL: **C10, C12, O47, Q43**

I. Introduction

The growth of energy consumption in the European Union countries poses serious development constraints in recent years. According to prognosis the global energy consumption will continue to increase in the next twenty years. It is estimated that global oil consumption will increase one percent and global natural gas consumption will increase 1.5 percent on average per year, so that total increase in energy demand will amount to 45 percent by 2030 (Ozkan 2011; Dudzevičiūtė 2012).

[1] Gitana Dudzevičiūtė is with the Faculty of Business Management, Vilnius Gediminas Technical University, Sauletekio ave. 11, LT-10223 Vilnius, and with the Department of Management, The General Jonas Žemaitis Military Academy of Lithuania, Šilo str. 5A, LT-10322 Vilnius Lithuania.

[2] Rima Tamošiūnienė is with the Faculty of Economics and Finance Management, Mykolas Romeris University, Ateities str. 20, LT-08303 Vilnius, Lithuania.

In academic research, the relationship between energy consumption and economic growth is analyzed from different theoretical aspects. Scientists discuss the causality between these two variables – the question whether this relationship exists and what is its nature has been raised. Some of them (Ho *et al.* 2007; Akinlo 2009; Ozturk 2010; Munim *et al.* 2010; Tsani 2010; Lee *et al*. 2011; Apergis 2012; Yildirim *et al*. 2014) assume unidirectional causality from energy consumption to economic growth and emphasize very significant role of energy consumption on economic growth. This relationship denotes an energy dependent economy and in the case of limited access to energy supply can result in poor economic development. Under this scenario, economic development programmes should aim at improving access to energy for all populations and sectors (Squalli 2007). While others signify that economic growth is the central factor which causes energy consumption and indicates an economy which is less energy dependent. In this case energy management policies, such as investments in energy efficiency will have no adverse impact on GDP growth (Ouedraogo 2013).

Also in recent academic research findings are presented that imply a mutual and complementary relationship between energy consumption and economic growth (Bartleet and Gounder 2010; Esso 2010; Eggoh *et al.* 2011; Belke e*t al.* 2011; Fuinhas and Marques 2012) or indicate that the energy consumption has no impact on economic growth (Huang *et al.* 2008; Payne 2009; Acaravci and Ozturk 2010; Yalta and Cakar 2012). In the case of the absence of causality between energy consumption and economic growth, policies to promote higher levels of energy consumption will not have an impact on economic growth (Ouedraogo 2013).

This research attempts to provide more reliable estimates of the causal relationship between energy consumption and economic growth in the Baltic countries and uses annual data of 2000-2013.

The paper is organized as follows. Section 2 gives a short summary of the relevant empirical literature review on the relationship of energy consumption and economic growth and research methodology. The investigations are summarized and the main insights are provided. Section 3 analyses the main trends and causal relationship between energy consumption and economic growth in three countries, such as Lithuania, Latvia and Estonia. Granger causality test and regression model are applied for the

estimations. Section 4 concludes summarizing the main trends observed.

II. EMPIRICAL RESEARCH REVIEW AND METHODOLOGY

A. Empirical research overview

As discussed above, in the context of economic growth, energy resources play a crucial role. Over the past decade, the causal relationship between energy consumption and economic growth has been analyzed extensively by energy specialists. Recently published researches on the energy – growth nexus were done in two ways (Dudzevičiūtė 2013) – some researchers analyze the causal relationship between separate energy resources (electricity, gas, coal, renewable resources and others) and economic growth (Bobinaitė *et al*. 2011; Li 2011; Georgantopoulas 2012; Tang and Tan 2012), others (Chontanawat *et al.* 2008; Odularu and Okonkwo 2009; Bojnec and Papler 2011; Zhixin and Xin 2011; Chen *et al*. 2012; Campo and Sarmiento 2013; Yildirim *et al.* 2014) examine energy – growth nexus focusing on total energy consumption. In general, the findings of the investigations show a strong relationship between energy and economic growth. However, the two focus variables have been a point of disagreement in the academic research.

An important research of the impact of energy consumption on economic growth was done by Chontanawat *el al.* (2008). The study examined the relationship for over 100 countries, divided into two categories such as developed OECD countries and developing non-OECD countries. The empirical estimates showed that there is the causality from energy to economic growth and it is stronger in the developed countries than in developing ones.

