University of Salford A Greater Manchester University
University of Essex ESSEX BUSINESS SCHOOL
International Centre for Entrepreneurship Research
The General Jonas Žemaitis Military Academy of Lithuania
Ministry of National Defence Republic of Lithuania
Vilnius Gediminas Technical University
RISEBA
Estonian Business School
NATO Energy Security Centre of Excellence
ENTREPRENEURSHIP AND SUSTAINABILITY CENTER
AVADA

Journal of Security and Sustainability Issues *www.lka.lt/index.php/lt/217049/*
ISSN 2029-7017/ISSN 2029-7025 online
2014 Volume 4(2): 123–130
http://dx.doi.org/10.9770/jssi.2014.4.2(2)

ENERGY SECURITY AND ECONOMIC GROWTH IN THE EUROPEAN UNION

Sergey Balitskiy[1], Yuriy Bilan[2], Wadim Strielkowski[3]

[1]Faculty of Social Sciences, Charles University in Prague
Smetanovo nabr. 6, 11001 Prague, Czech Republic;
[2]Microeconomics Department, Faculty of Economics Science and Management
University of Szczecin, ul. Mickiewicza 64, 71-101 Szczecin, Poland;
[3]Faculty of Social Sciences, Charles University in Prague
Smetanovo nabr. 6, 11001 Prague, Czech Republic

E-mails: [1]sergey.balitskiy1@gmail.com; [2]yuriy_bilan@yahoo.co.uk; [3]strielkowski@fsv.cuni.cz

Received 10 September 2014; accepted 25 November 2014

Abstract. Our paper tackles the issue of the European energy security and economic growth. Specifically, it evaluates the relationship between natural gas consumption and economic growth in the European Union (EU). Channels along which natural gas is supplied to the EU energy markets yield dependence from the Russian Federation which presents a threat to the European energy security. Our sample includes panel time series data over the period from 1997 to 2011 for a 26 EU countries. Based on neoclassical growth model, we create a multivariate model including gross fixed capital formation and total labor forces of a country as additional explanatory variables. Using panel cointegration tests, we found that there exists a long-run relationship between economic growth, natural gas consumption, labor and capital. In the short-run there is bidirectional causality between natural gas consumption and economic growth. The causality running from economic growth to natural gas consumption is positive. On the other hand, the causality, which runs from natural gas consumption to economic growth, is negative.

Keywords: natural gas consumption, energy security, economic growth, panel data, multivariate model, European Union, Russian Federation

Reference to this paper should be made as follows: Balitskiy, S.; Bilan, Y.; Strielkowski, W. 2014. Energy security and economic growth in the European Union, *Journal of Security and Sustainability Issues* 4(2): 123–130. DOI: http://dx.doi.org/10.9770/jssi.2014.4.2(2)

JEL Classifications: N70, O40, Q32, Q43

1. Introduction

The aim of this study is an assessment of energy security and economic growth in the EU. This objective is achieved through the evaluation of the relationship between natural gas consumption and basic macroeconomic indicators. The relationship between economic output and energy consumption has been analyzed in numerous empirical studies. Unfortunately, literature about relationship between economic output and natural gas consumption is quite limited. Nevertheless, many authors are dealing with energy consumption and economic growth, taking individual sources of energy as proxy variables for empirical testing the model. The nexus between energy consumption and economic growth can be tested in two different ways. One of them takes energy consumption at aggregate level. The other one, so called disaggregate level, compares economic growth and energy consumption given by individual sources of energy (e.g. natural gas, oil, coal and etc.). Also, we can find two kinds of correlation between energy consumption and economic growth. First of them is a correlation in time, when energy consumption changes in the same way like economic growth. The second one is correlation in space, which means that more developed countries also have higher level of energy consumption (Amar 2013). Especially, our investigation will be concentrate on the sample of 28 European Union countries. The sample of EU countries is interested for us, because natural gas is an important source of energy in Europe. While natural gas production in Europe has declining tendency, European dependence on natural gas as well as share of natural gas in electricity production is expected to grow. With growing world energy consumption and scarcity of non-renewable reserves, efficient allocation of energy recourses, in our case natural gas, and energy security of fuels markets, in particular natural gas markets, are taking a significant place in policy of many states of Europe and worldwide.

