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The effect of energy on output per worker in the Balkan Peninsula: A country-specific study of 12 nations in the Energy Community

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ABSTRACT

In this paper, we explore the long-run co-integration relationship between output per worker, capital per worker and energy per worker for 12 countries in the Balkan Peninsula (Albania, Austria, Bulgaria, Cyprus, Greece, Hungary, Italy, Macedonia, Romania, Slovakia, Slovenia and Turkey) which are part of the Energy Community. In line with the current developments in energy economics [62], we add to the literature by reviewing the elasticity coefficients for the 12 countries using the augmented Solow [63] framework and the ARDL bounds procedure [57]. The causality nexus is explored using the Toda and Yamamoto (1995) procedure. The results show that output, capital and energy (in per worker terms) are co-integrated. We note that all countries have positive and statistically significant long-run energy elasticity coefficients. Except for Macedonia, we note that energy is statistically significant in the short-run for all other countries. The causality results support the conservation hypothesis for 7 countries (Albania, Bulgaria, Cyprus, Hungary, Italy, Romania and Turkey); the growth hypothesis for 2 countries (Austria and Macedonia); and the feedback hypothesis for 3 countries (Greece, Slovakia and Slovenia), respectively.

1. Introduction

Energy plays a pivotal part in development economics. Effective technology uses, productivity, conservation of resources including energy and climate change are important issues in geo-economic planning. Amidst these, keeping pace with industrialization and balancing the use of clean energy are central to green growth policies. Notably, the use of energy for overall economic activities has noted a rise since the last three decades. The world primary energy consumption which comprises of petroleum, natural gas, coal, and renewable energy, is growing. The primary energy consumption grew by 0.73% in 2012 to 524.076 quadrillion British Thermal Units. In the same period, the world petroleum consumption grew by 1.64% from 89,721.1 to 91,914.8 thousands of barrels per day, and the net world electricity consumption figure was around 19,710.362 billion kilowatt hours which was an increment of 1.62% from the previous year. Similarly, in 2012, natural gas, coal and consumption of electricity from renewable resources at world level was 119,568 billion cubic feet, 8,186,103 thousand short tons and 4714.827 billion kilowatt hours, respectively [20].

The growth in energy consumption highlights the critical role that energy plays in supporting economic activities. In this paper, we review at country level, the role of energy consumption in the Balkans and neighbouring countries (Balkan Peninsula). Our sample includes Austria, Hungary and Slovakia (Central Europe), Slovenia (South Central Europe), Italy and Greece (Southern Europe), Albania, Bulgaria, Macedonia, Romania (Southeast Europe) and Cyprus (a neighbouring country in the Mediterranean Sea). These countries are members of the Energy Community (EC), an international organization dealing with energy policy in the region.

Additionally, we take Turkey (Asia), which has an observer status, into account.[1] The EC was established by an international treaty in October 2005 and came into effect in July 2006. The Community brought together members of the European Union (EU), countries of

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[1] Turkey has only an observer status like Norway or Armenia. The treaty differentiates between members and observers. Turkey is not a European country, only a part of Istanbul is located in Europe, the rest is Asia.

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southeast Europe and the Black sea region with a common objective to extend the EU internal energy market to Southeast Europe and beyond on the basis of a legally binding framework. Albania, alongside other Balkan and neighbouring countries, is one of the contracting parties to this treaty. With exception to Albania and Turkey, the other seven countries in the sample are members of the EU with Bulgaria, Hungary and Romania having their own currency. Additionally, Austria, Greece, Hungary and Italy are Schengen Area members while Bulgaria, Cyprus and Romania are candidate countries. Being part of the EC, these 12 countries in the region also share common characteristics, especially in terms of energy extraction and distribution.

The extraction and distribution of energy has been an important topic in policy dialogues in the region. Some of these countries have been considered for different gas pipeline plans to circumvent the three most important gas pipelines – Jamal, Druschba and Sojus from Russia to Europe, which goes through Ukraine. In the past, Ukraine was responsible for intermittent gas delivery which remains a concern for Austria, Hungary and other countries in the Balkan Peninsula, especially because these countries do not have any real alternatives. Since the early 2000s, a plan for a new pipeline has been developed to diversify the supply side. Currently, Gazprom, a Russian public joint stock company, is supplying nearly 50% of all gas in Europe. However, the location of the pipeline and source of gas is a politically sensitive matter, because there are at least three parties involved with varying interests – the EU (European Union), the USA and the Russian Federation. One proposal is the Nabucco pipeline, supported by the EU and the USA which is expected to connect mainly Iraq, Egypt, Azerbaijan and Turkmenistan with Austria. The pipeline is expected to pass through Turkey, Bulgaria, Romania and Hungary. However, the project seems to have finally come to a halt in 2013. Another proposal is the South-Stream pipeline supported by Russia and some European countries which is to connect Russia with Italy and Austria passing through the Black Sea, Bulgaria, Greece, Albania, Serbia and Hungary. However, this project was opposed by the EU and the USA and halted in 2014 due to the Crimean crisis and extreme political pressure on Bulgaria from the EU. An alternative to South Stream was developed by the EU proposing the Trans-Adria pipeline, connecting Azerbaijan with Italy via Turkey, Greece, and Albania. Following the trouble with the South Stream pipeline, Russia has developed a new proposal to circumvent Bulgaria. The so called Turkish Stream pipeline is expected to pass through Turkey, Greece, Macedonia, and then follow the South Stream pipeline. Whichever project transpires, obviously there will be some benefits for the potential transit countries to develop their industries at a much faster pace because of low energy prices.

Against these backdrops, the paper reviews: (a) the magnitude effect (elasticity coefficient and the level of significance) of energy for each country within the EC; (b) the direction of causality to report the types of hypothesis supported by energy-growth relationship; and (c) the possible energy policies for each country given that significant hopes have been generated should an energy proposal becomes successful. The rest of the paper is planned as follows. In Section 2, we provide a literature survey. In Section 3, we discuss the framework, data and method, followed by the results in Section 4. Lastly, in Section 5, some concluding remarks follow.

2. A literature review

A number of studies examine the relationship between energy consumption and economic growth which can be summarized as satisfying at least one of the four hypotheses proposed by Payne [54]: (a) *growth hypothesis* – presence of a unidirectional causality from energy consumption to economic growth; (b) *conservation hypothesis* – presence of a unidirectional causality from economic growth to energy consumption; (c) *feedback hypothesis* – presence of bi-directional causation between energy consumption and growth; and (d) *neutrality hypothesis* – absence of any causal relationship between energy consumption and economic growth.

Generally, the hypotheses are interpreted as follows. If there is evidence of a causality running from energy consumption to economic growth, the country is considered relatively energy-dependent and hence the energy sector is an important driver of growth. Subsequently, a reduction of energy consumption can negatively affect income [47]. The causality from growth to energy consumption implies a relatively less energy-dependent economy and hence the country can adopt green growth policies to improve income [32]. A bi-directional causality suggests that energy and economic growth are interdependent (mutually reinforcing) on each other [66]. Where no causality is noted, energy and income evolves independently [80]. However, we are sceptical if such simple and to some extent naïve interpretations are sufficient to deduce policy recommendations and therefore recommend that statistical results of this nature be interpreted with caution. Moreover, diversified research on the relationship between energy and growth is useful in complementing such analysis and crystalizing policy recommendations.

In Table 1, we provide a list of studies which confirm one of the four hypotheses for different countries around the world. As noted from Table 1, the countries for which the growth hypothesis is confirmed includes: the Philippines, Japan, USA, India, Indonesia, Turkey, France, Germany, China Congo, Tunisia, Nigeria, Lebanon, South Africa, Kenya, Tanzania, Gibraltar, Belgium, Span and Malaysia. On the other hand, countries which are shown to converge to conservation hypothesis include USA, India, West Germany, India, South Korea, Australia, Indonesia, Thailand, France, Italy, Japan, Congo, China, Albania, Bulgaria, Hungary, Romania, Canada, the Netherlands and Sweden among others. Furthermore, countries for which the feedback hypothesis is confirmed includes: Japan, Italy, Taiwan, Pakistan, Tanzania, Nigeria, South Korea, Singapore, Philippines, Thailand, Greece, Argentina, Canada, USA, Malaysia, Egypt, Gabon, Morocco, Venezuela, Burkina Faso and Portugal among others. On the other hand, a few studies find evidence of neutrality hypothesis for some of the aforementioned and other countries. Among these countries include: Kenya, South Africa, Sudan, USA, Malaysia, Singapore, Philippines, South Korea, Indonesia, India, Turkey, UK, Germany, Sweden, Algeria, Congo, Finland, Hungary, Thailand and the Philippines.