Another study of energy – growth nexus was conducted by Yildirim *et al*. (2014) in the next 11 countries. The findings implied that energy conservation-oriented policies should be implemented in Bangladesh, Egypt, Iran, Korea, Mexico, Indonesia, Pakistan and Philippines. In the case of Turkey, a unidirectional causal relationship was found between energy consumption and economic growth. It indicates that energy conservation policy poses an obstacle for economic growth in Turkey.

Campo and Sarmiento (2013) examined the long run relationship between energy consumption and economic growth for 10 Latin American countries. The results showed interconnection between two variables. According to the research results, a 1% increase in total energy consumption increases economic growth by 0.59%. At the same time, a 1% growth in GDP causes an increase in energy consumption by 0.59%. This finding supports the policies that promote energy conservation and efficiency (Campo and Sarmiento 2013).

The study of Lin and Wesseh (2014) revealed unidirectional causality running from energy consumption to economic growth in South Africa. The findings of research imply that energy conservation policies will negatively impact on economic growth in South Africa.

Given the wide range of empirical evidences in the scientific literature on the causal relationship between energy consumption and economic growth, no general conclusion can be made regarding the differences in research results between developed and developing countries. A similar picture appears in the scientific researches of the separate resources of energy (electricity, renewable and non-renewable resources and others) and growth nexus. More specifically, electricity consumption has become the dominant form and it is considered to be very important for economic growth. Many studies have been conducted on this topic (Chen et al. 2007; Squalli 2007; Ho et al. 2007; Gurgul and Lach 2011; Georgantopoulas 2012). The findings of these studies imply different forms of relationship between energy resources and economic growth such as unidirectional causality, the absence of causality, a mutual and complementary relationship.

The direction of causality between energy consumption and economic growth has significant policy implication. On the one hand, in the case of unidirectional causality running from energy consumption to economic growth, conserving or reducing energy could reduce economic growth. On the other hand, in the case of unidirectional causality from economic growth to energy consumption, conservation policies may be implemented with little or no effects on economic growth. When causality does not exist, it means that neither conservative nor expansive policies regarding energy consumption have any impact on economic growth.

All researchers have concluded that there are interdependency of energy consumption and economic growth, but the practices of different countries lead to different results regarding the presence of causality.

B. Research methodology

This research was guided by the estimation of energy consumption – growth nexus in the Baltic countries. The author refer to methodology on energy – growth relationship considered in studies of different countries (Chontanawat *et al.* 2008; Odularu and Okonkwo 2009; Bojnec and Papler 2011; Zhixin and Xin 2011; Eddrief-Cherfi and Kourbali 2012; Chen *et al*. 2012; Yildirim *et al.* 2014). The ratios of energy consumption per capita and GDP per capita (Eddrief-Cherfi and Kourbali 2012; Yildirim *et al.* 2014) are used in order to compare three Baltic countries – Lithuania, Latvia and Estonia as well. Granger (1969) causality test is applied for the estimation of causality and the direction of relationship between energy consumption and economic growth. Granger causality test requires estimating the following two regression equations (Kozhan 2010; Stern 2011):

$$y_t = \beta_{1,0} + \sum_{i=1}^{p} \beta_{1,i} y_{t-i} + \sum_{j=1}^{p} \beta_{1,p+j} x_{t-j} + \varepsilon_{1t} \quad (1)$$

$$x_t = \beta_{2,0} + \sum_{i=1}^{p} \beta_{2,i} y_{t-i} + \sum_{j=1}^{p} \beta_{2,p+j} x_{t-j} + \varepsilon_{1t} \quad (2)$$

where: *p* is the number of lags, β- parameter, ε- error. If the *p* parameters $\beta_{1,p+j}$ are jointly significant then the null hypothesis that x does not Granger cause y can be rejected. Similarly, if the p parameters $\beta_{2,i}$ are jointly significant then the null hypothesis that y does not Granger cause x can be rejected. Granger causality test is based on the concept of causal ordering and assumption as follows: a variable x is said to Granger cause another variable y if past values of x help predict the current level of y given all other appropriate information (Stern 2011).

Finally, a regression model would be more appropriate for more detailed analysis of energy consumption – economic growth nexus. When the relationship of the variables has been established as linear, a regression equation can be applied as follows (Kozhan 2010):

$$y_i = a + bx_i \quad (3)$$

where: y_i- dependent variable (energy consumption or economic growth taking into consideration the results of Granger causality), x_i – independent variable (energy consumption or economic growth taking into consideration the results of Granger causality), a, b- parameters. The parameter b indicates how much y may change on average, if x is changed by unit.

All calculations are made using Windows-based econometric software Eviews v. 6.0.

