ECONOMIC GROWTH AND ELECTRICITY CONSUMPTION IN EMERGING COUNTRIES OF EUROPA: AN ARDL ANALYSIS

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Abstract

The structure of energy intensity is not only important for the economists but also for the policymakers since it contributes to the policy debate on the link between energy use and economic growth and co-movement of the energy supply and growth policies. This study estimates the causal relationship between energy consumption and economic growth at per capita and aggregate levels for some transition countries in Europe; Albania, Belarus, Bulgaria, Czech Republic, Hungary, Lithuania, Poland, Romania and Slovakia.. The study also presents the income elasticities of total energy demand by using the ARDL (Auto Regressive Distributed Lag) method.

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1 Introduction

Importance of energy for economic growth and social welfare is a well known subject. However, economists could not agree upon the degree of this importance and interrelationship between the energy use and economic growth. Energy consumption may accelerate, impede or sluggish to the growth. Furthermore, as it is in the argument of Gales, Kander, Malanima and Rubio (2007), energy intensity shows an inverted U-curve pattern with a relative increase in the beginning of development and subsequent decline in the later phases of industrialization. The structure of energy intensity is not only important for the economists but also for the policymakers since it contributes to the policy debate on the link between energy use and economic growth and co-movement of the energy supply and growth policies. (Nepal, 2011).

Countries in Central and Eastern Europe are not very efficient in energy intensity, in which the ratio of energy demand to Gross Domestic Product (GDP) is much higher than the European Union (EU) average. According to Dobozi (1991), central planning that estimates energy demand with upward biased, a large reliance on heavy industries and energy resources in some countries, low energy prices, the lack of incentives and mechanisms to save energy and deceleration of technological progress have been the main reasons for this inefficiency. Cornillie and Fankhauser (2004) argue that the decline in the total use of energy in the transition period of these countries can be attributed to the decline in general economic activity since energy intensity has increased.

United Nations Development Programme (UNDP) report (Jochem, 2004) reveals that ratios of primary energy use to GDP have gone through new phases in the transition countries of Europe. In the early 1990s economic reforms began to restructure production and consumption patterns. In the Baltics, the Czech Republic, Hungary, and Poland this led to real declines in the ratios of primary energy to GDP as efficiency increased and the structure of manufacturing changed. Remarkable contraction in energy use by industry in transition economies were often not related to efficiency, mostly because of structural changes. However, structural changes in industry, integration with global markets, and investments in new processes, buildings, and infrastructure are expected to improve energy efficiency considerably over the next 20 years. Hence, this makes the knowledge about the relationship between energy consumption and economic growth more

significant for these countries.
The aim of this study is to estimate the relationship between energy consumption and economic growth by ARDL method in some developing countries of Eastern Europe. Finding whether there are differences or not in the energy demand elasticities and the direction of causality relations among analyzed countries are the other analyzed points. In the next section of the study, the survey of the elasticity, demand forecasting and causality literatures will be presented. Econometric theory and methodology are identified in the third section. Fourth section consists of from the empirical results while the last section includes conclusions and policy implications.

2 *Literature Review*

The causality studies were started at the extent of energy consumption then were disintegrated into sub-components like electricity and oil consumption and their relations with GDP and/or economic growth was investigated. Examinations on the relationship between electricity and growth were accelerated in the last decade. Rasche and Tatom's (1977) study was different from the other studies in the previous literature about the causality of electricity consumption and economic growth because they specified a production function for the United States. Kraft and Kraft (1978) found that the relationship between energy consumption and GNP for the 1947-1974 period could be approached with a Sims causality analysis.
Markandya, Pedroso and Streimikiene (2006) investigated the relationship between energy intensity in the 12 countries of Eastern Europe. Results show that the energy intensities of transition countries converge to EU levels significantly. The countries with the fastest convergence rates given these parameters are the Czech Republic, Bulgaria, Croatia and Turkey. Nepal's (2011) econometric results from the bias corrected fixed-effect analysis suggest that both large and small scale privatization process has been the sole driver of energy efficiency in transition countries. Cornilie and Frankhauser (2004) study the evolution of energy intensities in the transition countries by decomposing the energy data and using panel data model based on random effects to identify the main factors driving improvements in energy intensity. The study concludes that energy prices

