The Relationship between Electricity Consumption and GDP in Albania, Bulgaria and Slovenia

Rozeta Simonovska
University "Ss. Cyril and Methodius", Faculty of Economics, Skopje, Macedonia
Tel: +38975500916, e-mail: rozeta.simonovska@eccf.ukim.edu.mk

Abstract: *This paper investigates the causal relationship between electricity consumption and GDP in Slovenia, for the time period 1990-2010 and in Albania and Bulgaria for the time period 1980-2010. The causality is tested with the Granger causality test. But first we check whether or not the time series of GDP and electricity consumption are stationary. The augmented Dickey-Fuller (ADF) test and Phillips-Perron test are used to evaluate whether these two series have unit root.*

It can be concluded that the first differences of the two time series are stationary, i.e. they are integrated of order 1. The Johansen cointegration test shows that there is no cointegration equation for GDP and electricity consumption in these three countries. From the Granger causality test it can be concluded that there is unidirectional causality from GDP to electricity consumption for 2 and 5 years lags and a unidirectional causality from electricity consumption to GDP for 1 year lag. In the case of Albania and Slovenia the results suggest that there is no causality between electricity consumption and GDP.

Key words: Electricity consumption, economic growth, Granger causality

JEL Classification Codes : C32, Q43

Introduction

Electricity is a significant type of energy that people use constantly. It has a big part of our everyday life. Its wide use contributes to an impact in the overall economy. Hence, it is of a great importance to test the dependence between GDP as an economic variable and electricity consumption.

Examining the causality between electricity consumption and GDP describes the relationship that these two variables have. One of these four results can be obtained with testing for causality: (1) no causality; (2) unidirectional causality from electricity consumption to GDP; (3) unidirectional causality from GDP to electricity consumption and (4) bidirectional causality between electricity consumption and GDP.

An outcome where there is no causality between electricity consumption and GDP means that any variations in electricity consumption will not lead to a change in GDP, which favours the neutrality hypothesis. Unidirectional causality from electricity consumption to GDP indicates that reduction in electricity consumption will induce a drop in GDP. However, unidirectional causality from GDP to electricity consumption implies that the growth of GDP will lead to a larger demand of electricity. If there is bidirectional causality between electricity consumption and GDP, then these two variables influence each other at the same time.

Literature review

Depending on the studied countries and the time period that is analysed as well as the methodology, different results can be obtained for testing causality between electricity consumption and GDP.

The first attempt of testing causality between GNP and energy consumption was made in the paper of Kraft and Kraft (1978). The result of this paper was that over the period of 1947-1974 in the USA there is unidirectional causality running from GNP to energy consumption.

This topic has been very popular for the past few decades, so there were a number of papers concerning causality between energy consumption and GDP. Some of the most recent paper that examine causality between electricity consumption and GDP include: Altinay and Karagol (2005), Kiran and Guris (2009), Bekhet and Othman (2011), Hossain (2012) etc.

The relationship between energy consumption and GDP in Albania and Bulgaria was analized in the paper by Georgantopoulos and Tsamis (2011) „The Realationship between Energy Consumption and GDP: A Causality Analysis on Balkan Countries". This study employs annual data during the period 1970-2009. The conclusion of this paper is that in Bulgaria there is unidirectional causality from electricity consumption to GDP. This result implies that a shortage of energy may lead to a fall in GDP. For Albania the conclusion is that there is no causality between the two variables, i.e. the null hypothesis is accepted.

Because of the lack of statistical data for the period before 1990, no research has been made on this subject about Slovenia.

Data and methodology

The analysed data in this paper is: electricity consumption (EC) in kWh per capita and Gross Domestic Product (GDP) per capita in US$ in constant prices from 2005. Annual observations during the period 1980-2010 are used for Albania and Bulgaria. Because Slovenia was part of Yugoslavia until the early 1990s, there is no available data prior 1990. So the annual data for Slovenia is over the time period 1990-2010. All the data was obtained from the database of The World Bank[3]. In the analysis all the data is transformed into natural logarithms. The natural logarithm of EC per capita will be denoted by E and the natural logarithm of GDP per capita will be denoted by G.