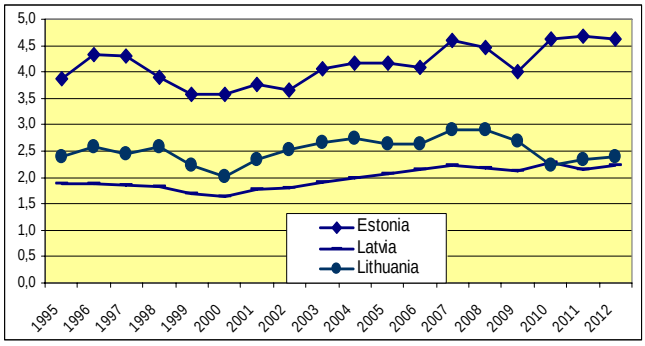
Section 3 analyses the relationship between energy consumption and economic growth.

III. Investigation of the Interrelationship between Energy Consumption and Economic Growth

A. Energy consumption and economic growth trends in the Baltic countries

Two approaches are employed in this research. First, annual data analysis of the three Baltic countries – Lithuania, Latvia and Estonia – is carried out in the period of 1995 - 2012. The aim of this exercise is to compare three Baltic countries according to energy consumption and economic growth ratios and analyze the relationship between these two variables. Second, the causal relationship and its direction is examined using Granger causality test; and regression model is made to describe reliance of one factor from another in quantitative way.

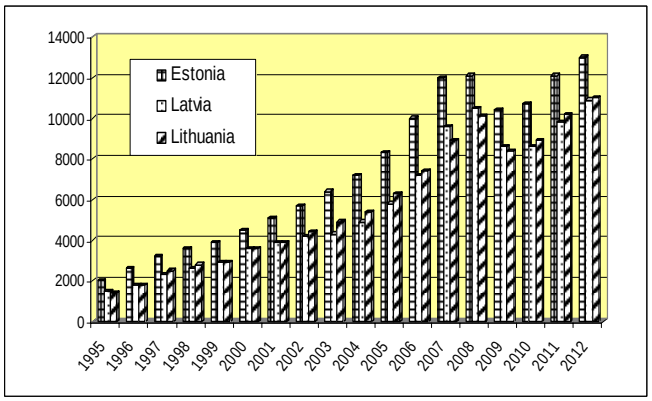
Figure 1 and figure 2 represent the tendencies of energy consumption per capita and GDP per capita in the Baltic countries. The analysis of these indicators has provided empirical insights into the long-run. Indeed, the general findings for all three countries have been as follows: 1) slight variation of energy consumption per capita, which has made over 9 percent; and 2) very big variation of GDP per capita, which has made over 50 percent. Over a period of 1995-2012, every Estonian has used energy twice as much than Lithuanian and Latvian. In 2012, the ratio of energy consumption per capita was amounted to 4.6 TOE in Estonia and 2.4 and 2.2 TOE in Lithuania and Latvia respectively. The Estonian energy consumption per capita increased from 3.9 TOE in 1995 to 4.6 TOE in 2012. In Latvia, the growth of the same ratio was from 1.9 TOE in 1995 to 2.2 TOE in 2012. In 1995 – 2012, the Lithuanian energy consumption per capita remained at the same level and made 2.4 TOE in 2012.



Source: Eurostat data

Figure 1. Energy consumption per capita, TOE

Over a period of 1995 – 2012, three Baltic countries have recorded the growth of GDP per capita. The greatest increase has been recorded in Estonia. It has increased from EUR 2 thou in 1995 to EUR 13 thou in 2012. In Lithuania, the growth was from EUR 1.4 thou to EUR 11 thou, and in Latvia from EUR 1.5 thou to EUR 10.9 thou. Estonia has declared relatively higher ratio of GDP per capita than other Baltic countries in 1995 – 2012. Average value of this indicator has made EUR 7.4 thou in Estonia and EUR 5.8 thou in Lithuania and Latvia.



Source: Eurostat data

Figure 2. GDP per capita, Euro

In order to evaluate the relationship and its direction between energy consumption and economic growth correlation analysis has been performed. The results have been summarized in Table 1.

The study of correlation analysis has shown different results of Baltic countries regarding energy consumption – economic growth nexus. It is noticeable that Lithuania has revealed weak and positive relationship between these factors. The t-test applied for this relationship has suggested statistical insignificance. The case of Latvia and Estonia has revealed strong and moderate relationships of

the same direction between energy consumption per capita and GDP per capita. The t-test for these countries has shown that these relationships are reliable; and energy consumption and economic growth have been directly related i.e. when one ratio increases the other grows as well and vice versa.