From these results, it is obvious to note that the outcomes in regards to the causal relationship between energy and economic growth are controversial. The ambiguity in the outcomes, especially for the countries or region which show contradictions, in most part is due to the differences in the sample size used, model specification, and methodology used. Additionally, a lot of the studies have only examined the causality nexus without regard to the magnitude effects. One plausible reason for this is that, examining the magnitude requires a sound theory and a subsequent model specification to minimise the problem of misspecification. Moreover, for policy purpose, contemporary studies on the energy-growth nexus require analysis at country-level in order to examine the magnitude and the long-run elasticities in addition to the usual causality nexus [62]. Nevertheless, it can be argued that quite a few recent studies have benefitted from the innovative methods and techniques to derive improved results.

3. Modelling strategy

3.1. Framework

The model applies a conventional extended Cobb-Douglas production function[2] with the Hicks-neutral technical progress where per-worker output (y_t) is defined as:

[2] The Cobb-Douglas model satisfies the Inada conditions that guarantee stability of the economic growth path.

Table 1
Selected studies supporting the causality hypotheses.

Country/Region	Reference	Country/Region	Reference
Growth hypothesis: ***energy → growth***		***Conservation hypothesis:*** ***growth → energy***	
Philippines	Yu and Choi [80]	USA	Kraft and Kraft [33]
Japan	Erol and Yu [22]	India	Yu and Choi [80]
USA	Stern [67,68]	West Germany	Erol and Yu [22]
India & Indonesia	Masih and Masih [46]	USA	Abosedra and Baghestani [1]
Singapore	Glasure and Lee [27]	Indonesia	Masih and Masih [46]
Turkey, France, Germany, & Japan	Soytas and Sari [64]	India	Ghosh [26]
China	Shiu and Lam [61]	Korea and Italy	Soytas and Sari [64]
Shanghai, China, Benin Congo & Tunisia	Wolde-Rufael [73,74]	Korea	Oh and Lee [51]
Turkey	Altinay and Karagol [6]	Australia	Narayan and Smyth [49]
18 developing countries	Lee [40]	Indonesia	Yoo and Kim [78]
China	Yuan et al. [82]	Indonesia & Thailand	Yoo [77]
Tanzania	Odhiambo [50]	6 African countries	Wolde-Rufael [74]
USA	Bowden and Payne [17]	France, Italy & Japan	Lee [41]
Nigeria	Akinlo [4]	Middle & high income countries	Huang et al. [30]
Lebanon	Abosedra et al. [2]	Congo (DRC)	Odhiambo [50]
South Africa & Kenya	Odhiambo [50]	China	Zhang [83]
South Africa & Kenya	Kumar and Kumar (2013a)	USA[a,b]	Menyah and Rufael [44]
Gibraltar	Kumar et al. [37]	16 emerging markets[a]	Apergis and Payne [10]
South Africa	Kumar et al. [38]	Albania, Bulgaria, Hungary & Romania	Kumar et al. (2014a)
Belgium and Spain[b]	Omri et al. [53]	Bulgaria, Canada, Netherlands and Sweden[b]	Omri et al. [53]
Malaysia	Azam et al. [13]		
Feedback hypothesis: ***growth↔energy***		***Neutrality Hypothesis: N***	
Japan & Italy	Erol and Yu [22]	Kenya, South Africa, Sudan & USA	Akarca and Long [3], Yu and Hwang [81], Yu and Choi [84], Erol and Yu [22]
Taiwan	Hwang and Gum [31]	Malaysia, Singapore & Philippines	Masih and Masih [46]
Pakistan	Masih and Masih [46]	South Korea	Glasure and Lee [27]
Tanzania and Nigeria	Ebohon [21]	9 Countries	Soytas and Sari [64]
South Korea & Singapore	Glasure and Lee [27]	Indonesia and India	Asafu-Adjaye [12]
Philippines and Thailand	Asafu-Adjaye [12]	Turkey	Altinay and Karagol [5]
Greece	Hondroyiannis et al. [29]	11 African countries	Wolde-Rufael (2005), Soytas and Sari [65]
Argentina	Soytas and Sari [64]	UK, Germany & Sweden	Lee [41]
Canada	Ghali and El-Sakka [24]	Algeria, Congo Republic	Wolde-Rufael [74]
Korea	Oh and lee [52]	Europe[a]	Menegaki [43]
USA	Lee [41]	Finland, Hungary, India, Japan, Switzerland and UK[b]	Omri et al. [53]
Malaysia	Tang [69]	Thailand and Philippines	Azam et al. [13]
Egypt, Gabon & Morocco	Wolde-Rufael [74]		
Korea, Malaysia & Singapore	Yoo [76,77]		
Energy exporting developed Nations	Mahadevan and Asafu-Adjaye [45]		
20 OECD Countries[1]	Apergis and Payne [7]		
Eurasia[1]	Apergis and Payne [8]		
Venezuela, Burkina Faso & Portugal	Yoo and Kwak [79], Ouedrago (2010), Shabaz et al. (2011)		
6 central American countries[a]	Apergis and Payne [9]		
80 Developed & developing countries[a]	Apergis et al. [11]		
G−7 countries[a]	Tugcu et al. [71]		
Pakistan	Shabaz et al. (2015)		
China	Bloch et al. [15]		
China	Bhattacharya et al. [14]		
Argentina, Brazil, France, Pakistan, and USA[b]	Omri et al. [53]		
Indonesia and Singapore	Azam et al. [13]		

Notes: '→'causality effect '↔' feedback effect; *N*-neutrality or absence of causality;
[a] study uses renewable energy;
[b] study uses nuclear energy.

$$y_t = A_t k_t^{\alpha}, \quad 0<a<1 \tag{1}$$

and A_t=stock of technology, k_t=capital per worker and $\alpha > 0$ is the profit share. The model is developed from intuition of Solow (1956) and hence assumes that the evolution of technology over time is given by:

$$A_t = A_0 e^{gt} \tag{2}$$

where A_0=the initial stock of knowledge and g is the growth rate of technology over time, t. By assuming the revised technology, $\widetilde{A}_t$, is a function of energy and A_t, we have:

$$\widetilde{A}_t = f(A_t, eng_t) \tag{3}$$

where *eng* is the proxy for energy use. The effect of energy consumption on total factor productivity and hence output can be captured by entering energy per worker as a shift variable in the production function (c.f. Rao, 2010; [34,36]). Subsequently,

$$\widetilde{A}_t = A_0 e^{gt} eng_t^{\beta} \tag{4}$$

and hence the revised output per worker, $\tilde{y}_t$ is:

$$\tilde{y} = \widetilde{A}_t k_t^{\alpha} = A_0 e^{gt} eng_t^{\beta} k_t^{\alpha} \tag{5}$$

where $\beta > 0$ is the elasticity coefficient of energy per worker. Taking the natural logarithm of (5), the basic equation for estimation becomes:

$$\ln\tilde{y} = \lambda + \alpha \ln k + \beta \ln eng + \varepsilon \tag{6}$$

where, $\ln\tilde{y}$=natural logarithm of output per worker, λ=constant term, and $\ln k$=natural logarithm of capital stock per worker, $\ln eng$=natural logarithm of the energy per worker and ε=error term.

3.2. Data and method

The annual data is obtained from the *World Bank Development Indicators and Global Development Finance* database [75] and International Energy Statistics (EIA, 2015). The sample data available and used for each country is as follows: Albania and Bulgaria – 1980–2011, Austria – 1970–2012, Cyprus – 1975–2010, Greece – 1960–2011, Hungary – 1991–2012, Italy – 1960–2012, Macedonia – 1990–2011, Romania – 1990–2011, Slovakia – 1992–2012, Slovenia - 1995–2013 and Turkey – 1986–2011.[3] The annual capital stock data, K at year t is built using the perpetual inventory method, where $K_t = (1 - \delta)K_{t-1} + I_t$, where I_t is the gross fixed capital formation at constant USD which we use as a proxy for investment, and $0<\delta<1$ is the depreciation rate. For Macedonia, we set the initial capital stock as 1.1 times the respective country's initial year constant GDP. In case of Albania, Cyprus, Greece, Italy, Romania, Slovenia and Turkey, we set the initial capital stock, K_0 as 1.2 times the respective country's initial year constant GDP. For Austria, Bulgaria, Hungary and Slovakia, we set the K_0 as 1.3 the respective country's initial year constant GDP. The depreciation rate δ is set at 0.10 for Albania, Austria, Bulgaria and Romania, 0.09 for Hungary and Italy, 0.08 for Greece, 0.05 for Slovenia, 0.04 for Cyprus and Turkey, and 0.03 for Macedonia and Slovakia. The annual labour stock data are estimated using the average employment rate times the respective year's population. The choice of the factor used to set the initial capital stock and depreciation rate is based on at least two considerations: (a) the capital per worker should exhibit diminishing returns to scale and hence demonstrate convergence over time; and (b) the capital share reported should be realistic and revolves around the stylized value of one third ([16,23,59]; Kumar et al., 2015). The data on energy use is measured in kilogram of oil equivalent per capita and is converted in per worker terms. The data on gross fixed capital formation, gross domestic product (in constant 2005 US dollars), population, and employment rate are sourced from World Bank [75] and energy data are sourced the from EIA (2015). We present the descriptive statistics and the correlation matrix in Table 2 (Panels 1–12) to examine the correlation between output per worker and energy per worker.