and progress in enterprise restructuring are the two most significant drivers for efficient energy use. Polimeni and Polimeni (2007) argue that improved energy efficiency leads to increased consumption of energy for the transitional economies of Romania, Bulgaria, Poland, and Hungary. Analysis of this kind is vital because it could enable policy makers to develop national energy strategies that would account for the stages of economic development that their countries reached. Differences in the causality results allows for four hypotheses: 1) the "neutrality hypothesis" (if no causality exists between GDP and energy consumption; 2) the "conservation hypothesis" (the unidirectional causal relationship moves from GDP to energy consumption); 3) the "growth hypothesis" (the unidirectional causal relationship moves from energy consumption to GDP); and 4) the "feedback hypothesis" (if there is a bi-directional causal relationship between GDP and energy consumption). According to the results of our survey about East European countries, 31.8% of them supported the neutrality hypothesis, 13.6% of them supported the conservation hypothesis, 31.8% of them supported the growth hypothesis, and 22.7% of them supported the feedback hypothesis. Causality studies about the East European Countries are presented in table 1 where EC is the energy consumption and Y is GDP.

TABLE 1 - Causality Literature

Author(s)	Country	Period	Methodology	Main Variables	causality
Conservation hypothesis					
Narayan and Prasad (2008)	Hungary	1960-2002	Granger causality	GDP, Electricity consumption	$Y \rightarrow EC$
Chontanawat and Hunt (2006)	Albania, Bulgaria	1971-2000	Granger causality	GDP, Energy consumption	$Y \rightarrow EC$
Growth Hypothesis					
Kayhan, Adıgüzel, Bayat and Lebe (2010)	Romania	2001-2010	Granger causality (Toda Yamamoto)	GDP, Electricity consumption	$EC \rightarrow Y$
Chontanawat and Hunt (2006)	Poland	1960-2000	Granger causality	GDP, Energy consumption	$EC \rightarrow Y$
Chontanawat and Hunt (2006)	Czech Republic	1971-2000	Granger causality	GDP, Energy consumption	$EC \rightarrow Y$
Narayan and Prasad (2008)	Czech Republic, Slovak Republic	1960-2002	Granger causality	GDP, Electricity consumption	$EC \rightarrow Y$
Bohm (2008)	Czech Republic, Slovak Republic	1960-2002	Granger causality	GDP, Electricity consumption	$EC \rightarrow Y$

End of Table 1.

Feedback hypothesis					
Öztürk and Acaravcı (2010)	Hungary	1980-2006	Bound test (ARDL)	GDP, Electricity consumption	
Chontanawat and Hunt (2006)	Slovakia, Romania	1971-2000	Granger causality	GDP, Energy consumption	
Chontanawat and Hunt (2006)	Hungary	1965-2000	Granger causality	GDP, Energy consumption	
Mutascu, Shahbaz and Tiwari (2011)	Romania	1980-2008	Bound test (Toda Yamamoto)	GDP, Electricity consumption	
Neutrality hypothesis					
Narayan and Prasad (2008)	Poland	1960-2002	Granger causality	GDP, Electricity consumption	none
Öztürk and Acaravcı (2010)	Albania, Bulgaria, Romania	1980-2006	Bound test (ARDL)	GDP, Electricity consumption	none
Öztürk and Acaravcı (2009)	15 East European and Eurasian Countries	1990-2006	Pedroni cointegation	GDP, Electricity consumption	none
Yu and Choi (1985)	Poland	1950-1976	Sims, Granger causality	GDP, Electricity consumption	none
Soytaş and Sarı (2003)	Poland	1965-1994	Cointegration, ECM	GDP, Electricity consumption	none