TABLE 1.
RESULTS OF CORRELATION ANALYSIS BETWEEN ENERGY CONSUMPTION AND GDP RATIOS

Country	Relationship strength		t-critical	t-observed	Statistical significance
Lithuania	0.27	Weak	2.12	1.12	Insignificant
Latvia	0.87	Strong	2.12	6.92	Significant
Estonia	0.69	Moderate	2.12	3.79	Significant

Correlations between the trending variables say nothing about causation and simply reflect that both factors have weak, strong or moderate trends relative to the fluctuations around the trend. Correlation does not show causation. In this light, Granger causality testing to modeling the relationship between energy consumption and economic growth has been applied to this research. It has revealed if energy consumption has caused economic growth or economic growth has driven increasing energy consumption; or the absence of causality.

The answers to these questions are important for analyzing and implementing energy policies. Next section is devoted for this issue.

IV. GRANGER CAUSALITY TESTING

Granger causality test is to study the forerunner-lag relationship between the two variables such as energy consumption per capita and GDP per capita have been investigated in this section of the paper. A variable – energy consumption is said to Granger cause another variable – economic growth – if past values of energy consumption help predict the current level of economic growth given all other appropriate information. This is based on the concept of causal ordering. Similarly, if economic growth in fact causes energy consumption, then given the past history of economic growth it is likely that information will help predict energy consumption. Table 2 presents the results of Granger causality test.

TABLE II.
GRANGER CAUSALITY TEST RESULTS

Country/hypothesis	Lags	Observations	F-statistic	Probability	Test results
Lithuania					
Null hypothesis:					
GDP does not Granger cause of EC	1	17	0.00690	0.93495	Accepted
EC does not Granger cause of GDP			0.74326	0.40315	Accepted
GDP does not Granger cause of EC	2	16	3.53249	0.06532	Rejected
EC does not Granger cause of GDP			0.29764	0.74836	Accepted
GDP does not Granger cause of EC	3	15	2.00282	0.19224	Accepted
EC does not Granger cause of GDP			0.47894	0.70580	Accepted
GDP does not Granger cause of EC	4	14	2.13009	0.21420	Accepted
EC does not Granger cause of GDP			0.29456	0.87012	Accepted
Latvia					
Null hypothesis:					
GDP does not Granger cause of EC	1	17	2.03865	0.17527	Accepted
EC does not Granger cause of GDP			2.72381	0.12111	Accepted
GDP does not Granger cause of EC	2	16	1.08794	0.37057	Accepted
EC does not Granger cause of GDP			1.69870	0.22756	Accepted
GDP does not Granger cause of EC	3	15	1.07542	0.41261	Accepted
EC does not Granger cause of GDP			0.51644	0.68247	Accepted
GDP does not Granger cause of EC	4	14	1.03463	0.47213	Accepted
EC does not Granger cause of GDP			0.52719	0.72259	Accepted
Estonia					
Null hypothesis:					
GDP does not Granger cause of EC	1	17	1.97441	0.08178	Rejected
EC does not Granger cause of GDP			0.03202	0.86054	Accepted
GDP does not Granger cause of EC	2	16	2.80232	0.10385	Rejected
EC does not Granger cause of GDP			0.33273	0.72393	Accepted
GDP does not Granger cause of EC	3	15	3.72760	0.06069	Rejected
EC does not Granger cause of GDP			0.84221	0.50810	Accepted
GDP does not Granger cause of EC	4	14	5.47515	0.04521	Rejected
EC does not Granger cause of GDP			2.79341	0.14492	Accepted

The results of Granger causality test provide new empirical insights into the long – run relationship between energy consumption per capita and GDP per capita. The rejection rule is applied, when the probability value is no more than the level of significance at 5% and 10%. The research suggests different results of the Baltic countries. In general, the case of Lithuania reveals that no causality exists between variables, except two lags situation, when GDP per capita leads the energy consumption per capita at 7% level of significance. In the case of Latvia, it is shown that the null hypothesis that GDP does not Granger-cause of energy consumption and energy consumption does not Granger-cause of GDP cannot be rejected. In this light, we can conclude that there is absence of Granger causality between these two variables, no matter that they strongly correlate. According to Ouedraogo (2013), under this scenario, policies to promote energy access and higher levels of consumption will not have impact on economic growth. The case of Estonia shows the running causality from GDP per capita growth to energy consumption per capita. This unidirectional causality signifies that economy is less energy dependent and economic growth causes the development of energy sector. Under this scenario, energy conservation policies, such as investments in energy efficiency and demand management policies will have no adverse impact on GDP growth (Ouedraogo 2013). Applying regression model, this causal relationship could be described as follows:

$$y_i = 3.63 + 0.07\, x_i \qquad (4)$$

where: y_i- dependent variable – energy consumption per capita, x_i – independent variable – GDP per capita.