Notably, energy and output is positively correlated for 9 out of the 12 countries. A marginal negative correlation between energy and output is noted for Bulgaria (−0.35), Romania (−0.20) and Slovakia (−0.25). While it is plausible that negative correlation can influence the co-integration, it is not necessary that correlation implies co-integration (long-run association), as shown in the results (see below).[4] To inspect the existence of a long-run association between output, capital and energy (in per worker terms), we use the autoregressive distributed lag (ARDL) procedure developed by Pesaran et al. [57]. Some advantages of using the ARDL approach to co-integration is that it is relatively simple to implement and recommended for a small sample size [25,48,57]. Moreover, on the assumption that the maximum order of integration of all the series used is one, the method does not require the examination of the unit root properties. Generally, this is the case for most time series data, it is recommended that the unit root properties of a series are examined because testing for unit root in series: (a) enables one to identify the maximum order of integration (without assuming it); (b) provides information which are useful when applying the Toda and Yamamoto [72] non-Granger causality test; (c) validates the use of ARDL procedure; and (d) with a relatively advanced methods can assist in identifying structural breaks in the series and the latter information can be used both in examining co-integration and causality. For conventional unit root tests, we use the Augmented Dickey and Fuller (ADF) [19], the Phillips and Perron (P-P) [58] and the Kwiatkowski et al. [39] (KPSS) tests, respectively; and to examine the breaks in series, we use the Perron [55] and Zivot and Andrews [84] test, respectively.

3.3. ARDL procedure

The ARDL bounds approach is applied to examine the co-integration between $\ln\tilde{y}$, $\ln k$ and $\ln eng$. The primary equation of interest to examine the long-run association is specified as:

$$\Delta \ln \tilde{y}_t = \beta_{10} + \beta_{11} \ln \tilde{y}_{t-1} + \beta_{12} \ln k_{t-1} + \beta_{13} \ln eng_{t-1} + \alpha_{10}T + \sum_{i=1}^{p} \alpha_{11i}\Delta \ln \tilde{y}_{t-i} + \sum_{i=0}^{p} \alpha_{12i}\Delta \ln k_{t-i} + \sum_{i=0}^{p} \alpha_{13i}\Delta \ln eng_{t-i} + \varepsilon_{1t} \tag{7}$$

where $\tilde{y}$ is the output per worker, k is the capital per worker, eng is the energy consumption per worker (in natural log form); $T\in\{TB, TREND\}$, where TB=break and/or pulse dummy identified using break tests and $TREND$ is the time variable; and ε is the error term.

To identify co-integration, we follow two steps. First, Eq. (7) is estimated using the ordinary least squares technique. Second, considering the null hypothesis of no co-integration ($H_0 : \beta_{i1} = \beta_{i2} = \beta_{i3}=0$) against the alternative hypothesis of cointegration ($H_0 : \beta_{i1} \neq \beta_{i2} \neq \beta_{i3}\neq 0$), the existence of a long-run relationship is examined by equating the coefficients of the level variables to zero. The null hypothesis of no co-integration is rejected when the F-statistics is above the upper bound $\{F - stat>I(1)_{critical}\}$, and accepted when the F-statistics is below the lower bound $\{F - stat<I(0)_{critical}\}$. In the situation where the F-statistics is within the upper and lower bounds, $\{I(0)_{critical}<F - stat<I(1)_{critical}\}$, the outcome is inconclusive. We compute the bounds using Microfit (Mfit) 5.0 [56] which is the successor of Mfit 4.1 [57]. However, the advantage of the former tool is that one can compute the F- and W-statistic and the respective bounds at the corresponding 90% and 95% confidence level via stochastic simulations using 20,000 replications with the given sample size. In this respect, the statistics generated are adjusted with the sample size. Nevertheless, we compare the results with the bounds reported by Narayan [48] for small sample size ($30 \leq n \leq 80$) to further support the outcomes. Since the Narayan-bounds are provided in the intervals of 5, we identify the interval in which the sample lies and consider the bounds reported at the lower end of the sample size as a conservative measure.[5] In case where the sample is below 30 ($n < 30$), we use the Narayan-bounds at $n = 30$, in addition to relying on the sample adjusted bounds generated by Mfit 5.0.

3.4. The Toda-Yamamoto approach to Granger non-causality

Next, we examine the direction of causality using the Granger non-causality test of Toda and Yamamoto [76]. The test allows to examine

[3] Since our study is at country level, we consider all available data for each country which is not same across countries (c.f. Kumar et al., 2014). We thank an anonymous reviewer for seeking clarification on this.

[4] By including a trend variable and/or structural break dummy variable whilst examining the long-run association can further support the cointegration outcomes.

[5] For alternative methods to compute sample-specific bounds, see Cheung and Lai (1995), Sephton (1995) and Tang and Abosedra (2014).

Table 2
Descriptive statistics for each country.
Source: Authors' estimation using Eviews 8.