Source: Authors calculation

3 *Data and Methodology*

3.1 *Data*

Data consists of from the per capita Gross Domestic Product (PCY), total energy consumption (EC) and Gross Domestic Product (Y) for some Emerging European countries: Albania (1980–2009), Belarus (1971–2009), Bulgaria (1971–2009), Czech Republic (1971–2009), Hungary (1971-2009), Lithuania (1990–2010), Poland (1970–2009), Romania (1980–2009) and Slovakia (1982-2009). In order to gain from the largest number of observations, Y was used for Belarus, Bulgaria, Czech Republic, Hungary, Lithuania and Poland whereas PCY was used for Albania, Romania and Slovakia. Y (PCY) is log(Y/Y_{t-1}) (log(PCY/PCY_{t-1}). EC is taken as log(EC/EC_{t-1}). Data periods seem to be short. However, ARDL method is suitable for especially shorter time periods. Data are obtained annually and were taken from International Energy Agency, gapminder and Worldbank.

3.2 *Methodology*

3.2.1 *Cointegration Analysis*

In this paper, the ARDL approach to cointegration involves two steps for estimating a long-run relationship. The first step is to investigate the existence of a long-run relationship among all variables. If there is a long-run relationship (cointegration) among variables, the second step is to estimate the following long-run and short-run models. Panel data method is not used since the aim of this paper is to see the differences in the energy consumption behaviors of the countries in the sample. The ARDL model for the standard log-linear functional specification with an OLS estimation technique is as follows:

$$\Delta Y = \alpha_0 + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \sum_{i=1}^{m} \phi_i \Delta EC_{t-i} + \delta_1 Y_{t-1} + \delta_2 EC_{t-1} + \varepsilon_t \qquad (1)$$

$$\Delta EC = \alpha_0 + \sum_{i=1}^{m} \beta_i \Delta EC_{t-i} + \sum_{i=1}^{m} \phi_i \Delta Y_{t-i} + \phi_1 EC_{t-1} + \phi_2 Y_{t-1} + \varepsilon_t \qquad (2)$$

where Δ *and* ε_t are the first difference operator and the white noise term, respectively. An appropriate lag selection is based on the Akaike Information Criterion (AIC). The bounds testing procedure is based on the joint F-statistic or Wald statistic that tests the null hypothesis of no cointegration. That is; $H_0: \delta_1 = \delta_2 = 0$ against the alternative hypothesis $H_1: \delta_1 \neq \delta_2 \neq 0$ for equation 1 and $H_0: \phi_1 = \phi_2 = 0$ against the alternative hypothesis $H_1: \phi_1 \neq \phi_2 \neq 0$ for equation 2. The distribution of the test statistics under the null is non-standard, in which critical values depend on the order of integration of the variables involved. Thus, rather than using standard critical F statistic values, the upper (for I(1)) and lower (for I(0)) bounds of the F statistics presented by Pesaran et al. (2001) are used.[1]

3.2.2 *Granger Causality*

Vector Error Correction model that was used to analyze the short run relationships between the variables were constructed as follows:

$$\Delta Y = \alpha_0 + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \sum_{i=0}^{n} \phi_i \Delta EC_{t-i} + \varphi_1 ECT_{t-1} + e_t \tag{3}$$

$$\Delta EC = \alpha_0 + \sum_{i=1}^{m} \theta_i \Delta EC_{t-i} + \sum_{i=0}^{n} \vartheta_i \Delta Y_{t-i} + \varphi_2 ECT_{t-1} + e_t \tag{4}$$

where residuals, e_t are independently and normally distributed (i.i.d.) with zero mean and constant variance and $ECT_{t-1}$is the error correction term resulting from the long-un equilibrium relationship and $\beta,\ \phi,\ \theta\ and\ \vartheta$ are parameters to be estimated. φ is a parameter indicating the speed of adjustment to the equilibrium level after a shock. The F statistics on the lagged explanatory variables of the ECT indicates the significance of the short-run causal effects.