According to the regression model, an increase by EUR 1thou in GDP per capita increases total energy consumption per capita by 0.07 TOE. The regression model describes approx. 48% of the variation in energy consumption per capita.

IV. Conclusion

The paper investigates the causal relationship between energy consumption and economic growth in the Baltic countries in a period of 1995 – 2012. Granger causality test is applied in order to suggest which variable in the model has significant impact on the future value of other variable in the system. Based on the causal relationship, regression model has been employed for the estimation of interrelationship between variables observed.

The empirical results highlight a weak and insignificant correlation between energy consumption per capita and GDP per capita for Lithuania, strong and significant relationship for Latvia and moderate one for Estonia.

In terms of causality, there is causal relationship running from GDP to energy consumption in Estonia. This unidirectional causality signifies that economy is less energy dependent and economic growth causes the development of energy sector. The assumption could be made that the energy conservation policies will not have impact on economic growth. Economic growth, however, impacts on energy consumption. According to the regression model based on Granger causality test's results and applied for the case of Estonia, an increase by EUR 1thou in GDP per capita increases total energy consumption per capita by 0.07 TOE. This regression model describes approx. 48% of the variation in energy consumption per capita.

What is more, the research highlights the absence of Granger causality between variables observed in the case of Lithuania and Latvia. In this light, national energy policies will not have impact on economic growth as well as economic growth will not has influence on energy consumption.

References

Akinlo, A. E. (2009). Electricity consumption and economic growth in Nigeria: Evidence from co-integration and co-feature analysis, *Journal of Policy Modeling* 31: 681–693.

Apergis, N.; Payne, J. E. (2012). Renewable and non-renewable energy consumption-growth nexus: Evidence from a panel error correction model, *Energy Economics, Elsevier* 34(3): 733-738.

Bartleet, M.; Gounder, R. (2010). Energy consumption and economic growth in New Zealand: results of trivariate and multivariate models, *Energy Policy* 38: 3508–3517.

Belke, A.; Dobnik, F.; Dreger, C. (2011). Energy consumption and economic growth: new insights into the cointegration relationship, *Energy Economics* 33(5):782–789.

Bobinaitė, V.; Juozapavičienė, A.; Konstantinavičiūtė, I. (2011). Assessment of causality relationship between renewable energy consumption and economic growth in Lithuania. *Engineering Economics* 22(5): 510-518. http://dx.doi.Org/10.5755/j01.ee.22.5.969.

Bojnec, S.; Papler, D. (2011). Economic efficiency, energy consumption and sustainable development, *Journal of Business Economics and Management* 12: 353-374. doi:10.3846/16111699.2011.573278.

Campo, J.; Sarmiento, V. (2013). The relationship between energy consumption and GDP: evidence from a panel of 10 Latin American countries, *Latin American Journal of Economics* 50 (2): 233-255.

Chen, P.Y.; Chen, S.T.; Chen, C.C. (2012). Energy consumption and economic growth – new evidence from meta analysis, *Energy Policy* 44: 245 – 255.

Chen, S.T.; Kuo, H.I.; Chen, C.C. (2007). The relationship between GDP and electricity consumption in 10 Asian countries, *Energy Policy* 35: 2611–2621.

Chontanawat, J.; Hunt, L. C.; Pierse, R. (2008). Does energy consumption cause economic growth?: evidence from a systematic study of over 100 countries, *Journal of Policy Modeling, Elsevier* 30(2): 209-220.

Dudzevičiūtė, G. (2012). Lithuanian security of energy supply and consumption in the context of the European Union countries. International Scientific Conference *"Whither Our Economies"* October 15-16. Proceedings: p. 32-38. ISSN (online) 2029-8501.

Dudzevičiūtė, G. (2013). The research of the economic structural changes: energy consumption aspect, *Journal of Security and Sustainability Issues* 2(4): 13–23. http://dx.doi.org/10.9770/jssi.2013.2.4(2).