Statistics	**Panel 1: Albania**			**Panel 2: Austria**			**Panel 3: Bulgaria**		
	$\ln\tilde{y}$	In*k*	ln*eng*	$\ln\tilde{y}$	In*k*	ln*eng*	$\ln\tilde{y}$	In*k*	ln*eng*
Mean	8.2864	8.9499	7.1814	11.0001	11.6258	8.8339	8.7839	9.1953	8.7005
Median	8.2210	8.9200	7.2169	11.0375	11.6851	8.8187	8.6998	9.1345	8.6498
Maximum	8.9019	9.5856	7.7088	11.3670	12.0513	9.0572	9.2320	9.8672	8.9323
Minimum	7.6926	8.3686	6.6139	10.4647	10.7271	8.5276	8.4777	8.7401	8.4830
Std. Dev.	0.3204	0.2731	0.3190	0.2642	0.3578	0.1491	0.2285	0.2961	0.1495
Skewness	0.2904	0.5682	−0.2930	−0.2638	−0.7561	−0.0888	0.8250	0.9836	0.4078
Kurtosis	2.4884	3.3766	1.9661	1.9415	2.7444	1.9576	2.3834	3.2014	1.5849
Jarque-Bera	0.7988	1.9110	1.8831	2.5063	4.2144	2.0032	4.1373	5.2144	3.5571
Probability	0.6707	0.3846	0.3900	0.2856	0.1216	0.3673	0.1264	0.0737	0.1689
Correlation									
$\ln\tilde{y}$	1.0000	–	–	1.0000	–	–	1.0000	–	–
In*k*	0.7492	1.0000	–	0.9853	1.0000	–	0.9381	1.0000	–
ln*eng*	0.3342	0.0125	1.0000	0.9747	0.9508	1.0000	−0.3456	−0.4076	1.0000
Statistics	**Panel 4: Cyprus**			**Panel 5: Greece**			**Panel 6: Hungary**		
	$\ln\tilde{y}$	In*k*	ln*eng*	$\ln\tilde{y}$	In*k*	ln*eng*	$\ln\tilde{y}$	In*k*	ln*eng*
Mean	9.9201	10.6842	8.0079	10.2981	10.8752	8.0374	9.9909	10.5326	8.6877
Median	10.0418	10.9193	8.1420	10.3736	11.0597	8.2117	10.0065	10.5528	8.6790
Maximum	10.3489	11.3150	8.3353	10.8263	11.5374	8.6727	10.2201	10.9323	8.7622
Minimum	8.9951	9.1774	7.3238	9.3485	9.5308	6.4284	9.7379	10.0357	8.6187
Std. Dev.	0.3628	0.5755	0.2925	0.3739	0.5115	0.6418	0.1811	0.3076	0.0374
Skewness	−0.8389	−1.2095	−0.6841	−0.9138	−1.1271	−1.1451	−0.1228	−0.1474	0.2797
Kurtosis	2.7284	3.4959	2.1464	3.2169	3.4521	3.1701	1.3776	1.6018	2.4979
Jarque-Bera	4.3336	9.1458	3.9009	7.3389	11.4531	11.4260	2.4681	1.8717	0.5180
Probability	0.1145	0.0103	0.1422	0.0255	0.0033	0.0033	0.2911	0.3923	0.7718
Correlation									
$\ln\tilde{y}$	1.0000	–	–	1.0000	–	–	1.0000	–	–
In*k*	0.9867	1.0000	–	0.9900	1.0000	–	0.9783	1.0000	–
ln*eng*	0.9805	0.9583	1.0000	0.9802	0.9812	1.0000	0.4027	0.2594	1.0000
Statistics	**Panel 7: Italy**			**Panel 8: Macedonia**			**Panel 9: Romania**		
	$\ln\tilde{y}$	In*k*	ln*eng*	$\ln\tilde{y}$	In*k*	ln*eng*	$\ln\tilde{y}$	In*k*	ln*eng*
Mean	11.1148	11.5464	8.8584	8.9411	9.6281	8.2108	8.8973	8.8706	8.1369
Median	11.2083	11.7444	8.9055	8.9035	9.6477	8.2114	8.8179	8.9512	8.1194
Maximum	11.5467	12.2173	9.2097	9.1657	9.9703	8.3187	9.2945	9.9231	8.4869
Minimum	10.2536	9.0671	7.8257	8.8048	9.1169	8.1071	8.6273	7.1156	7.9785
Std. Dev.	0.3829	0.6930	0.3325	0.1185	0.2267	0.0626	0.2296	0.7763	0.1158
Skewness	−0.7239	−1.5620	−1.4768	0.5960	−0.5155	−0.0182	0.5552	−0.5862	1.1802
Kurtosis	2.3074	5.3542	4.6251	1.9786	2.6251	2.0588	1.7564	2.6153	4.9217
Jarque-Bera	5.6881	33.7898	25.0963	2.2588	1.1032	0.8133	2.5479	1.3955	8.4927
Probability	0.0582	0.0000	0.0000	0.3232	0.5760	0.6659	0.2797	0.4977	0.0143
Correlation									
$\ln\tilde{y}$	1.0000	–	–	1.0000	–	–	1.0000	–	–
In*k*	0.9600	1.0000	–	0.5539	1.0000	–	0.7833	1.0000	–
ln*eng*	0.9549	0.9828	1.0000	0.3123	0.5013	1.0000	−0.1986	−0.7195	1.0000
Statistics	**Panel 10: Slovakia**			**Panel 11: Slovenia**			**Panel 12: Turkey**		
	$\ln\tilde{y}$	In*k*	ln*eng*	$\ln\tilde{y}$	In*k*	ln*eng*	$\ln\tilde{y}$	In*k*	ln*eng*
Mean	9.9023	10.8089	8.7713	10.3488	11.0970	15.2002	9.4981	10.1146	7.8334
Median	9.8551	10.9113	8.7708	10.3887	11.1879	15.1898	9.4838	10.1880	7.8327
Maximum	10.2858	11.4783	8.8205	10.5704	11.5846	15.3801	9.8381	10.6965	8.1470
Minimum	9.4806	9.7429	8.6925	10.0460	10.2284	15.1057	9.1801	9.3624	7.5304
Std. Dev.	0.2711	0.5228	0.0351	0.1607	0.4377	0.0603	0.1946	0.3876	0.1750
Skewness	0.0444	−0.5470	−0.6420	−0.4866	−0.5726	1.1863	0.2284	−0.3337	0.1609
Kurtosis	1.6965	2.1818	2.8717	1.9895	2.0854	5.3531	1.9060	2.0499	1.9934
Jarque-Bera	1.4935	1.6332	1.4568	1.5583	1.7007	8.8401	1.5814	1.5167	1.2563
Probability	0.4739	0.4419	0.4827	0.4588	0.4273	0.0120	0.4535	0.4684	0.5336
Correlation									
$\ln\tilde{y}$	1.0000	–	–	1.0000	–	–	1.0000	–	–
In*k*	0.9682	1.0000	–	0.9714	1.0000	–	0.9629	1.0000	–
ln*eng*	−0.2468	−0.1819	1.0000	0.3784	0.2407	1.0000	0.9911	0.9686	1.0000

the causality irrespective of whether the variables are I(0), I(1) or I(2), not co-integrated or co-integrated of an arbitrary order. Furthermore, the method fits well with the ARDL procedure as the part of the information derived, such as the lag-length, the maximum order of integration and structural breaks can be useful in examining causality. To examine causality, the following vector autocorrelation regression

(VAR) equations are specified:

$$\ln \tilde{y}_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \ln \tilde{y}_{t-i} + \sum_{j=k+1}^{d\max} \alpha_{2j} \ln \tilde{y}_{t-j} + \sum_{i=1}^{k} \eta_{1i} \ln k_{t-i} + \sum_{j=k+1}^{d\max} \eta_{2j} \ln k_{t-j} + \sum_{i=1}^{k} \varphi_{1i} \ln eng_{t-i} + \sum_{j=k+1}^{d\max} \varphi_{2j} \ln eng_{t-j} + \lambda_{1t} \quad (8)$$

$$\ln k_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} \ln k_{t-i} + \sum_{j=k+1}^{d\max} \beta_{2j} \ln k_{t-j} + \sum_{i=1}^{k} \theta_{1i} \ln \tilde{y}_{t-i} + \sum_{j=k+1}^{d\max} \theta_{2j} \ln \tilde{y}_{t-j} + \sum_{i=1}^{k} \vartheta_{1i} \ln eng_{t-i} + \sum_{j=k+1}^{d\max} \vartheta_{2j} \ln eng_{t-j} + \lambda_{2t} \quad (9)$$

$$\ln eng_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} \ln eng_{t-i} + \sum_{j=k+1}^{d\max} \gamma_{2j} \ln eng_{t-j} + \sum_{i=1}^{k} \phi_{1i} \ln \tilde{y}_{t-i} + \sum_{j=k+1}^{d\max} \phi_{2j} \ln \tilde{y}_{t-j} + \sum_{i=1}^{k} \mu_{1i} \ln k_{t-i} + \sum_{j=k+1}^{d\max} \mu_{2j} \ln k_{t-j} + \lambda_{3t} \quad (10)$$

where $\tilde{y}$, k and eng are defined following Eq. (3); λ is the error term and the terms η, ϕ, θ, φ, μ, γ and ϑ are the coefficient of respective variables that are examined via hypothesis testing to deduce the presence or absence of causality. The null hypothesis of no-causality is rejected when the p-value falls within the conventional (1–10%) levels of statistical significance. Hence in (8), Granger causality from $\ln k$ to $\ln\tilde{y}$ and $\ln eng$ to $\ln\tilde{y}$ implies $\eta_{1i} \neq 0 \forall\ i$ and $\phi_{1i} \neq 0 \forall\ i$. Similarly, in (9) $\ln\tilde{y}$ and $\ln eng$ granger causes $\ln k$ if $\theta_{1i} \neq 0 \forall\ i$ and $\vartheta_{1i} \neq 0 \forall\ i$, respectively;

Table 3
Results of conventional unit root tests for each country.
Source: Authors' estimation using Eviews 8.

