British Journal of Economics, Management & Trade
14(1): 1-8, 2016, Article no.BJEMT.26184
ISSN: 2278-098X

SCIENCEDOMAIN *international*
www.sciencedomain.org

The Link between Energy Consumption and Economic Growth: Empirical Evidence for Black Sea Countries

Iuliana Matei[1*]

[1]Department of Economics, IESEG Paris and University of Paris1, France.

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/BJEMT/2016/26184
Editor(s):
(1) Chen Zhan-Ming, School of Economics, Renmin University of China, Beijing, China.
Reviewers:
(1) Mohamed Ibrahim Mugableh, Irbid National University, Jordan.
(2) Chun-Chien Kuo, National Taipei University of Business, Taiwan.
Complete Peer review History: http://sciencedomain.org/review-history/14820

Original Research Article

Received 4th April 2016
Accepted 16th May 2016
Published 30th May 2016

ABSTRACT

The aim of this paper is to investigate the energy consumption-economic growth nexus for 7 Black Sea countries for the period 1990-2012. By using panel data techniques, findings show that increases in real per capita GDP have a positive and statistically significant effect on per capita energy consumption (and vice-versa). In the long term, a 1% increase in real per capita GDP increases energy consumption per capita by a value between 0.63% and 0.64% while a 1% increase in per capita energy use increases the real per capita GDP by a value between 1.02% and 1.03%. Thus, the impact of real GDP on energy consumption is less important than vice versa. All these outcomes should be taken as evidence that energy appears as a key input in the production function. Furthermore, energy saving policy and efficiency improvement appear to have both a favorable influence on the GDP growth.

Keywords: The energy- growth nexus; panel cointegration methods; black sea countries.

**Corresponding author: E-mail: Iuliana.Matei@malix.univ-paris1.fr;*

1. INTRODUCTION

The relationship between energy consumption and economic growth was greatly debated in the resources economic literature since the seminal article by Kraft and Kraft [1] both for developing and developed countries: Yu and Wang [2], Al-Iriani [3], Lee and Chang [4], Mehrara [5], Apergis and Payne ([6,7,8,9,10,11]), Coers and Sanders [12], Salim et al. [13] among others. The main reason is that there is still no consensus regarding the direction of causality between these two factors. While the supply-side studies argue that energy consumption has a positive effect on economic growth, the demand-side studies show a direct impact from economic activity to energy consumption. From an empirical point of view, the diverging results could be explained by the type of selected models (time series or panel data), the length of the period or the country samples. Furthermore, time series models (such as Augmented Dickey-Fuller unit root test - Dickey and Fuller [14], the Johansen [15] cointegration test, the Sims [16] vector autoregressive model (VAR), the vector error correction model (VECM) and autoregressive distributed lag models (ARDL)) were widely used at the beginning to appraise energy-growth nexus (because of the availability of data). Although the recent literature has applied more innovative models (e.g., Pesaran and Smith [17], Pesaran et al. [18]) in which the time series dimension and the cross-sectional dimension of data are simultaneously exploited to obtain additional information (e.g., Apergis and Payne [7]; Sadorsky [19], the empirical models still produce conflicting results.

The works by Ozturk et al. [20] and Apergis and Payne [8] reorganize this theoretical framework in four major hypotheses: “the growth hypothesis” (implying a unidirectional causality from energy use to economic growth), “the conservation hypothesis” (imposing unidirectional causality from growth to energy consumption), “the neutrality hypothesis” (meaning no causality between these two factors) and “the feedback hypothesis” (allowing for a bi-directional causality between these dimensions). These hypotheses have key policy implications. For example, the growth hypothesis implies that a decline in energy consumption negatively influences economic growth or that policies aiming to restrict energy consumption will not promote growth. Conversely, under the conservation hypothesis and the neutrality hypothesis, adjustments in energy policies do not impact economic growth.