As can be seen from table 1, the Granger causality test was widely used to analyze the causal relationships and was used in the last stage of our study. As Narayan and Smyth (2009) point out, after estimating the long-run model to obtain the estimated residuals, the next step is to employ the following error-correction based on the Granger causality model. However, according to Bahmani-Oskooee and Alse (1993), if the variables are cointegrated, then the standard Granger Causality test results will be invalid. In this case, the Vector Error Correction model should be a starting point for the causality analysis.

[1] The critical values (CVs) are reported in Narayan (2005) for sample sizes ranging from 30 to 80 observations.

Granger causality can be examined in three ways (Lee and Chang 2008, Ozturk and Acaravci 2011, Bildirici and Kayıkçı: 2012). First, short run or weak Granger causalities are tested by $H_0 : \phi_i = 0$ and $H_0 : \vartheta_i = 0$ for all i in Equations (3) and (4). Second, Long run Granger causalities are tested from the ECTs in those equations. Long-run causalities are tested by $H_0 : \varphi_1 = 0$ and $H_0 : \varphi_2 = 0$. Third, Strong Granger causalities are tested by $H_0 : \phi_i = \varphi_1 = 0$ and $H_0 : \vartheta_i = \varphi_2 = 0$ for all i in Equations (3) and (4).

4 *Empirical Results*

4.1 *Unit Root Tests*

In order to test for the presence of stochastic stationarity in our data, we first investigate the integration of our individual time-series, using the Augmented Dickey Fuller (ADF) test. The results reported in Table 2 clearly show that the levels are non-stationary and the first differences are stationary.

TABLE 2—Unit Root Test Results

Variable	Level	First Difference	Variable	Level	First Difference
ALBANIA			**BULGARIA**		
Y	-0.76	-3.41	Y	-1.18	-4.85
EC	-1.45	-4.21	EC	-1.23	-3.69

End of Table 2.

CZECH REPUPLIC			**HUNGARY**		
Y	-1.41	-4.09	Y	-0.93	-3.40
EC	-0.99	-5.66	EC	-2.03	-4.24
POLAND			**ROMANIA**		
Y	-1.62	-4.96	Y	-1.87	-3.01
EC	-0.62	-3.72	EC	-1.30	-3.26
SLOVAKIA			**LITHUANIA**		
Y	-1.11	-4.86	Y	-0.97	-3.75
EC	-1.92	-3.34	EC	-2.60	-5.64
BELARUS					
Y	-1.32	-3.97			
EC	-1.06	-3.78			

Source: Authors calculation

4.2 *Testing for Cointegration*

The lag length that supplies the smallest critical value is determined as the lag length of the model by using the Akaike Information Criterion (AIC). Models were determined after applying the LM test to all possible models. The results of the ARDL bounds tests are shown in Table 3. The null hypothesis of no long run relationship can be rejected at 1%, 5% and 10% level (only at the 10% level for some countries) of significance. That means, there is a long run equilibrium relationship between energy consumption and economic growth for the emerging countries of Europe. The majority of studies in the literature do not examine the coefficients with respect to both the sign (positive or negative) and the magnitude of the relationship between electricity consumption and economic growth. The long run elasticities results (t-ratios in parenthesis) with literature comparisons are also displayed in Table 3.

TABLE - 3 Bound Testing for Cointegration[2]

	ARDL Bound Test Results			Elasticities Literature		
Countries	F (Y / EC) F (EC / Y)	Long-Run Coefficients	ECT	Author(s)	Income elasticity	Price elasticity
ALBANIA	2.125 4.184	0.083 (5.876)	-0.566 (3.826)	Iimi (2010)	0.164	-0.774
BELARUS	6.515 0.051	2.55 (2.901)	-0.630 (2.499)	-	-	-
BULGARIA	5.001 1.501	-1.231 (4.88)	-0.357 (2.515)	Iimi (2010)	0.089	-0.330
CZECH REPUBLIC	11.37 2.826	1.172 (2.772)	-0.156 (2.41)	Bruha and Scasny (2004)	0.68	-0.21
HUNGARY	0.42 6.338	-0.06 (2.99)	-0.131 (2.55)	Lee (2010)	0.464	0.079
LITHUANIA	2.065 5.287	3.919 (6.814)	-0.388 (2.273)	-	-	-