Country	***Variables***	***ADF***		***PP***		***KPSS***	
		Level	1st Diff	Level	1st Diff	Level	1st Diff
Albania	$\ln\tilde{y}$	−1.8744[1]	−3.8530[0]^{B}	−1.3844[1]	−3.6825[4]^{B}	0.1829[4]^{C}	0.0785[2]^{A}
	Ink	−4.0128[5]^{B}	−3.4668[8]^{C}	−1.5124[4]	−3.5040[3]^{B†}	0.1423[4]^{B}	0.1526[4]^{C}
	lneng	−1.2950[1]	−3.8985[0]^{B}	−1.2477[2]	−3.8985[0]^{B}	0.1652[4]^{C}	0.0797[1]^{A}
Austria	$\ln\tilde{y}$	−2.1011[0]	−5.8491[1]^{A}	−2.1195[1]	−6.2999[3]^{A}	0.1954[4]^{C}	0.0768[2]^{A}
	Ink	−1.6448[1]	−4.4622[1]^{A}	−5.6348[5]^{A}	−3.2662[1]^{C}	0.1962[5]^{C}	0.1529[5]^{C}
	lneng	−3.5369[0]^{B}	−7.1412[0]^{A}	−3.5917[1]^{B}	−8.0159[6]^{A}	0.0635[2]^{A}	0.0943[5]^{A}
Bulgaria	$\ln\tilde{y}$	−1.8283[1]	−3.1834[0]^{B†}	−1.4006[3]	−3.2449[2]^{C}	0.1541[4]^{C}	0.0958[2]^{A}
	Ink	−3.5929[1]^{B}	−3.2870[7]^{C}	−1.1468[4]	−1.7854[3]	0.1424[4]^{A}	0.1176[4]^{A}
	lneng	−1.6661[0]	−4.0457[3]^{B}	−1.6661[0]	−4.1159[4]^{B}	0.1302[4]^{B}	0.0985[4]^{A}
Cyprus	$\ln\tilde{y}$	−4.5350[0]^{A}	−5.6503[0]^{A}	−4.5350[0]^{A}	−6.4892[6]^{A}	0.2204[4]	0.1380[2]^{B}
	Ink	−10.4764[1]^{A}	−4.0463[1]^{A†}	−6.4938[2]^{A}	−1.6270[1]^{C‡}	0.2010[4]^{C}	0.1914[4]^{C}
	lneng	−1.0152[1]	−8.0093[0]^{A}	−1.7291[3]	−9.6898[8]^{A}	0.2098[4]^{C}	0.5985[1]^{B†}
Greece	$\ln\tilde{y}$	−1.8030[1]	−4.5793[0]^{A}	−2.2680[4]	−4.7789[4]^{A}	0.1709[5]^{C}	0.1320[4]^{B}
	Ink	−2.7555[1]	−2.9814[11]^{B†}	−3.0015[5]	−1.8615[1]^{C‡}	0.1971[5]^{C}	0.2028[5]^{C}
	lneng	−1.7500[5]	−5.5255[0]^{A}	−1.6877[2]	−5.5411[2]^{A}	0.2231[5]	0.1083[3]^{A}
Hungary	$\ln\tilde{y}$	−0.7931[0]	−3.3206[0]^{C}	−1.2891[2]	−3.3206[0]^{C}	0.1194[3]^{B}	0.1691[2]^{C}
	Ink	−1.5178[1]	−1.0994[0]	1.2256[3]	−1.0994[0]	0.1468[3]^{C}	0.1680[3]^{C}
	lneng	−2.1943[0]	−6.0155[0]^{A}	−2.4913[2]	−6.0159[1]^{A}	0.1074[2]^{A}	0.1438[1]^{B}
Italy	$\ln\tilde{y}$	0.2013[0]	−6.8670[0]^{A}	0.4057[4]	−6.8663[3]^{A}	0.2513[5]	0.0702[4]^{A}
	Ink	−3.8907[3]^{B}	−4.1498[1]^{A}	−11.9358[4]^{A}	−22.7198[3]^{A}	0.2256[5]	0.1971[4]^{C}
	lneng	−3.9381[0]^{B}	−5.9858[0]^{A}	−3.6485[4]^{B}	−6.1786[4]^{A}	0.1901[5]^{C}	0.1674[4]^{C}
Macedonia	$\ln\tilde{y}$	−3.4394[0]^{C}	−2.3067[0]^{B‡}	−3.2966[1]^{C}	−2.2249[0]^{B‡}	0.1701[3]^{C}	0.1257[1]^{B}
	Ink	−1.4014[1]	−4.5784[0]^{A}	−6.2946[3]^{A}	−5.2668[3]^{A}	0.1592[2]^{C}	0.19997[2]^{C}
	lneng	−3.2980[0]^{C}	−5.4585[0]^{A}	−3.2401[2]	−6.9637[9]^{A}	0.1028[0]^{A}	0.0862[2]^{A†}
Romania	$\ln\tilde{y}$	−2.2368[1]	−3.4757[1]^{B†}	−3.0259[2]	−3.6545[11]^{B}	0.1463[3]^{C}	0.1152[2]^{A}
	Ink	−1.9544[1]	−8.2711[8]^{A}	−3.7363[2]^{B}	−3.0945[6]^{A‡}	0.1573[3]^{C}	0.1466[2]^{C}
	lneng	−2.3752[1]	−3.6267[0]^{C}	−3.1921[1]	−3.6251[2]^{C}	0.1578[2]^{C}	0.1013[0]^{A}
Slovakia	$\ln\tilde{y}$	−2.3407[1]	−2.7675[1]^{C†}	−3.1981[2]	−3.2155[2]$^{\mathbf{B}\dagger}$	0.0709[2]^{A}	0.1007[0]^{A}
	Ink	−3.1280[2]	−3.1749[0]^{A‡}	−3.7069[1]^{B}	−4.8990[7]^{A‡}	0.1724[3]^{C}	0.1630[2]^{C}
	lneng	−1.9870[0]	−6.4282[0]^{A}	−1.8436[1]	−7.0244[3]^{A}	0.1562[2]^{C}	0.1342[3]^{B}
Slovenia	$\ln\tilde{y}$	0.0624[0]	−3.6296[0]^{C}	0.1495[2]	−3.6097[4]^{C}	0.1707[2]^{C}	0.1088[2]^{A}
	Ink	−0.2648[1]	−4.0428[5]^{B}	0.1032[1]	−2.7716[0]^{A‡}	0.1945[2]^{C}	0.0770[1]^{A}
	lneng	−3.1616[0]	−6.5993[0]^{A}	−3.3343[2]^{C}	−6.5993[0]^{A}	0.1008[1]^{A}	0.0906[2]^{A}
Turkey	$\ln\tilde{y}$	−2.8553[0]	−5.7144[0]^{A}	−2.8553[0]	−5.7609[2]^{A}	0.0925[2]^{A}	0.0784[4]^{A}
	Ink	−2.0298[1]	−2.7115[0]	−2.5330[2]	−1.6893[6]^{C‡}	0.1814[3]^{C}	0.1334[2]^{B}
	lneng	−3.0302[0]	−6.0869[0]^{A}	−3.0302[0]	−6.5246[4]^{A}	0.0773[2]^{A}	0.1716[7]^{C}

Notes: The ADF and PP critical values are based on MacKinnon (1996) while the KPSS critical values are based on Kwiatkowski et al [39]. The optimal lag length for ADF and the bandwidth for KPSS are chosen on the basis of the Akaike Information Criterion (AIC). All variables assume intercept and trend. The null hypothesis for both the ADF and the Phillips-Perron tests is that a series has a unit root while for the KPSS unit root test, it is that a series is stationary. A, B and C denote the 1%, 5% and 10% level of significance at which the respective series are stationary. † indicates stationarity with intercept only. ‡ indicates stationarity without intercept and trend.

and from (10) $\ln\tilde{y}$ and $\ln k$ Granger cause $\ln eng$ if $\varphi_{1i} \neq 0 \forall\, i$ and $\mu_{1i} \neq 0 \forall\, i$. The maximum lag length for the Toda-Yamamoto [72] Granger non-causality test is derived as the sum of the maximum order of integration and the lag length selected in the ARDL estimation. Furthermore, it is important to examine the properties of the inverse roots of the AR (auto-regressive) characteristics polynomial diagram to ensure dynamic stability of the ARDL model. For robustness, it is necessary that the inverse roots, I_R, are within the positive and negative unity i.e. $-1 \leq I_R \leq 1$. If the inverse roots are outside the unit circle, some corrective measures that can be employed are: (a) use of appropriate lags greater than those of endogenous variables; and (b) including a trend variable and/or structural break or 'pulse' dummies as exogenous (instruments) variables in the VAR system.

4. Results

4.1. Unit root results

Table 3 presents the unit root results based on ADF, PP and KPSS tests, respectively. Overall, we note that the variables are a mix of I(0) and I(1) and the maximum order of integration is one. Furthermore, in Table 4, we examine the breaks in the intercept and/or time trend using the Perron [55] and Zivot and Andrews [84] test of single break in series, respectively.

4.2. Results of bounds test for co-integration

Following the unit root results in Tables 3, 4, we apply the ARDL

Table 4
Unit root test with structural break in intercept for each country.
Source: Authors' estimation using Eviews 8.