The augmented Dickey-Fuller test is used for unit root testing in the case of Albania and Slovenia and the Philips-Perron test is used for unit root testing in the case of Bulgaria.

The Augmented Dickey-Fuller (ADF) test is based on $H_0: Y_t\ is\ not\ I(0)$ which is given by the following equation:

$$\Delta Y_t = \beta + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha \Delta Y_{t-i} + \varepsilon_t \qquad (1)$$

Where β, δ and α are the parameter to be estimated, ε_t is the error term or the white noise term, t is the linear time period and m is the difference between two consecutive periods ($\Delta Y_{t-1} = Y_{t-1} - Y_{t-2}$, $\Delta Y_{t-2} = Y_{t-2} - Y_{t-3}$ etc).

The Phillips-Perron (PP) test is similar to the ADF test, but it incorporates an automatic correction to the Dickey-Fuller procedure to allow for autocorrelated residuals.

3 http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=world-development-indicators

For examining the cointegration between the two variables, the Johansen cointegration test is applied. The Johansen cointegration test starts with setting a VAR model with k lags. This VAR model is given by:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_k y_{t-k} + u_t \quad (2)$$

Where, y_t is $n \times 1$, the coefficients $A_1, A_2, \dots A_k$ are $n \times n$ and n $(n \geq 2)$ is the number of variables which are I(1).

The VAR (2) needs to be turned into a vector error correction model (VECM) of the form

$$\Delta y_t = \Pi y_{t-k} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + u_t \quad (3)$$

where $\Pi = \left(\sum_{l=1}^{k} A_l\right) - I_n$ and $\Gamma_i = \left(\sum_{j=1}^{i} A_j\right) - I_n$.

The number of cointegration equations is determined by the rank r of the matrix Π via its eigenvalues. The rank of the matrix is equal to the number of characteristic roots (eigenvalues) which are different from zero.

The Johansen cointegration test considers two test statistics - the trace statistics and maximum eigenvalues matrix statistics, i.e.:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \qquad (4)$$

and

$$\lambda_{max}(r, r+1) = -T \ln\left(1 - \hat{\lambda}_{r+1}\right) \qquad (5)$$

where r is the number of cointegrating vectors under the null hypothesisc, $\hat{\lambda}_i$ is the estimated value fot the ith ordered eigenvalue from the from the Π matrix. Every significantly non-zero eigenvalue indicates a significant cointegrating vector.

At the end of the analysis, the Granger causality test is used in order to examine if there exists causality between the variables. The Granger causality test assumes that the information which is in the service of predicting the variables is contained by data of the time series of those variables. The test states that, if past values of a variable Y significantly contribute to forecast the value of another variable Xt+1 then Y is said to Granger cause X.

This test consists of assessing the following regressions:

$$Y_t = \sum_{i=1}^{n} \alpha_i X_{t-i} + \sum_{j=1}^{n} \beta_j Y_{t-j} + u_{1t} \quad (6)$$

$$X_t = \sum_{i=1}^{n} \lambda_i X_{t-i} + \sum_{j=1}^{n} \delta_j Y_{t-j} + u_{2t} \quad (7)$$

We assume that u_{1t} and u_{2t} are not correlated.

Four possibilities are considered:

- If $\sum \alpha_i \neq 0$ and $\sum \delta_j = 0$, then there is an unidirectional causality from X to Y.
- If $\sum \alpha_i = 0$ and $\sum \delta_j \neq 0$, then there is an unidirectional causality from Y to X.
- Bidirectional causality exists if the sets of coefficients before X and before Y are statisticly different from zero in each of the regressions
- There is no causality if the sets of coefficients before X and Y are statisticly insignificant in each of the regressions

Results

Table 1 displays the t-statistics in levels and in first difference of the data with intercept, with intercept and trend, and with none. The Augmented Dickey Fuller test is used in the case of Albania and Slovenia and the Phillips-Perron test is used for the data from Bulgaria. The McKinnon Critical Values are used for both tests on the basis of 5% significance level. The test statistics for both variables are not statistically significant at levels, not even at 10% level of significance. The next step is to examine the significance of the test statistic of the first difference of the variables. In that case both variables for Albania and Slovenia are statistically significant at a level of 10%. Only for Bulgaria the test statistic with intercept and trend is statistically significant at a level of 18%. Therefore, all variables are integrated of order one, i.e. they are I(1).