The aim of this paper is to investigate this controversial relationship for Black Sea countries over the period 1990-2012. It contributes in a number of ways to the existing empirical literature. Firstly, very little studies have been done on modeling this relationship for this region and the most part of them used time series models (e.g., Caraiani et al. [21], Bildirici and Kayikci [22], Kayhan et al. [23]). Furthermore, at our best knowledge, no panel study has been performed to evaluate this relationship for the Black Sea region. This region is a production and a transit area of strategic importance for EU energy supply security, and is therefore a key component of the EU’s external energy strategy. It is well known that Russia, the Middle East, North Africa, and Norway stand currently for the largest EU’s suppliers, and almost all (except Norway) carry substantial risks of supply disturbance, competition, and, sometimes, the exercise of market power as a political weapon (Yakobashvili [24], Tsereteli [25]; Çelikpala [26]). The Black Sea’s area potential may prove to be of particular interest for EU’s energy supply diversification strategy as it brings together key-transit and safest countries (some of them NATO and EU member’s) for several west energy-consuming nations of EU. However, the Black Sea’s energy infrastructure may be vulnerable to disruptions in the form of conflicts and terrorism with considerable financial and political costs for EU’s energy supply security. These vulnerabilities may arise because some of the region’s existing pipelines are much more often in the existing or potential conflict zones where regularly acts of terrorism targeting pipelines have occurred. In terms of policy implications, the disruptions of European energy supply due to diverse forms of conflicts may cause substantial energy price increases for European consumers. This is why, a potential solution would be the development of a well integrated Black Sea electricity grid that could significantly reduce EU consumer prices and allow for cheaper purchases from neighboring countries. A second solution would be to develop and diversify additional energy supply routes to avoid the manipulations of monopoly providers for a more resilient network. Secondly, the paper uses up-to date panel data models such as: Kao and Chiang [27] - the group-means fully modified ordinary least squares (FMOLS) estimator that incorporates a semi-parametric correction to the ordinary least squares (OLS) estimator, a parametric dynamic OLS (DOLS). Finally, the outcomes give additional support for the economic approaches analyzing the link between energy and income. Results show that increases in real per capita GDP have a positive and statistically significant effect on per capita energy consumption (and vice-versa) which sustain the feed-back hypothesis.

The rest of the paper is constructed as follows. Section 2 presents the empirical approach used in this paper to examine the link between energy consumption and growth. It also displays and discusses the obtained results. The section 3 concludes.

2. DATA, METHODOLOGY AND RESULTS

2.1 Data

This paper uses annual data from 1990 to 2012 for 7 Black Sea countries (BSC). These countries are Bulgaria, Romania, Moldavia, Turkey, Georgia, Russia and Ukraine. Data on real GDP per capita in constant 2000 U.S. dollars is used as a proxy for measuring the economic growth (G) and energy consumption is represented by energy use in kilograms of oil equivalent per capita (E). Since all variables are in natural logarithms, each estimated coefficient needs to be interpreted as a constant elasticity of the dependent variable with respect to the independent variable. All data are given by World Bank database.

The descriptive statistics on the selected variables for each country are displayed below in Table 1. The highest level of GDP per capita is reaching by Turkey (8471,6) while the lowest level is for Moldova (570,1). The lowest value of energy consumption is given by Georgia (583,9) while the highest level is reaching by Russia (5928,8) followed by Ukraine (4855,9).

The Figs. 1 and 2 show the evolution of GDP per capita and of energy consumption per capita in Black Sea's countries. Both variables displayed below are in levels. Georgia has the lowest evolution of energy consumption per capita while Russia and Ukraine have the highest trends of energy consumption per capita. Regarding the evolution of GDP per capita, Turkey has the highest levels of GDP per capita and Moldova the lowest levels of GDP per capita during the selected period 1990-2012.