Given the numerous researches, e.g. Eggoh *et al.* (2011), To *et al.* (2012) and Śmiech and Papież (2013), Gazda (2010), Asafu-Adjaye (2000) showing the relationship between the basic macroeconomic indicator of economic development of a country such as GDP on the one hand and gross fixed capital formation, and labor forces in a country on the other hand, in the empirical part the effects of these variables are also taken into account. Time series period includes 15 years, which helps us to include in our analysis as largest size of a sample of countries as possible.

2. Natural gas consumption in Europe: a literature review

Natural gas consumption is a crucial aspect for the energetic sectors in most of the European countries. According to Eurostat (2014), in terms of supply of natural gas in 2012-2013, Norway was the country of origin for 23.8 % of natural gas imports (with the Intra-EU trade excluded), Russian Federation supplies 17.5 %, Qatar 7.1 % and Algeria 6.0 %. When it comes to natural gas dependency for EU-28, it makes about 65.2 % in 2013 (marking a small decrease from 66.0 % in 2012) with the Netherlands and Denmark being the only net exporters amongst the EU countries. It has to be noted, however, that for 16 EU Member States, natural gas dependency is higher than 90 %. After the hit of financial crisis in 2008 natural gas consumption feel down during the period from 2008 to 2009 in the European Union. But next period from 2009 to 2010 it is observed a sharp growth to previous level of year 2008. After that, during the period from 2010 to 2012 it again extremely fell down, even more than in previous fall.

It can be seen that individual countries differ in their natural gas consumption. For example, countries of Western Europe (Germany, Spain, France, Italy, Netherlands and United Kingdom) have higher natural gas consumption in comparison with other countries of European Union. Belgium, Poland and Romania consume natural gas more or less on the level of 500 thousand terajoules. Other countries consume natural gas on the level below 500 thousand terajoules. Luxembourg, Estonia, Latvia, Lithuania, Sweden and Slovenia consume natural gas in quite low rate. A little bit more natural gas is consumed by Czech Republic, Denmark, Ireland, Greece, Hungary, Austria, Portugal, Slovakia and Finland. Malta and Cyprus do not consume natural gas at all. For Bulgaria there is no data for this time period.

There are some benefits of using natural gas. For example, from environmental point of view, natural gas does not contain solid particles and inorganic materials. The other thing is that natural gas does not increase SO2 emissions in the atmosphere. In comparison with other fuels natural gas produces less CO2 emissions, so it is becoming more advantageous to use for safeguard the environment. Comparing natural gas with renewable and nuclear sources of energy, it is should be pointed that natural gas has wider application than renewable and nuclear forms of energy because of its less necessary investment costs. Also, political decision making initiatives play important role for choosing the source of energy (Homer 1993; Tvaronavičienė 2012; Vosylius *et al.* 2013; Mačiulis, Tvaronavičienė 2013; Baublys *et al.* 2014). To *et al.* (2012) tested the casual relationship between energy consumption and economic growth over the period from 1970 to 2011 in Australia using labor, capital, human capital, and energy consumption as explained variables for Australian gross domestic product (GDP). This multivariate model is based on the production function in order to reduce potential omitted-variable biases. For analyzing short-run and long-run elasticities the bound testing cointegration approach was used. This cointegration testing is based on the autoregressive distributed lag (ARDL) model. Results suggest that in the long-run as well as in the short-run there is no any causal relationship between energy consumption and economic growth (To *et al.* 2012).

The same testing of the long-run and short-run elasticities was provided by Bhusal (2010). There had been found bidirectional causality between energy consumption and economic growth in the short-run and long-run using specific statistical techniques, like Augmented Dickey–Fuller (ADF) unit root test, Johansen maximum likelihood test of cointegration and Error Correction Modelling (ECM) (Bhusal 2010).

Studies (e.g. Adhikari and Chen (2013); Belke *et al.* (2011); Chontanawat *et al.* (2006); Dilaver *et al.* (2014); Farhani and Rejeb (2012); Stern (2004, 2010); Stern and Kander (2010); Sickles (2008) describing relationship between energy consumption and economic growth mostly show an existence of causality whether running from energy consumption to economic growth or, opposite, running from economic growth to energy consumption, or bidirectional causality. It supports the assumption about causal relationship between energy consumption and economic growth. Taking into account these results, in empirical part of this work we will use some statistical techniques, which are going to help investigate the relationship between energy consumption and economic growth in European Union countries with a time series data trend.