Table 1: Unit Root Test results

		Levels		
Country	Variable	With Intercept	With Intercept and trend	none
Albania	***E***	(0) -1,343984	(0) -1,858883	(0) 0,255178
	G	(1) -0,524310	(0) -1,858883	(0) 0,723712
Bulgaria	***E***	[0] -1,589187	[0] -1,704218	[2] 0,319941
	G	[3]-0,346884	[3] -1,206835	[3] 1,706929
Slovenia	***E***	(0) -0,768747	(0) 1,772835	(0) 1,024226
	G	(0) -0,089340	(1) -3,036988	(0) 2,053782

		1st diff.		
Country	Variable	With Intercept	With Intercept and trend	none
Albania	***E***	(0) -5,297810*	(0) -5,369008*	(0) -5,371343*
	G	(0) -3,481625*	(1) -4,219695**	(0) -3,428773*
Bulgaria	***E***	[5] -3,712970*	[5] -3,607529**	[5] -3,795599*
	G	[2] -2,928596***	[3] -2,914754****	[1] -2,719205*
Slovenia	***E***	(0) -3,622852**	(0) -3,587818***	(0) -3,424810*
	G	(2) -2,968250***	[8] -4,403651**	(0) -2,759017*

Note: * denotes significance at a level of 1%, ** significance at 5%, ***significance at 10%, **** significance at 18%, ()- Lag length obtained with SIC, []- Bandwidth (For Bulgaria the Phillips-Perron test is used. Leg length is chosen with Newey-West Bandwidthn and Bartlett kernel)

Table 2 provides the results for the Johansen cointegration test. When cointegration of the two variables is analyzed, the same result is obtained for the three countries - the variables are not cointegrated. In all three cases the conclusion is that the null hypothesis is not rejected which states that there are no cointegration equations between the two variables. This means that there is no long-term relationship between electricity consumption and GDP in these three countries (Albania, Bulgaria and Slovenia).

Table 2: Johansen Cointegration test

County	Hypothesized number of cointegration equations	Eigenvalue	Trace Statistic	Probability	Max-Eigen Statistic	Probability
Albania	**None**	0,252807	8,588706	0,4048	8,451527	0,3347
	At most 1	0,004719	0,137179	0,7111	0,137179	0,7111
Bulgaria	**None**	0,204739	6,495530	0,6369	6,414363	0,5606
	At most 1	0,002895	0,081167	0,7757	0,081167	0,7757
Slovenia	**None**	0,456599	12,24839	0,1454	11,58824	0,1271
	At most 1	0,034148	0,660151	0,4165	0,660151	0,4165

The results for the Granger Causality test are given in Table 3. The causality testing for Albania shows that there is no causality between electricity consumption and GDP. For one year lag there is unidirectional causality from electricity consumption to GDP in Bulgaria, but for 2, 3 etc. lags no causality exist in that direction. Unidirectional causality from GDP to electricity consumption exist for lags 2 and 5 for level of significance of 10% and 5%, respectively. In the case of Slovenia, no causality exist between electricity consumption and GDP and as in the case of Albania, the null hypothesis applies.

Table 3: Granger Causality Test Results

Country	Null hypothesis	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5	Lag 6
Albania	**E /-> G**	1.15347	0.49846	0.43797	1.38232	1.17342	1.01509
	G /-> E	1.84167	1.90645	1.31873	2.09339	1.33255	0.96655
Bulgaria	**E /-> G**	4.60658**	2.15426	1.65014	1.22210	2.17953	2.17883
	G /-> E	0.35928	2.74452***	1.71613	1.60118	3.07659**	0.60287
Slovenia	**E /-> G**	1.75017	0.24589	0.91646	1.37774	0.89133	0.13834
	G /-> E	0.00271	0.72018	1.25053	3.09461	2.38252	0.77699

Note: ** denotes significance at 5%, ***significance at 10% and E /-> G denotes that E does not Granger cause G

Conclusions

This paper tries to examine the relationship between electricity consumption (measured in kWh) and GDP in current US dollars for three Balkan countries (i.e. Albania, Bulgaria and Slovenia). It was attempted to find the direction of the causality and four possibilities were considered as a result of the causality testing between these two variables.