Eddrief-Cherfi, S.; Kourbali, B. (2012). Energy consumption and economic growth in Algeria: cointegration and causality

analysis. *International Journal of Energy Economics and Policy* 2 (4): 238-249.

Eggoh, J.C.; Bangake, C.; Rault, C. (2011). Energy consumption and economic growth revisited in African countries, *Energy Policy* 39 (11): 7408-7421.

Esso, L.J. (2010). Threshold cointegration and causality relationship between energy use and growth in seven African countries, *Energy Economics* 30: 2391–2400.

Eurostat database on energy indicators. Available on the Internet: http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database.

Fang, Y. (2011). Economic welfare impacts from renewable energy consumption: the China experience, *Renewable and Sustainable Energy Reviews* 15 (9): 5120–5128.

Fuinhas, J.; Marques, A. C. (2012). An ARDL approach to the oil and growth nexus: Portuguese evidence, *Energy Sources* 7(3): 282-291.

Georgantopoulas, A. (2012). Electricity consumption and economic growth: analysis and forecasts using VAR/VEC approach for Greece with capital formation, *International Journal of Energy Economics and Policy* 2 (4)*:* 263-278.

Granger, C.W.J. (1969). Investigating causal relations by econometric models and crossspectral methods*, Econometrica* 37 (3): 424–438.

Gurgul, H.; Lach, L. (2011). The electricity consumption versus economic growth of the Polish economy, *Energy Economics* 34 (2): 500-510.

Ho, Chun-Yu.; Siu, Kam Wing, (2007). A dynamic equilibrium of electricity consumption and GDP in Hong Kong: An empirical investigation, *Energy Policy, Elsevier* 35(4): 2507-2513.

Kozhan, R. (2010). Financial Econometrics. Roman Kozhan & Ventus Publishing ApS. 119 p.

Lee, Chien-Chiang; Chiu, Yi-Bin, 2011. Oil prices, nuclear energy consumption, and economic growth: new evidence using a heterogeneous panel analysis, *Energy Policy, Elsevier* 39(4): 2111-2120.

Li, J.; Li, Z. (2011). A causality analysis of coal consumption and economic growth for China and India, *Natural Resources* 2: 54-60.

Lin, B.; Wesseh, P.K. (2014). Energy consumption and economic growth in South Africa reexamined: a nonparametric testing apporach, *Renewable and sustainable energy reviews* 40: 840-850.

Munim, J. M. A.; Hakim, M. M.; Abdullah-Al-Mamun, M. 2010. Analysis of energy consumption and indicators of energy use in Bangladesh, *Economic Change Restructuring* 43: 275–302.

Odhiambo, N. (2010). Energy consumption, prices and economic growth in three SSA countries: A comparative study, *Energy Policy* 38 (5): 2463-2469.

Odularu, G. O.; Okonkwo, Ch. (2009). Does energy consumption contribute to economic performance? Empirical evidence from Nigeria, Journal of Economics and Business 12 (2): 43-79.

Ouedraogo N. S. (2013). Energy consumption and economic growth: evidence from the economic community of West African States*, Energy Economics* 36: 637–647.

Ozkan, G. (2011). The Nabucco project within the context of energy supply security and international politics, *China-USA Business Review*, 10 (8): 689-699.

Ozturk, I. (2010). A literature survey on energy-growth nexus, *Energy Policy* 38: 340–349.

Payne, J. E. (2010). Survey of the international evidence on the causal relationship between energy consumption and growth, *Journal of Economic Stu*dies 37(1): 53–95.

Squalli, J. (2007). Electricity consumption and economic growth: bounds and causality analyses of OPEC members, *Energy Economics* 29 (6): 1192–1205.

Stern, D. I. (2011). From correlation to Granger causality. Crawford School Research Paper No 13. 37 p.

Tang, C.F.; Tan, E. CH. (2012). Electricity consumption and economic growth in Portugal: evidence from a multivariate framework analysis, *Energy Journal* 33 (4), 27 p. http://dx.doi.org/10.5547/01956574.33.4.2.

Tsani, S. (2010). Energy consumption and economic growth: a causality analysis for Greece. *Energy Economics* 32: 582-590.

Yildirim, E.; Sukruoglu, D.; Aslan, A. (2014). Energy consumption and economic growth in the next 11 countries: the bootstrapped autoregressive metric causality approach, *Energy Economics* 44: 14-21.

Zhixin, Z.; Xin, R. (2011). Causal relationships between energy consumption and economic growth, *Energy Procedia* 5: 2065-2071.