[2] 95 percent boundaries are 3.39-4.42 for Albania, 3.24-4.26 for Bulgaria, 3.24-4.26 and 3.34-4.43 for Czech Republic, 3.27-4.29 for Hungary, 3.27-4.29 and 3.40-4.41 for Poland, 3.34-4.47 for Romania, 3.39-4.50 and 3.34-4.43 for Slovakia.

End of Table - 3.

POLAND	7.284	1.185	-0.585	Meyers et.all	0.25	
	0.114	(5.683)	(-3.847)	(1994)		
ROMANIA	5.329	0.007	-0.197	Bianco et.all	0.13(SR)	-0.07(SR)
	2.022	(14.717)	(2.168)	(2010)	0.49(LR)	-0.27(LR)
				Iimi (2010)	0.126	-0.210
SLOVAKIA	7.947	-2.941	-0.174	-	-	-
	0.334	(6.909)	(4.139)			

Source: Authors calculation

ECT coefficients were negative and statistically significant, as expected, for nearly all countries. ECT coefficients range from -0.35 to -0.63 for Albania, Belarus, Bulgaria, Lithuania and Poland which indicates that the speed of adjustment is fast. ECT coefficients range from -0.13 to -0.19 for Hungary, Czech Republic, Romania and Slovakia which indicates that the speed of adjustment is rather slow (5 to 7 years).

4.3 *Stability of the Cointegration Relation*

We have implemented CUSUM and CUSUM-Q tests to see whether the parameters in the models are stable. Since the sample includes many countries, we have presented only the results of CUSUM-Q tests. It is clear from the figures that parameters are stable; both sum of the residuals and sum of the squared residuals are moving inside the boundaries. The straight lines represent critical bounds at 5% significance level.

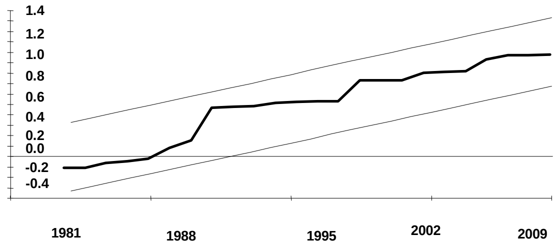

FIGURE 1— Plot of Cumulative Sum of Squares of Recursive Residuals for Albania

Source: Authors calculation

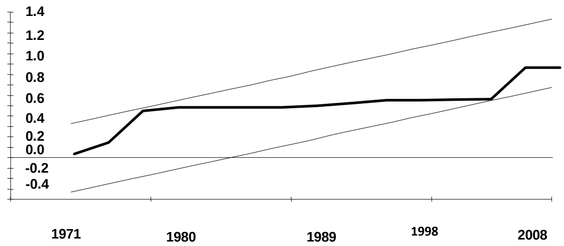

FIGURE 2— Plot of Cumulative Sum of Squares of Recursive Residuals for Belarus

Source: Authors calculation

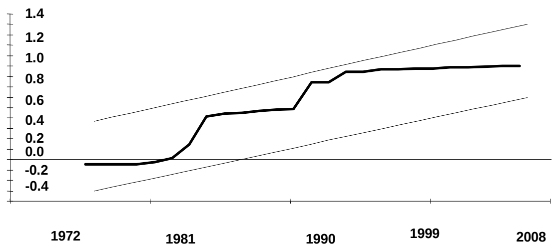

FIGURE 3— Plot of Cumulative Sum of Squares of Recursive Residuals for Bulgaria

Source: Authors calculation

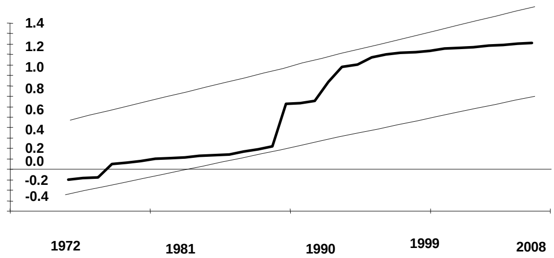

FIGURE 4— Plot of Cumulative Sum of Squares of Recursive Residuals for Czech Republic