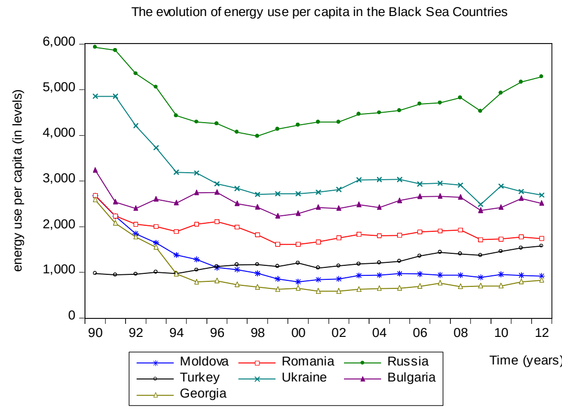

Fig. 1: The evolution of energy use per capita in Black Sea countries

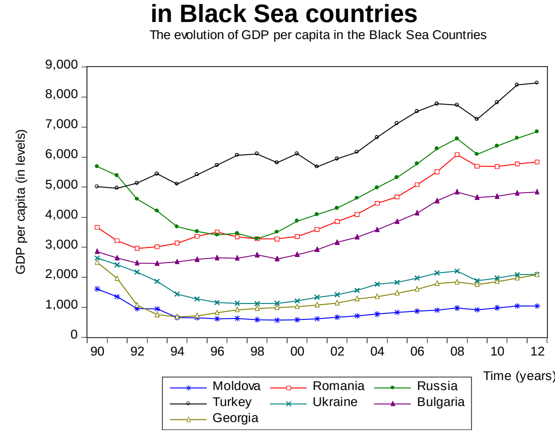

Fig. 2: The evolution of GDP per capita in Black Sea countries

2.2 Methodology and Results

<u>2.2.1 Exploring cross-sectional dependence</u>

Firstly, we apply cross-section dependence tests to verify if data are cross-sectional correlated. Interdependencies between BSC may occur after certain common shocks with different impacts across countries (e.g., the sovereign debt crisis, oil shocks, political shocks, terrorist attacks) and other unobserved components due to the economic integration process experienced in the last decade by the selected EU countries. To this end, we apply the Pesaran [28] test based on pair-wise correlation coefficients and report the results in the Table 2. The results strongly reject the null hypothesis of no cross-sectional dependence at the 1% level of significance for all variables meaning that these variables potentially exhibit a quite-similar dynamics to the countries.

Table 1. Main descriptive statistics by country

Moldavia	**Statistics**	**GDP per capita**	**Energy use**
	Moyenne	848,5	1170,7
	Médiane	831,2	956,0
	Écart-type	259,2	485,1
	Minimum	570,1	792,1
	Maximum	1613,1	2676,5
Bulgaria	***Statistics***	***GDP per capita***	***Energy use***
	Moyenne	3402,4	2538,2
	Médiane	2921,0	2511,0
	Écart-type	914,5	204,5
	Minimum	2456,9	2225,9
	Maximum	4837,0	3237,4
Georgia	***Statistics***	***GDP per capita***	***Energy use***
	Moyenne	1373,7	933,6
	Médiane	1276,5	701,8
	Écart-type	513,9	532,8
	Minimum	679,8	583,9
	Maximum	2499,0	2585,6
Romania	***Statistics***	***GDP per capita***	***Energy use***
	Moyenne	4194,3	1896,1
	Médiane	3662,9	1832,0
	Écart-type	1088,8	234,2
	Minimum	2962,1	1613,8
	Maximum	6079,6	2683,2
Russia	***Statistics***	***GDP per capita***	***Energy use***
	Moyenne	4893,4	4686,2
	Médiane	4632,8	4530,7
	Écart-type	1205,1	540,2
	Minimum	3282,9	3981,5
	Maximum	6845,8	5928,8
Turkey	***Statistics***	***GDP per capita***	***Energy use***
	Moyenne	6409,2	1204,5
	Médiane	6107,5	1169,6
	Écart-type	1119,1	188,6
	Minimum	4964,9	946,6
	Maximum	8471,6	1577,6
Ukraine	***Statistics***	***GDP per capita***	***Energy use***
	Moyenne	1732,7	3140,3
	Médiane	1828,7	2935,2
	Écart-type	455,6	650,3
	Minimum	1123,4	2487,0
	Maximum	2640,7	4855,9

Note: The selected variables are in levels

Table 2. Cross section dependence results of Pesaran (CD)

	Panel: Variables in log			
	CD	**p-value**	**CD model**	**p-value**
BSC – 7				
Energy Consumption	8.81^{a}	0.00	16.74^{a}	0.00
GDP	15.11^{a}	0.93		0.00

Notes: A means significant at the 1% level

2.2.2 Panel unit root results

We check now for the stationarity of the selected variables (i.e., the order of integration of series) by applying second-generation panel unit root tests (PURT). Since Pesaran [28] test shows evidence in favor of cross-section correlation, we use the second generation test of Pesaran [29]. Under the null hypothesis, the test assumes nonstationarity and allows for cross-section dependence implying that variables follow a common factor. Results of Table 3 show that the selected variables (in levels) are nonstationary (i.e., I(1)).