3. The data and the model

The aim of the empirical model executed in our paper is a statistical verification of the relationship between natural gas consumption expressed by gross inland natural gas consumption and economic growth of a country measured by GDP per capita. Also relationship between natural gas consumption and economic growth will be verified by including gross inland natural gas consumption, as component of production, into multivariate model, based on production function, on the one side with capital measured by gross fixed capital formation and labor expressed by total labor forces in the country.

Assuming that the dependent variable is influenced by the compilation of independent variables, we have composed the collection of independent variables which captures the local labour market structure. The analysis of causal relationship between natural gas consumption and economic growth will be based on the secondary annual panel data, which was taken for 28 member states of European Union, except Cyprus and Malta, which are not using natural gas. So, the final sample will contain 26 countries. This sample will employ annual time series data from 1997 to 2011 sourced from the Eurostat and World Bank database to estimate the model.

In our study we are using gross domestic product (GDP), which is taken as dependent variable in our model, as a measure of an economic output. GDP is represented per capita in current US dollars. As explanatory variables we take stock of capital, stock of labor and energy consumption. Stock of capital is represented by Gross fixed capital formation in current US dollars, also given as gross domestic fixed investment. Stock of labor is given by total labor force in a country represented by people older than 15 years, who is economically active according to the definition of International Labor Organization. Natural gas consumption has been chosen as a proxy for energy consumption and it is expressed as the final natural gas consumption in thousands of tons of oil equivalent (TOE).

Although, many studies used bivariate and multivariate models to investigate the relationship between energy consumption and economic growth, there is a big advantage of multivariate model, because it helps us to solve the problem of omitted variables (To *et al.* 2012). Our empirical model is based on neoclassical growth model proposed by Solow (1956) with neoclassical aggregate production function:

$$Y = F(K, L, A) \quad (1)$$

where Y is an aggregate real output, K – stock of capital, L – stock of labor, and A – technology.

According to Olusegun Odularu and Okonkwo (2009) energy is one of the key components of technology. The usage of energy determines technological change, but it should be noticed that it's not only one determinant factor.

After studying empirical works and theoretical concepts related to our paper's main topic and taking into account that energy can be taken as a part of technology, we reconstruct our model in the following way:

$$Y = F(K, L, E) \quad (2)$$

where Y – Economic output (GDP), K – Gross fixed capital formation (K), L – Labor forces (L), and E – Energy consumption, represented by natural consumption (GC).

4. Empirical model estimations and results

The results of Pedroni (1999, 2000) residual cointegration test using four within-dimension based tests and three within-dimension tests between four variables (LGDP, LGC, LK and LL) without deterministic trend, without deterministic intercept or trend, and with deterministic intercept and trend are presented in Table 1. LGDP is taken as dependent variable.

Table 1. The results of Pedroni residual cointegration test between LGDP, LGC, LK and LL. LGDP is taken as dependent variable

	No deterministic trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	0.024	0.49	0.75	0.22
Panel rho-Statistic	2.88	0.99	2.32	0.98
Panel PP-Statistic	1.84	0.96	0.65	0.74
Panel ADF-Statistic	-0.96	0.16	-4.15	0.0000
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	4.43	1.00		
Group PP-Statistic	0.58	0.72		
Group ADF-Statistic	-6.63	0.0000		
	Deterministic intercept and trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	9.64	0.0000	2.39	0.0083
Panel rho-Statistic	3.95	1.00	3.58	0.99
Panel PP-Statistic	-1.64	0.049	-1.98	0.023
Panel ADF-Statistic	-4.96	0.0000	-4.93	0.0000
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	5.66	1.00		
Group PP-Statistic	-2.73	0.0031		
Group ADF-Statistic	-5.36	0.0000		
	No deterministic intercept or trend			
	Alternative hypothesis: common AR coefficients (within-dimension)			
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-0.60	0.72	-1.93	0.97
Panel rho-Statistic	2.017	0.97	1.88	0.97
Panel PP-Statistic	1.60	0.94	0.78	0.78
Panel ADF-Statistic	-0.24	0.40	-1.93	0.026
	Alternative hypothesis: individual AR coefficients (between-dimension)			
	Statistic	Prob.		
Group rho-Statistic	4.27	1.00		
Group PP-Statistic	2.33	0.99		
Group ADF-Statistic	-3.85	0.0001		

Source: Own results

Statistics based on common and individual coefficients without deterministic trend suggests that two of eleven tests reject the null hypothesis about non-cointegrated relationship between variables. Taking into account deterministic intercept and trend, eight of eleven tests reject the null hypothesis about non-cointegrated relationship between variables. Two of eleven tests can reject the null hypothesis about non-cointegrated relationship between variables without deterministic intercept or trend. The results of Kao (1999) residual cointegration test between four variables (LGC, LGDP, LK and LL) are presented in Table 2. In this case, LGDP is taken as dependent variable.