Country	Variables	Perron [55]				Zivot Andrews [84]			
		Level		1st Diff		Level		1st Diff	
		PP Stat	TB	PP Stat	TB	ZA Stat	TB	ZA Stat	TB
Albania	$\ln\tilde{y}$	−5.1946[1]^{C}	1989	−7.0942[0]^{A}	1991	−5.3905[1]^{A}	1990	−5.7378[1]^{A}	1994
	$\ln k$	−5.3713[1]^{B}	1990	−3.5038[1]	1997	−4.0595[3]	1991	−3.5347[1]	1998
	$\ln eng$	−5.1560[0]^{C}	1990	−1.1039[0]	1994	−4.2980[1]	1991	−1.0522[0]	1994
Austria	$\ln\tilde{y}$	−2.9658[0]	2006	−6.5458[0]^{A}	1993	−2.6713[0]	2006	−6.2678[1]^{A}	1998
	$\ln k$	−2.9906[1]	1990	−3.2635[0]	1989	−2.9847[1]	1988	−3.4456[0]	1978
	$\ln eng$	−4.0250[0]	1979	−7.6667[0]^{A}	1981	−3.9362[0]	1996	−5.1752[3]^{B}	1995
Bulgaria	$\ln\tilde{y}$	−4.1220[1]	1998	−4.2717[0]	1998	−4.0063[1]	1990	−4.1628[0]	1998
	$\ln k$	−4.7964[1]	1989	−3.1480[1]	2000	−4.8358[1]^{C}	1990	−2.9808[1]	2000
	$\ln eng$	−5.1295[0]^{C}	1990	−1.8065[0]	1993	−5.2254[0]^{B}	1991	−1.8631[0]	1994
Cyprus	$\ln\tilde{y}$	−5.9721[0]^{A}	1987	−5.9251[0]^{A}	1980	−6.0090[0]^{A}	1987	−6.1049[1]^{A}	1991
	$\ln k$	−12.546[1]^{A}	1992	−4.5094[0]^{A}	1980	−12.371[1]^{A}	1993	−4.3641[2]	1985
	$\ln eng$	−3.9216[0]	1986	−8.9519[0]^{A}	1994	−3.1848[1]	1986	−8.8404[0]^{A}	1995
Greece	$\ln\tilde{y}$	−2.0212[1]	1975	−5.5056[0]^{B}	1973	−3.1939[3]	1975	−5.5874[0]^{B}	1974
	$\ln k$	−3.0655[1]	1979	−4.2281[0]	1973	−3.5959[3]	1977	−3.7864[2]	1974
	$\ln eng$	−2.7286[0]	1969	−7.6605[0]^{A}	1973	−2.7180[0]	1969	−7.5469[0]^{A}	1974
Hungary	$\ln\tilde{y}$	−5.6281[0]^{B}	2008	−5.2174[0]^{C}	2006	−4.6409[4]^{C}	2009	−5.2693[0]^{B}	2007
	$\ln k$	−1.9845[1]	2009	−3.3147[0]	2008	−1.9194[1]	2009	−3.1745[1]	2009
	$\ln eng$	−3.8886[0]	2008	−7.011[0]^{A}	2007	−4.0311[0]	2009	−7.211[0]^{A}	2007
Italy	$\ln\tilde{y}$	−0.9123[0]	1960–2005$^{\Theta}$	−7.2253[0]^{A}	1975	−0.7761[0]	1960–2005$^{\Theta}$	−4.9446[4]^{B}	1988
	$\ln k$	−1.7285[4]	2005	−6.7323[2]^{A}	1793	−1.4612[4]	2005	−3.2876[4]	1994
	$\ln eng$	−4.5827[0]	2004	−6.0149[1]^{A}	1970	−4.4330[0]	2004	−4.0205[3]	1971
Macedonia	$\ln\tilde{y}$	−4.6870[0]	2001	−3.6984[0]	1993	−4.1125[0]	2004	−3.8043[0]	1994
	$\ln k$	−3.1321[1]	1999	−5.9437[0]^{A}	1997	−3.0728[4]	2000	−3.1829[3]	2004
	$\ln eng$	−4.4781[0]	2000	−6.1803[0]^{A}	1996	−4.5237[0]	2000	−6.2054[0]^{A}	2003
Romania	$\ln\tilde{y}$	−4.4037[0]	2003	−4.2664[0]	2008	−3.8891[1]	1997	−4.4051[0]	2009
	$\ln k$	−0.7406[1]	2010	−2.2728[4]	1997	−0.4911[1]	2010	−2.0743[4]	1998
	$\ln eng$	−4.8612[0]	1997	−0.7024[0]	2008	−2.3875[4]	2005	−0.4746[2]	2002
Slovakia	$\ln\tilde{y}$	−3.6227[1]	2005	−4.0778 [0]	2007	−4.4701[3]	2007	−3.8325[0]	2008
	$\ln k$	−6.3034[0]^{A}	1996	−5.9018[0]	1998	−3.2680[2]	2002	−5.8997[1]^{B}	1999
	$\ln eng$	−2.6134[0]	2010	−4.6756[0]	2001	−2.8906[1]	2004	−5.9363[1]^{A}	2002
Slovenia	$\ln\tilde{y}$	−2.8813[0]	2008	−7.9223[0]^{A}	2009	−3.1379[0]	2009	−7.9752[0]^{A}	2009
	$\ln k$	−3.0389[0]	2009	−3.7526[0]	2008	−4.3689[2]	2009	−3.4808[1]	2006
	$\ln eng$	−4.948[0]^{C}	2009	−10.9689[0]^{A}	2008	−4.4739[0]	2005	−9.2722[0]^{A}	2009
Turkey	$\ln\tilde{y}$	3.8173[0]	2001–2004$^{\Theta}$	−5.9233[0]^{A}	1999	−4.0068[0]	2001–2005$^{\Theta}$	−6.0411[0]^{A}	2003
	$\ln k$	−3.4106[1]	2000	−3.9682[0]	2004	−3.4605[1]	2001	−4.1776[0]	2004
	$\ln eng$	−3.8514[0]	2000	−6.4596[0]^{A}	1998	−4.0708[0]	2001	−6.6125[0]^{A}	1998

Notes: TB=break period, A, B and C represents the 1%, 5% and 10% level at which the series is stationary. Θ refers to further inclusion of pulse dummy to correct for CUSUMQ plot and normality biasness

Table 5
Results of bounds test for each country – dependent variable is $\ln\tilde{y}$.

Country	ARDL	N	F-Stat.	F-bounds[B]		W-Stat.	W-bounds[B]		Narayan-bounds		
				I (0)	I (1)		I (0)	I (1)	N-used	I (0)	I (1)
Albania	(1,1,0)	32	16.6749	5.5587	6.6382	50.0246	16.6760	19.9147	30	7.977	9.413[A]
Austria	(1,1,0)	43	11.4382	5.3636	6.3965	34.3146	16.0909	19.1896	40	7.527	8.803[A]
Bulgaria	(1,1,0)	32	8.1773	5.5587	6.6382	24.5319	16.6760	19.9147	30	7.977	9.413[A]
Cyprus	(1,0,0)	36	8.3124	5.4201	6.4907	24.9371	16.2602	19.4722	35	7.643	9.063[A]
Greece	(1,1,0)	52	17.1254	5.2158	6.3353	51.3763	15.6474	19.0058	50	7.337	8.643[A]
Hungary	(1,1,0)	23	7.6766	4.7527	6.1183	23.0298	14.2580	18.3550	30	5.550	6.747[B]
Italy	(1,1,1)	53	17.9739	4.8831	6.0190	53.9217	14.6494	18.0569	50	7.337	8.643[A]
Macedonia	(1,1,1)	22	9.4795	4.8917	6.2796	28.4386	14.6750	18.8389	30	7.977	9.413[A]
Romania	(1,1,0)	22	14.4836	6.0457	7.2609	43.4509	18.1370	21.7828	30	7.977	9.413[A]
Slovakia	(1,0,0)	21	11.2374	3.7797	5.2802	33.7121	11.3391	15.8407	30	–	–
Slovenia	(1,1,0)	19	13.0220	4.7593	6.1195	39.0661	14.2779	18.3584	30	7.977	9.413[A]
Turkey	(1,1,0)	26	53.6405	5.4678	6.4620	160.9215	16.4033	19.3861	30	7.977	9.413[A]

Notes: A and B indicate the rejection of the null hypothesis (of no co-integration) at 1% and 5% levels, respectively. The F- and W- critical value bounds are computed by stochastic simulations using 20,000 replications using Mfit 5.0 (Pesaran and Pesaran, 1999) and Narayan bounds are from Narayan (2005: 1990); '-' refers to bound not available for no intercept and trend.

bounds procedure to examine the co-integration relationship. We review that computed F- and W-statistic against the critical F- and W-statistic bounds. Additionally, we examine the computed F-statistic against the Narayan F-statistic bounds. Overall, the results confirm the existence of a long-run relationship for each of the 12 countries in the sample (Table 5).