Table 3. The second generation PURT results

Tests for BSC 7	Pesaran (2007) CIPS
Energy consumption	-0.123 (0.451)
GDP	-0.615 (0.269)
Nb of years	23

Notes: The values in brackets are the associated probabilities; the selected models are with trend and constant, lags is 3 for GDP and 1 for energy; variables in levels

2.2.3 Panel cointegration analysis

The previous results show that there are strong interdependencies between countries. Second-generation cointegration tests assuming the cross-section dependence in cointegrating vectors can be applied such as the Westerlund [30] test and the Pedroni ([31,32]) test. The first test assumes under the null hypothesis the absence of cointegration and the existence of an error correction term for individual panel members (with the group-mean statistics - G_t and G_a) and/or for the panel as a whole (with the panel statistics - P_t and P_a) without any common-factor restriction. As explained by Westerlund [30], the test is general enough to account for a large degree of heterogeneity, both in the long-run cointegrating relationship and in the short-run dynamic, and for dependence within, as well as across, the cross-sectional units. The second test allows for cross-section interdependence with diverse individual effects and establishes whether a long-run equilibrium relationship exists:

$$lnGDP_{it} = \alpha_{it} + \gamma_i t + \beta_{1i} lnEC_{it} + \varepsilon_{it} \qquad (1)$$

$$ln\,EC_{it} = \alpha'_{it} + \gamma_i t + \beta'_{1i} lnGDP_{it} + \varepsilon'_{it} \qquad (2)$$

where i = 1,…,N for each country of the panel and t=1,…,T refers to the time period. The parameters α_{it} and γ_{it} of equation (1) capture the possibility of country-specific fixed effects and deterministic trends, and deviations from the long-run equilibrium relationship are measured by the estimated residuals ε_{it} . The equation (1) assumes that energy consumption ($lnEC_{it}$) is the driving force of the economic activity ($lnGDP_{it}$). Still, the equation (2) illustrates that GDP (in natural logarithms) can potentially affect energy consumption.

By applying the unit root test on the residuals ε_{it} ($\varepsilon_{it} = \gamma_i\ \varepsilon_{it-1} + u_{it}$), Pedroni ([31,32]) test the null hypothesis of no cointegration. The panel tests provide four statistics in the within dimension: panel v - statistic, panel ρ - statistic, panel *PP* - statistic and panel *ADF* - statistic. In the between dimension (i.e., group mean panel cointegration statistics), the test has only three statistics: group ρ - statistic, group *PP* - statistic, group *ADF* - statistic based on the averages of the individual autoregressive coefficients related with the unit root test of the residuals for each country in the panel. All these tests are distributed asymptotically as standard normal, as highlighted by Pedroni [32]. Table 4 displays the results reported by these seven statistics for the equation (1). The results indicate that is some evidence of cointegration between output and energy. More precisely, in the case of equation (1), at 5% and 1% significance levels, the test statistics reject the null hypothesis of no cointegration (for the panel-*ADF*, the panel-*PP* and the group-*PP*).

Table 4.The Pedroni (1999) panel cointegration tests for BSC 7

Panel test statistics	**Value**
panel v - statistic	-1.661 (0.95)
panel ρ - statistic	0.892 (0.81)
panel *PP* - statistic	-2.098** (0.02)
panel *ADF* - statistic	0.359** (0.64)
Group mean test statistics	**Value**
group ρ - statistic	0.572 (0.72)
group *PP* - statistic	-2.319*** (0.01)
group *ADF*- statistic	-0.372 (0.36)

*Note: (i) the null hypothesis is no cointegration; all reported values are distributed N(0,1) under the null of unit root or no cointegration; iii) ***p<0.01,**p<0.05; *p<0.10; iv) the estimations based on AIC criterion with of max lag of 4*

Table 5 reports the results of the Westerlund test in the case of models with constant and trend (alternative specifications - models including the constant only-are available upon request and are qualitatively similar). Two statistics show evidence of cointegration for the panel as a whole (P_a), and, at least, for one of the countries (as shown by G_t statistic).