Table 2. The results of Kao residual cointegration test between LGDP, LGC, LK and LL. LGDP is taken as dependent variable

Kao Residual Cointegration Test

	t-Statistic	Prob.
ADF	-6.55	0.0000
Residual variance	0.0032	
HAC variance	0.0049	

Augmented Dickey-Fuller Test Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.29	0.034	-8.57	0.0000
D(RESID(-1))	0.52	0.050	10.43	0.0000
R-squared	0.24	Mean dependent var		0.014
Adjusted R-squared	0.24	S.D. dependent var		0.067
S.E. of regression	0.058	Akaike info criterion		-2.81
Sum squared resid	1.16	Schwarz criterion		-2.79
Log likelihood	478.16	Hannan-Quinn criter.		-2.80
Durbin-Watson stat	1.83			

Source: Own results

The results of Kao residual cointegration test based on Augmented Dickey-Fuller statistics suggest that there is cointegrated relationship between LGDP, LGC, LK and LL on significance level of 5 %. The results of our empirical estimation are represented in Table 3 that shows the results of Error Correction Model (ECM) based on the two steps Engle and Granger (1987) procedure between four variables (GDP, capital, labor and natural gas consumption). Each of the relationship is based on the equations represented above.

The results for the model where GDP is dependent variable indicate that in the short-run only labor has positive and statistically significant impact on economic growth, 1% increase of labor increases GDP by 0.43%. Both, natural gas consumption and capital have negative and statistically significant impact on economic growth, 1% increase of natural gas consumption increases GDP decreases GDP by 0.02%, and 1% increase of capital decreases GDP by 0.46%. In the long-run we can see unidirectional causal relationship running from capital, labor and natural gas consumption to GDP. Natural gas consumption responds to deviations from long-run equilibrium at 1% level of significance.

Table 3. The results of causal relationship between GDP, capital, labor and natural gas consumption

Dependent variable	Sources of causality				
	Short-run				Long-run
	ΔLNGDP	ΔLNK	ΔLNL	ΔLNGC	ECT
(13) ΔLNGDP	-	-0.467732	0.432817	-0.020960	-0.553551
		(0.0000)	(0.0000)	(0.0093)	(0.0000)
(14) ΔLNK	1.385251	-	1.520729	0.020982	1.640241
	(0.0000)		(0.0000)	(0.0008)	(0.0000)
(15) ΔLNL	0.000731	0.006865	-	-0.009445	-0.027114
	(0.9206)	(0.3772)		(0.0013)	(0.0020)
(16) ΔLNGC	0.135580	0.075212	0.340463	-	0.988354
	(0.0000)	(0.0000)	(0.0000)		(0.0000)

Source: Own results

The results of the next model where capital is represented as dependent variable suggest that in the short-run all independent variables, GDP, labor and natural gas consumption have positive and statistically significant impact on gross fixed capital formation, 1% increase of GDP increases gross fixed capital formation by 1.38%, 1% increase of total labor forces increases and natural gas consumption increases gross fixed capital formation by 1.52%, and 0.02% respectively. In the long-run we can see unidirectional causal relationship running from capital, labor and natural gas consumption to GDP.

The model where labor is taken as dependent variable shows that both, GDP and capital, doesn't have statistically significant impact on total labor forces, even if coefficients of the relationship are positive. On the other hand, natural gas consumption has negative and statistically significant impact on total labor forces, 1% increase of natural gas consumption decrease total labor forces by 0.009%.Also, there is unidirectional causality, which runs from GDP, capital and natural gas consumption to total labor forces at 1% of significance.

If we look at the model with natural gas consumption as dependent variable, we will see that GDP, labor and capital have positive and statistically significant impact on natural gas consumption in the short-run. 1% increase of GDP increases natural gas consumption by 0.13%, 1% increase of capital leads to increase of natural gas consumption by 0.075%, and 1% increase of labor increases natural gas consumption by 0.34% respectively. In the long-run there is unidirectional causal relationship, which runs from GDP, capital and labor to natural gas consumption. GDP responds to deviations from long-run equilibrium at significance level of 1% of the error correction term.