Source: Authors calculation

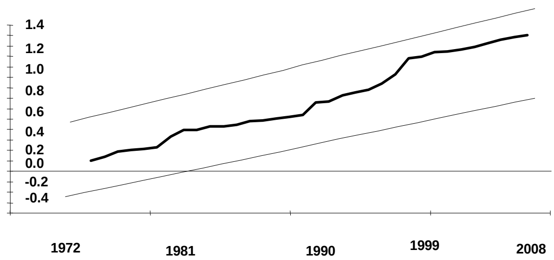

FIGURE 5— Plot of Cumulative Sum of Squares of Recursive Residuals for Hungary

Source: Authors calculation

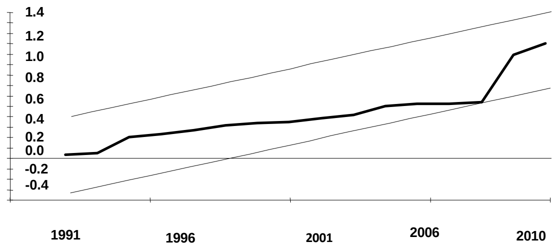

FIGURE 6— Plot of Cumulative Sum of Squares of Recursive Residuals for Lithuania

Source: Authors calculation

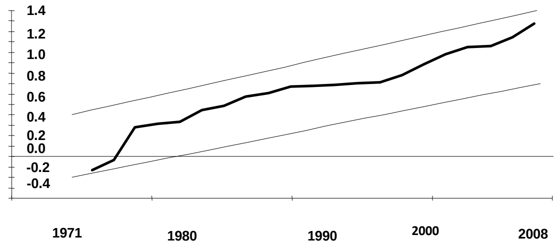

FIGURE 7— Plot of Cumulative Sum of Squares of Recursive Residuals for Poland

Source: Authors calculation

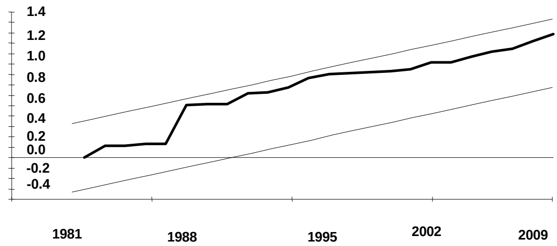

FIGURE 8— Plot of Cumulative Sum of Squares of Recursive Residuals for Romania

Source: Authors calculation

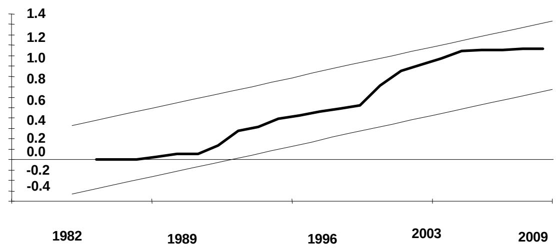

FIGURE 9— Plot of Cumulative Sum of Squares of Recursive Residuals for Slovakia

Source: Authors calculation

4.4 *Granger Causality Results*

The results in Table 4 show the results from Granger causalities. If the series are cointegrated, there are a causal relationship at least in one direction.
The causality results in the table seem to present the diversity of Emerging European Countries for the energy consumption and economic growth relationship. Table 4 suggests that there is unidirectional causality from the GDP to the energy consumption for Albania, Hungary, Lithuania and Poland in the short run causality which supports the conversation hypothesis. Bulgaria and Slovakia are the countries in which the causality supports growth hypothesis and runs from the energy consumption to the GDP in the short run causality. Furthermore, there is a bidirectional causality that supports the feedback hypothesis for the Belarus, Czech Republic and Romania. According to the long run causality result, there is a bi-directional causality that supports the feedback hypothesis for the Belarus, Czech Republic, Hungary, Poland and Romania. There is unidirectional causality from the GDP to the energy consumption only for Albania in long-run which supports the conversation hypothesis. Bulgaria and Slovakia are the countries in which the causality supports growth hypothesis and runs from the energy consumption to the GDP. There are bi-directional causality for Belarus, Bulgaria, Hungary, Lithunia, Romania and Slovakia in strong causality. There are evidence to support neutrality hypothesis for Albenia in strong causality result.

TABLE 4—Results of Granger Causality[3]

Countries	$\Delta EC \rightarrow \Delta Y$ / $\Delta Y \rightarrow \Delta EC$	$ECT \rightarrow \Delta EC$ / $ECT \rightarrow \Delta Y$	$\Delta EC, ECT \rightarrow \Delta Y$ / $\Delta Y, ECT \rightarrow \Delta EC$
ALBANIA	4.96	3.29	1.01