Overall, the results indicate that most of variables are integrated of order one and are cointegrated. Hence, the findings enable exploring the long-run impact of energy consumption on economic activity (and vice-versa). For this purpose, two techniques are applied to estimate these long-run relationships – the Fully Modified Least Squares (FMOLS) and the Dynamic Ordinary Least Squares (DOLS). We present the results in Tables 6 and 7.

Table 5. The Westerlund (2007) cointegration test results for BSC 7: EC – GDP

Statistics with constant and trend	Value	Z-value	P-value
G_t	-5.032***	-8.187	0.000
G_a	-13.164	-0.504	0.307
P_t	-6.347	-0.881	0.189
P_a	-22.566**	-6.029	0.000

*Note: i) ***p<0.01, **p<0.05, *p<0.10; ii) the p -values are based on the normal distribution; ii) The average AIC selected lag length is 2.86 and the average AIC selected lead length is 2.43*

Table 6. Long-run panel estimators (dependent variable – real GDP per capita)

Independent variables	FMOLS	DOLS
Energy consumption per cap	1.020*** (0.089)	1.033*** (0.071)
Nb of panel observations	154	146

*Note: ***p<0.01, **p<0.05; *p<0.10; constant and trend are integrated in models with panel group FMOLS and DOLS (Pedroni cointegration models are employed); the standard errors are in the parenthesis*

Results of Table 6 show that a 1% increase in energy use per capita raises GDP per capita by a value between 1.02% (in the FMOLS) and 1.033% (in the DOLS). In summary, the results of this set of estimations (see Table 6) show that energy variable included in the models has a long-run impact on the GDP growth per capita. Both models (FMOLS and DOLS) indicate a positive and significant effect of the energy consumption per capita on the economic activity. Overall, the results are quasi-similar in magnitude and sign across these two techniques.

Regarding the energy consumption per capita equation, the results suggest that a 1% increase in GDP per capita increases energy use per capita by a value between 0.64% (in the FMOLS) and 0.63% (in the DOLS).

Table 7. Long-run panel estimators (dependent variable – energy use per capita)

Independent variables	FMOLS	DOLS
GDP per cap	0.644 *** (0.059)	0.630*** (0.066)
R-squared	0.979	0.994
Nb of panel observations	154	140

*Note: ***p<0.01, **p<0.05; *p<0.10; only constant are integrated in models with panel group FMOLS and DOLS (Pedroni cointegration techniques are employed); the standard errors are in the parenthesis*

3. CONCLUSIONS

This paper presents new findings about the long-run links between energy consumption and economic growth 7 Black Sea Countries over the 1990-2012 period (because of the availability of data). Our data suggest the use of panel cointegration methods. Findings show evidence in favor of a long-run positive impact of energy consumption on the per capita GDP. 1% increase in energy consumption per capita increases GDP per capita by about 1.02% (in the FMOLS) and 1.033% (in the DOLS). Furthermore, the impact of economic activity on energy consumption is also positive and significant because a 1% increase in GDP per capita increases energy use per capita by a value between 0.64% (in the FMOLS) and 0.63% (in the DOLS). All these outcomes should be taken as evidence that energy appears as a key input in the production function. Energy saving policy and efficiency improvement appear to have a favorable influence on the GDP growth.