Following the confirmation of co-integration, we examine the short-run and the long-run results. We first examine the diagnostic properties derived from the respective country's ARDL lag estimate results. The key diagnostic tests are: the Lagrange multiplier test of residual serial correlation (χ^2_{sc}); the Ramsey's RESET test using the square of the fitted values for the correct functional form (χ^2_{ff}); the normality test based on the skewness; and the kurtosis of residuals (χ^2_n) and heteroscedasticity test based on the regression of the squared residuals on the squared fitted values (χ^2_{hc}). The results for each country are reported in Table 6. As noted, the respective country model performs relatively well as the error terms are normally distributed and with no statistically significant serial correlation of disturbances. Furthermore, we report the cumulative sum of recursive residual (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMQ) for each country in Figs. 1a–12b, respectively. The respective figures indicate the parameters of the model for each country is stable across time.[6]

4.3. Short-run and long-run elasticity coefficients

The short- and the long-run results are presented in Table 7 (panels 1–12). As noted, in the short-run, the coefficient of capital per worker is positive and statistically significant for all the countries, thus implying that capital productivity is an important part of the short-run growth for all the countries in the Balkan Peninsula. In regards to the short-run energy consumption, we note that 11 out of 12 countries have positive and statistically significant coefficient (Albania=0.25, Austria=0.12, Bulgaria=0.42, Cyprus=0.19, Greece=0.14, Hungary=0.22, Italy=0.50, Romania=0.46, Slovakia=0.31, Slovenia=0.18 and Turkey=0.58). However, in case of Macedonia, the coefficient is positive (0.06) however, not statistically significant within the 1–10% (conventional) levels. We also note that the error correction term (ECM_{t-1}), which provides the speed of adjustment to the long-run equilibrium given the shocks from the previous ($t-1$) period, is negative,$-1 < ECM_{t-1}<0$, and statistically significant for all the countries (Table 7 – panels 1-12).

[6] In case of Italy and Turkey, we corrected for the normality biasness by including additional break points identified in the initial stages of analysis from the CUSUM and CUSUMQ plots.

The long-run results reported in Table 7 show the respective elasticity coefficients. As noted the capital share ($\ln k$), we note that it is statistically significant for all the countries in the sample: Albania=0.22, Austria=0.48, Bulgaria =0.22, Cyprus=0.24, Greece=0.43, Hungary=0.67, Italy=0.37, Macedonia=0.72, Romania=0.27, Slovakia =0.37, Slovenia=0.57 and Turkey=0.23, and revolves around the stylized value of one-third [16,23,35,59]. Nevertheless, notable deviations from the stylized value can be due to, among other things: (a) the quality of data and the small sample size; (b) capital and labour inputs growing at relatively similar rates; (c) a significant share of the labour force earning its income in the shadow economy; and (d) a large number of self-employed persons earning income from both capital and their own labour [28].

The elasticity of output with respect to energy (energy elasticity – $\ln eng$) is statistically significant for all countries. This implies that a 1% increase in energy consumption per worker will result in an increase in the output per worker for: Albania by 0.29%, Austria by 0.17%, Bulgaria by 0.67%, Cyprus by 0.33%, Greece by 0.27%, Hungary by 0.55%, Italy by 0.60%, Macedonia=0.45%, Romania by 0.57%, Slovakia by 0.67%, Slovenia by 0.18% and Turkey by 0.72%.

From these results, it is clear that energy has a positive association with long-run growth in all of the countries in the sample.

4.4. Causality assessment

From the unit root results (Tables 3, 4), we note that the maximum order of integration is 1, i.e. d_{max}=1, and the lag used for the ARDL estimation is also 1 for all the estimations. Hence, the maximum lags to be used to carry out the non-causality test are 2 for all the countries. Considering these constraints, we applied the lags that ensured the dynamic stability of the causality model, i.e. $|I_R| \le 1$. The results of the causality tests are presented in Table 8.

A unidirectional causality running from energy to output (growth hypothesis) is confirmed for Austria ($\ln eng \to \ln y : \chi^2$=9.3581) and Macedonia ($\ln eng \to \ln\tilde{y} : \chi^2$=2.8165) at 1% and 10% level of statistical significance, respectively. A conservation hypothesis is confirmed for Albania ($\ln\tilde{y} \to \ln eng : \chi^2$=14.7241), Bulgaria ($\ln\tilde{y} \to \ln eng : \chi^2$=5.1325), Cyprus ($\ln\tilde{y} \to \ln eng : \chi^2$=14.2370), Hungary ($\ln\tilde{y} \to \ln eng : \chi^2$=10.6185), Italy ($\ln\tilde{y} \to \ln eng : \chi^2$=6.2112), Romania ($\ln\tilde{y} \to \ln eng : \chi^2$=9.4135), and Turkey ($\ln\tilde{y} \to \ln eng : \chi^2$=7.9636). Finally, for Greece ($\ln\tilde{y} \leftrightarrow \ln eng : \chi^2$=16.0388,4.9414), Slovakia ($\ln\tilde{y} \leftrightarrow \ln eng : \chi^2$=4.9147,5.2089), and Slovenia ($\ln\tilde{y} \leftrightarrow \ln eng : \chi^2$=9.1145,33.5400), a bi-directional causality between energy and output is confirmed thus supporting the feedback hypothesis.

Table 6
Diagnostic tests from the ARDL lag estimates for each country.
Source: Authors' estimation using Mfit 5.0

Country	Test type	Test versions			
		LM Version	P value	F Version	P value
Albania	χ^2_{sc}	$\chi^2(1)=4.6629^B$	0.031	$F(1,24)=4.2491^C$	0.050
	χ^2_{ff}	$\chi^2(1)=2.7708^A$	0.605	$F(1,24)=0.2140^A$	0.527
	χ^2_{n}	$\chi^2(2)=0.0234^A$	0.988	NA	–
	χ^2_{hc}	$\chi^2(1)=0.6694^A$	0.413	$F(1,29)=0.6401^A$	0.430
Austria	χ^2_{sc}	$\chi^2(1)=4.8234^C$	0.028	$F(1,35)=4.5410^C$	0.040
	χ^2_{ff}	$\chi^2(1)=0.0787^A$	0.779	$F(1,35)=0.0657^A$	0.799
	χ^2_{n}	$\chi^2(2)=0.6739^A$	0.981	NA	–
	χ^2_{hc}	$\chi^2(1)=1.6153^A$	0.125	$F(1,49)=2.3742^A$	0.213
Bulgaria	χ^2_{sc}	$\chi^2(1)=0.8549^A$	0.355	$F(1,24)=0.6807^A$	0.417
	χ^2_{ff}	$\chi^2(1)=0.4249^A$	0.514	$F(1,24)=0.3336^A$	0.569
	χ^2_{n}	$\chi^2(2)=2.5209^A$	0.284	NA	–
	χ^2_{hc}	$\chi^2(1)=0.2351^A$	0.628	$F(1,29)=0.2216^A$	0.641
Cyprus	χ^2_{sc}	$\chi^2(1)=2.0916^A$	0.148	$F(1,29)=1.8432^A$	0.185
	χ^2_{ff}	$\chi^2(1)=0.0007^A$	0.933	$F(1,29)=0.0059^A$	0.939
	χ^2_{n}	$\chi^2(2)=1.3486^A$	0.510	NA	–
	χ^2_{hc}	$\chi^2(1)=0.1138^A$	0.736	$F(1,33)=0.1076^A$	0.745
Greece	χ^2_{sc}	$\chi^2(1)=0.0006^A$	0.980	$F(1,44)=1.2658^A$	0.982
	χ^2_{ff}	$\chi^2(1)=10.0469$	0.002	$F(1,44)=10.7944$	0.002
	χ^2_{n}	$\chi^2(2)=0.0380^A$	0.981	NA	–
	χ^2_{hc}	$\chi^2(1)=2.3569^A$	0.125	$F(1,49)=2.3742^A$	0.130
Hungary	χ^2_{sc}	$\chi^2(1)=3.9992^B$	0.046	$F(1,14)=3.2933^B$	0.091
	χ^2_{ff}	$\chi^2(1)=1.8663^A$	0.172	$F(1,14)=1.3656^A$	0.262
	χ^2_{n}	$\chi^2(2)=0.1284^A$	0.938	NA	–
	χ^2_{hc}	$\chi^2(1)=1.8674^A$	0.172	$F(1,19)=1.8545^A$	0.189
Italy	χ^2_{sc}	$\chi^2(1)=0.4932^A$	0.482	$F(1,44)=0.4213^A$	0.520
	χ^2_{ff}	$\chi^2(1)=2.2522^A$	0.133	$F(1,44)=1.9920^A$	0.165
	χ^2_{n}	$\chi^2(2)=0.9480^A$	0.622	NA	–
	χ^2_{hc}	$\chi^2(1)=2.0753^A$	0.150	$F(1,50)=2.0784^A$	0.156
Macedonia	χ^2_{sc}	$\chi^2(1)=0.0773^A$	0.781	$F(1,13)=0.0481^A$	0.830
	χ^2_{ff}	$\chi^2(1)=0.4996^A$	0.480	$F(1,13)=0.3168^A$	0.583
	χ^2_{n}	$\chi^2(2)=0.2102^A$	0.900	NA	–
	χ^2_{hc}	$\chi^2(1)=0.1393^A$	0.709	$F(1,19)=0.1269^A$	0.726
Romania	χ^2_{sc}	$\chi^2(1)=0.0953^A$	0.758	$F(1,14)=0.0638^A$	0.804
	χ^2_{ff}	$\chi^2(1)=1.0280^A$	0.311	$F(1,14)=0.7206^A$	0.410
	χ^2_{n}	$\chi^2(2)=1.0152^A$	0.602	NA	–
	χ^2_{hc}	$\chi^2(1)=0.3021^A$	0.583	$F(1,19)=0.2773^A$	0.605
Slovakia	χ^2_{sc}	$\chi^2(1)=0.3224^A$	0.570	$F(1,15)=0.2458^A$	0.627
	χ^2_{ff}	$\chi^2(1)=2.0651^A$	0.151	$F(1,15)=1.7271^A$	0.209
	χ^2_{n}	$\chi^2(2)=0.9791^A$	0.613	NA	–
	χ^2_{hc}	$\chi^2(1) = 1.1242^A$	0.289	$F(1,18)=1.0720^A$	0.314
Slovenia	χ^2_{sc}	$\chi^2(1)=0.0613^A$	0.804	$F(1,12)=0.0410^A$	0.843
	χ^2_{ff}	$\chi^2(1)=0.0214^A$	0.884	$F(1,12)=0.0143^A$	0.907
	χ^2_{n}	$\chi^2(2)=0.2008^A$	0.904	NA	–
	χ^2_{hc}	$\chi^2(1)=1.1738^A$	0.279	$F(1,16)=1.1161^A$	0.306
Turkey	χ^2_{sc}	$\chi^2(1)=0.3132^A$	0.576	$F(1,19)=0.23169^A$	0.636
	χ^2_{ff}	$\chi^2(1)=1.3385^A$	0.247	$F(1,19)=1.0312^A$	0.323
	χ^2_{n}	$\chi^2(2)=0.7543^A$	0.686	NA	–
	χ^2_{hc}	$\chi^2(1)=1.6153^A$	0.204	$F(1,24)=1.5899^A$	0.219