Conclusions and discussions

Based on the estimation of our econometric model, we were able to find that there exists long-run relationship between economic growth, natural gas consumption, labor and capital. In the short-run there is bidirectional causality between natural gas consumption and economic growth. The causality running from economic growth to natural gas consumption is positive, in other words, increase of GDP by 1% leads to increase of natural gas consumption by 0.13%. Surprisingly, the causality, which runs from natural gas consumption to economic growth, is negative. Increase of natural gas consumption by 1% leads to decrease of GDP by 0.02%.

As one can see, growing economic output in European Union countries requires more natural gas for maintaining the sustainable economic growth. Additional natural gas consumption with growing production need more investments for building infrastructure of processing natural gas terminals and delivery pipelines for transmission natural gas to consumers. On the other hand, one clearly sees that the increase of natural gas consumption leads to the decrease of economic growth. The same results were provided by Ucan *et al.* (2014) for 15 European developed countries. He found that non-renewable energy consumption leads to decrease of economic growth. The other thing is that consumption of renewable energy increases economic growth. The results of estimated model are dependent on the kind of energy, which is included into the model, and resources of its energy.

As was pointed above, we can find an effort of European countries with developed economic systems to reduce greenhouse gas emissions. In that case, Governments and policy makers should focus on renewable sources of energy, like, e.g. solar energy, wind power and hydropower. Also, as points Nwosa (2013), environmental costs should be taken into account when Government provides some energy consumption policies. It is particularly important if energy consumption has impact on economic growth (Kasperowicz 2011). But if this influence is absent, then implementation of these energy conservation policies will not have negative effect on economic development of a state. All these facts suggest that natural gas will remain an important source of energy for European countries in next years.

The role of natural gas on European market also can be viewed in terms of dependence of the majority of the European Union countries on supplies of natural gas from Russian Federation. Market power of Russian Federation on European natural gas market can harm European energy security. Possible solution of this problem lays in diversification of natural gas suppliers. Besides supply from the Russian Federation, European Union countries should increase presence of other potential players on its market, e.g. possible supply from Caspian region countries. It should not be forgotten about political aspect of Russian Federation's influence. The gas dispute between Russian Federation and Ukraine in years 2006 and 2009 clearly shows possible risks. Also in future we can expect a creation of new cartels between suppliers of natural gas. As a result, possible changes in European energy security will need more time. Effectiveness of their application will be seen in the long-term perspective.

As policy implications for further investigations about this topic, we would recommend analyzing how the results can change taking into account comparison between different sectors economy. For example, it would be interesting to compare relationship between economic growth and natural gas consumption in industrial and household sectors with its possible further dividing in some subsectors. Also, it is possible to try to find time series sample for more years and use not annual, but quarterly data to get stronger causal relationship. With growing usage of renewable resources in European countries, it will be good to include into the model impact of renewable resources of energy.

Knowing of natural gas consumption can help us in determination of natural gas prices volatility or if we are dealing with long-term natural gas contracts. Also it reduces uncertainty about future demand of natural gas. For governments, energy companies and financial institutions it represents opportunity for best realization of investment projects. The better managing of demand and supply and more efficient usage of natural gas in total economy as well as in different sectors of economy will be profitable for sustainable economic development of European countries.

References

Adhikari, D. and Chen, Y. 2013. Energy consumption and economic growth: A panel cointegration analysis for developing countries, *Review of Economics & Finance* 3: 68–80.

Amar, M. 2013. Energy consumption and economic growth: The case of African countries, *The Journal of Energy and Development* 38(1/2): 65–78.

Asafu-Adjaye, J. 2000. The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries, *Energy Economics* 22: 615–625.

Baublys, J.; Miškinis, V.; Konstantinavičiūtė I.; Lekavičius V. 2014. Aspirations for sustainability and global energy development trends, *Journal of Security and Sustainability Issues* 3(4): 17–26. DOI:http://dx.doi.org/10.9770/jssi.2014.3.4(2)

Belke, A.; Dreger, C.; Haan, F. 2011. Energy consumption and economic growth: New insights into the cointegration relationship, *Energy Economics* 3: 782–789.

Bhusal, T. P. 2010. Economic analysis of oil consumption and economic growth in Nepal, *Economic Journal of Development Issues* 11/12(1/2): 135–143.