ACKNOWLEDGEMENT

The author gratefully acknowledges the anonymous referees for their constructive comments and remarks on this paper.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Kraft J, Kraft A. On the relationship between energy and GNP. Journal of Energy and Development. 1978;3:401-403.
2. Yu ESH, Wang BK. The relationship between energy and GNP: Further results. Energy Economics. 1984;6:186-190.
3. Al-Iriani M. Energy–GDP relationship revisited: An example from GCC countries using panel causality. Energy Policy. 2006;34(17):3342–3350.
4. Lee C, Chang C. Energy consumption and GDP revisited: A panel analysis of developed and developing countries. Energy Economics. 2007;29(6):1206-1223.
5. Mehrara M. Energy consumption and economic growth: The case of oil exporting countries. Energy Policy. 2007;35(5):2939-2945.
6. Apergis N, Payne JE. Energy consumption and economic growth: Evidence from the commonwealth of independent states. Energy Economics. 2009;31:641-647.
7. Apergis N, Payne JE. Energy consumption and growth in South America: Evidence from a panel error correction model. Energy Economics. 2010a;32:1421-1426.
8. Apergis N, Payne JE. The emissions, energy consumption, and growth nexus: Evidence from the commonwealth of independent states. Energy Policy.2010b; 38:650–655.
9. Apergis N, Payne JE. Renewable energy consumption and growth in Eurasia. Energy Economics. 2010c;32(6):1392-1397.
10. Apergis N, Payne JE. Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. Energy Policy. 2010d;38:656-660.
11. Apergis N, Payne JE. The renewable energy consumption-growth nexus in Central America. Applied Energy. 2011;88:343-347.
12. Coers R, Sanders M. The energy-GDP nexus: Addressing an old question with new methods. Energy Economics. 2014;36:708-715.
13. Salim RA, Hassan K, Shafiei S. Renewable and non-renewable energy consumption and economic activities: Further Evidence from OECD countries. Energy Economics. 2014;44:350-360.
14. Dickey DA, Fuller WA. Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association. 1979;74(366):427-431.
15. Johansen S. Likelihood-based inference in cointegrated vector autoregressive models. Oxford: Oxford University Press; 1995.
16. Sims C. Macroeconomics and reality, Econometrica. 1980;48(1):1-48.
17. Pesaran MH, Smith R. Estimating long-run relationships from dynamic heterogeneous panels. Journal of Econometrics. 1995; 68(1):79-113.
18. Pesaran MH, Shin Y, Smith RP. Pooled mean group estimation of dynamic heterogeneous panels. Journal of the American Statistical Association. 1999; 94(446):621-634.
19. Sadorsky P. Renewable energy consumption and income economies. Energy Policy. 2009;37:4021-4028.
20. Ozturk I, Aslan A, Kalyoncu H. Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries. Energy Policy. 2010;38(8):4422-4428.
21. Caraiani C, Lungu C, Dascalu C. Energy consumption and GDP causality: A three step analysis for emerging European countries. Renewable and Sustainable Energy Reviews. 2015;44:198-210.
22. Bildirici ME, Kayikci F. Economic growth and electricity consumption in emerging countries of Europe: An ARDL analysis. Economic Research. 2012;25(3):538.
23. Kayhan S, Ugur A, Tayfur B, Fuat L. Causality relationship between real GDP and electricity consumption in Romania. Romanian Journal of Economic Forecasting. 2010;4:169-83.
24. Yakobashvili T. The role of the Black Sea region in European energy security. In Europe's Energy Security: Gazprom's Dominance and Caspian Supply Alternatives, In: Svante EC, Niklas N., editors. Central Asia-Caucasus Institute, Washington. 2008;87-98.
25. Tsereteli M. Economic and energy security: Connecting Europe and the Black Sea-Caspian region. Silk Road Paper. The Central Asia-Caucasus Institute & Silk Road Studies Program; 2008.
26. Çelikpala M. Turkey and the new energy politics of the Black Sea region, Neighbourhood Policy Paper 05. January; 2013.
27. Kao C, Chiang MH. On the estimation and inference of a cointegrated regression in

panel data. Advances in Econometrics. 2000;15:179-222.
28. Pesaran MH. General diagnostic tests for cross section dependence in panels. CESifo Working No. 1229; 2004.
29. Pesaran MH. A simple panel unit root test in the presence of cross section dependence. Journal of Applied Econometrics. 2007;22:265-312.
30. Westerlund Y. Testing for Error Correction in Panel Data. Oxford Bulletin of Economics and Statistics. 2007;69(6):709-748.
31. Pedroni P. Critical values for cointegrating tests in heterogeneous panels with multiple regressors. Oxford Bulletin of Economics and Statistics. 1999;61:653-670.
32. Pedroni P. Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. Econometric Theory. 2004; 20(3):597–625.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/14820