The data used in this paper is annual, taken from the World Bank Database. The analyzed period for Slovenia is 1990-2010 and for Bulgaria and Albania is 1980-2010. The data for the two variables is per capita and natural logarithm is computed.

The method for causality testing was the Granger causality test, but first, the ADF and PP tests were applied. The result from the unit-root testing was that all variables are integrated of order one. Furthermore, the Johansen cointegration test was used and the outcome was that the null hypothesis of no contegration equations should not be rejected.

The empirical results for Bulgaria uncover that for lag 1 year there is unidirectional causality from electricity consumption to GDP, but for leg of 5 years there exists causality in the opposite direction. For other number of lags there is no evidence of causality between the two variables. Therefore, it can be concluded that electricity consumption in Bulgaria has an impact on GDP only for one year period and if the number of lags if different from 1 these two variables do not influence each other significantly.

For Slovenia the results indicate that there is no causal relationship between GDP and electricity consumption. The same outcome is also obtained for Albania, i.e. the neutrality hypothesis is accepted. This implies that reducing electricity consumption does not have an effect on GDP and additionally the GDP growth does not lead to an increase of electricity consumption in Albania and Slovenia.

The final conclusion from this paper is that any policies that are introduced into managing electricity consumption in Albania, Bulgaria and Slovenia may not have significant effect on GDP growth in these countries.

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Appendex 1: GDP and electricity consumption in Albania, Bulgaria and Slovenia

	Bulgaria		Albania		Slovenia	
	EC[4]	GDP[5]	EC	GDP	EC	GDP
1980	3973,691	2217,62	1116,728	1810,483		
1981	4125,353	2318,547	1094,542	1870,348		

[4] in kWh per capita
[5] per capita (US$ in constant prices from 2005)

1982	4397,891	2365,666	1066,377	1882,093		
1983	4582,125	2440,718	1039,125	1859,739		
1984	4772,295	2517,718	985,2315	1793,034		
1985	4678,286	2585,317	767,074	1779,541		
1986	4646,261	2694,812	1357,905	1829,747		
1987	4838,62	2853,768	1101,949	1765,482		
1988	4940,518	3162,548	947,4187	1696,113		
1989	4963,179	3094,5	968,4503	1825,756		
1990	4758,732	2863,551	498,1314	1630,584	5334,905	12514,81
1991	4361,145	2647,809	376,0373	1143,836	5087,452	11393,75
1992	3735,525	2481,758	416,6113	1065,454	4943,155	10787,04
1993	3807,697	2464,604	492,7896	1177,845	4950,932	11120,23
1994	3825,387	2517,947	554,3134	1288,012	5240,16	11726,22
1995	4211,125	2601,526	612,5929	1470,838	5312,905	12150,73
1996	4350,443	2378,844	840,7554	1612,76	5365,508	12601,83
1997	3970,131	2353,987	643,2891	1452,487	5434,662	13244,34
1998	3932,402	2484,949	679,0046	1639,838	5574,706	13739,81
1999	3613,367	2548,003	1315,876	1809,551	5675,615	14461,2
2000	3673,607	2706,574	1342,835	1949,281	5777,996	15033,47
2001	3853,73	2872,957	1246,773	2097,704	6006,345	15451,05
2002	3838,485	3066,022	1459,433	2173,411	6380,952	16022,47
2003	3973,257	3253,222	1378,657	2314,466	6578,034	16482
2004	3939,001	3490,1	1691,75	2468,691	6830,705	17196,48
2005	4121,629	3733,263	1622,587	2620,821	6917,86	17854,64
2006	4311,328	3997,037	1146,695	2766,192	7123,538	18838,85
2007	4455,751	4274,643	1137,949	2941,749	7137,824	20020,84
2008	4594,279	4561,328	1510,482	3177,913	6920,244	20706,67
2009	4400,583	4332,199	1706,977	3288,434	6103,441	18877,11
2010	4476,468	4378,879	1800,871	3404,655	6521,093	19054,26

Source: The World Bank http://databank.worldbank.org/data/views/variableselection/selectvariables.aspx?source=world-development-indicators