	90.26	91.05	0.75
BELARUS	14.001	243.57	259.16
	31.17	51.16	252.16
BULGARIA	27.63	107.83	112.16
	4.44	0.66	108.53
CZECH REPUBLIC	58.50	81.16	5.77
	14.81	58.49	7.55
HUNGARY	4.39	398.16	414.41
	50.73	414.43	412.21
LITHUANIA	1.79	1.001	460.12
	45.98	1.58	459.51
POLAND	5.88	103.22	29.58
	23.31	99.05	0.15
ROMANIA	18.49	75.18	185.15
	47.54	20.95	176.47
SLOVAKIA	23.46	85.04	171.04
	3.52	0.08	172.17

Source: Authors calculation

5 *Conclusion*

We investigated the cointegration and causality relationship of the energy consumption and economic growth in Emerging European countries by using ARDL bounds test and Granger causality methods.

[3] In this table, the symbol $\longrightarrow$ shows the direction of causality

There is evidence to support the growth hypothesis for Bulgaria and Slovakia. Energy policies aimed at improving the energy infrastructure and increasing the energy supply are the appropriate options for these countries because energy consumption increases the income level. This is theoretically expected outcome for these countries since they are developing countries. However, there is evidence to support the conservation hypothesis for Albania in short and long run causality . This suggests that the policy of conserving energy consumption may be implemented with little or no adverse effects on economic growth, such as in a less energy-dependent economy. This finding also suggests that economic growth may stimulate increased consumption of energy. In addition, feedback hypothesis is validated for Belarus, Czech Republic and Romania that there is a bi-directional relationship between energy consumption and economic growth for short and long run causality. Thus, both type of energy policies are valid for these countries.

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EKONOMSKI RAST I POTROŠNJA ELEKTRIČNE ENERGIJE U EUROPSKIM ZEMLJAMA U RAZVOJU: ARDL ANALIZA

Sažetak

Struktura intenziteta energije nije važna samo za ekonomiste već i za kreatore politike s obzirom da doprinosi raspravi o vezi između potrošnje energije i ekonomskog rasta te sukladnog kretanja opskrbe energijom i politike rasta. Ovaj rad procjenjuje kauzalni odnos između potrošnje energije i ekonomskog rasta kako po glavi stanovnika tako i na ukupnoj razini za nekoliko tranzicijskih zemalja u Europi; Albaniju, Bjelorusiju, Bugarsku, Češku, Mađarsku, Litvu, Poljsku, Rumunjsku i Slovačku. Rad također prezentira elastičnost prihoda u ukupnoj potražnji energije koristeći ARDL (auto-regresijsku s vremenskim pomakom) metodu.

Ključne riječi: Rast, razvoj, potrošnja električne energije, ARDL