Chontanawat, J.; Hunt, L. C.; Pierse, R. 2006. Causality between energy consumption and GDP: Evidence from 30 OECD and 78 non-OECD countries. *Surrey Energy Economics Discussion Papers, SEEDS No. 113*. Surrey Energy Economics Centre (SEEC), University of Surrey.

Dilaver, O.; Dilaver, Z.; Hunt, L. 2014. What drives natural gas consumption in Europe? Analysis and Projections, *Journal of Natural Gas Science and Engineering* 19: 125–136.

Eggoh, J. C.; Bangaké, C.; Rault, C. 2011. Energy consumption and economic growth revisited in African countries. *CESifo Working Paper* No. 3590.

Engle, R. E.; Granger, C. W. J. 1987. Cointegration and error-correction: representation, estimation, and testing, *Econometrica* 55: 251–276.

Eurostat. 2014. Available online: <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/>.

Farhani, S.; Ben Rejeb, J. 2012. Link between economic growth and energy consumption in over 90 countries, *Interdisciplinary Journal of Contemporary Research in Business* 3(11): 282–297.

Gazda, J. 2010. Real Business Cycle Theory – Methodology and Tools, *Economics and Sociology* 3(1): 42–48.

Homer, J. 1993. Natural gas in developing countries: Evaluating the benefits to the environment. *World Bank discussion papers,* No. 190.

Kao, C. 1999. Spurious regression and residual-based tests for cointegration in panel data, *Journal of Econometrics* 90: 1–44.

Kasperowicz, R. 2011. The Causality Relationships between Energy Variables and Sold Industrial Output in Polish Economy, *Journal of International Studies* 4(1): 69–80.

Mačiulis, A.; Tvaronavičienė, M. 2013. Secure and sustainable development: Lithuania's new role in taking the Presidency of the EU, *Journal of Security and Sustainability Issues* 3(2): 5–13. DOI: http://dx.doi.org/10.9770/jssi.2013.3.2(1)

Nwosa, P. I. 2013. Long run and short run effects between domestic fuel consumption and economic growth in Nigeria, *Journal of Sustainable Development in Africa* 15(4): 130–142.

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

Pedroni, P. 1999. Critical values for cointegration tests in heterogeneous panels with multiple regressors, *Oxford Bulletin of Economics & Statistics* 61: 653–670.

Pedroni, P. 2000. Fully modified OLS for heterogeneous cointegrated panels, *Nonstationary Panels, Panel Cointegration and Dynamic Panels* 15: 93–130.

Sickles, R. 2008. Energy economics. *The New Palgrave Dictionary of Economics.* 2nd edition.

Śmiech, S.; Papież, M. 2013. Energy consumption and economic growth in central and eastern European countries: A panel data analysis. *The 7th International Days of Statistics and Economics,* Prague, September 19-21.

Solow, R. M. 1956. A contribution to the theory of economic growth, *Quarterly Journal of Economics* 70: 65–94.

Stern, D. I.; Kander A. 2010. The role of energy in the Industrial Revolution and modern economic growth. *CAMA Working Papers*.

Stern, D. I. 2004. Economic growth and energy, in Cleveland, C. J. (Ed.). *Encyclopedia of Energy*. Academic Press, San Diego CA, 35–51.

Stern, D. I. 2010. The role of energy in economic growth. *CCEP Working Papers*.

To, H.; Wijeweera, A.; Charles, M. 2013. Energy consumption and economic growth – The case of Australia. *Australian Conference of Economists*. Business School, Southern Cross University.

Tvaronavičienė, M. 2012. Contemporary perceptions of energy security: policy implications, *Journal of Security and Sustainability Issues* 1(4): 235–247. DOI: http://dx.doi.org/10.9770/jssi.2012.1.4(1)

Ucan, O.; Aricioglu, E.; Yucel, F. 2014. Energy Consumption and Economic Growth Nexus: Evidence from Developed Countries in Europe, *International Journal of Energy Economics and Policy* 4(3): 411–419.

Vosylius, E.; Rakutis, V.; Tvaronavičienė, M. 2013. Economic growth, sustainable development and energy security interrelation, *Journal of Security and Sustainability Issues* 2(3): 5–14. DOI: http://dx.doi.org/10.9770/jssi.2013.2.3(1)

World Bank. 2012. *The World Bank Data Bank.* Available online : <http://data.worldbank.org>