(continued on next page)

Table 6 (continued)

Notes: χ^2_{sc} – serial correlation, χ^2_{ff} – functional form, χ^2_{n} – normality, χ^2_{hc} – heteroscedasticity. A, B and C implies the rejection of the null hypothesis of the presence of the respective test types at 1%, 5% and 10% level of significance, respectively. NA – not applicable.

5. Conclusion and policy implications

In this paper, we review the energy elasticity for 12 countries in the Balkan Peninsula. In doing so, we examine the magnitude effects and the causality dynamics. What becomes evident is that energy is positively associated with economic growth at least in the long-run. Moreover, we note that the causality nexus supports the conservation hypothesis for Albania, Bulgaria, Cyprus, Hungary, Italy, Romania and Turkey; the growth hypothesis for Austria and Macedonia; and the feedback hypothesis for Greece, Slovakia and Slovenia. The study contributes to the existing literature by providing estimates of the energy elasticity for the 12 countries which are part of the European Energy Community. Additionally, the causality results provide policy suggestions in terms of the effective energy use for each country given that a number of proposals have been put forward to create a gas transit pipeline in the Balkan Peninsula. At best, the studies show that all countries in the sample will gain through access to secure energy.

Subsequently, considering the three hypothesis (growth, conservation and feedback), we argue that energy is an important driver of growth for Austria and Macedonia because the respective results conform to the growth hypothesis. In this regard, the two countries need to strategically position themselves to exploit energy resources for their long term growth. On the other hand, the results for Albania, Bulgaria, Cyprus, Hungary, Italy, Romania, Turkey, Greece, Slovakia and Slovenia conform to the conservation hypothesis and therefore these countries should consider green-growth policies and environmental protection which will have spill-over benefits in other sectors of the economy, such as tourism. Moreover, Greece, Slovakia and Slovenia are well positioned to benefit from having a balance between environment conservation through green growth policies and energy-driven economic growth spurred by industrialization among other things which are expected to have subsequent flow on effects on other key

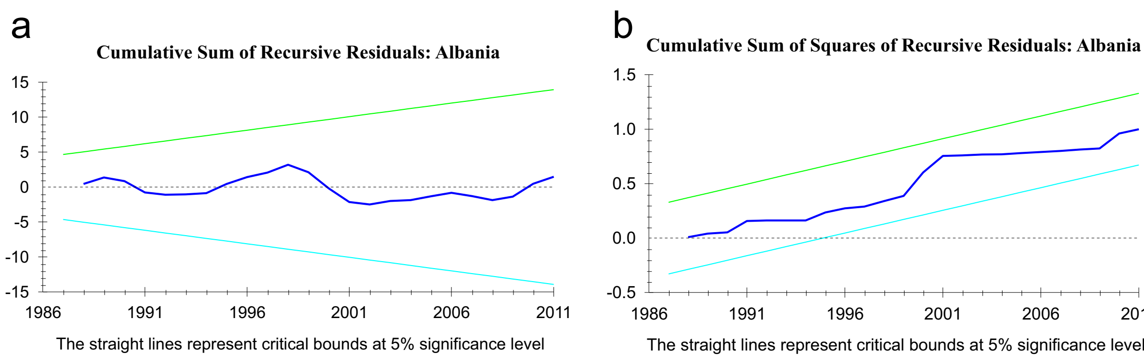

Fig. 1. a: Cumulative sum of recursive residuals: Albania, 1b: cumulative sum of squares of recursive residuals: Albania.

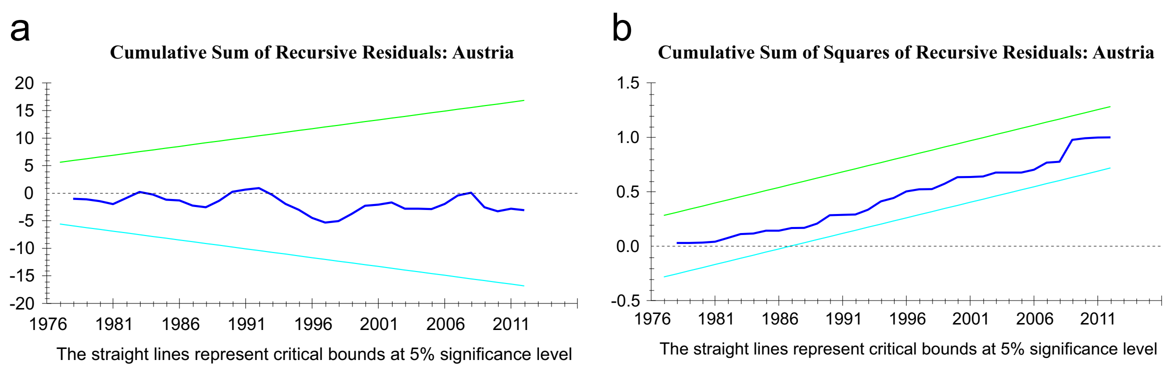

Fig. 2. a: Cumulative sum of recursive residuals: Austria, 2b: cumulative sum of squares of recursive residuals: Austria.

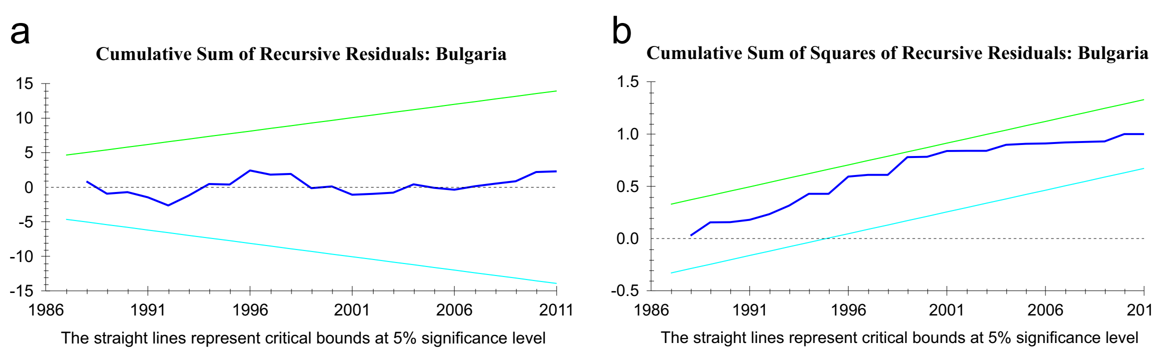

Fig. 3. a: Cumulative sum of recursive residuals: Bulgaria, 3b: cumulative sum of squares of recursive residuals: Bulgaria.

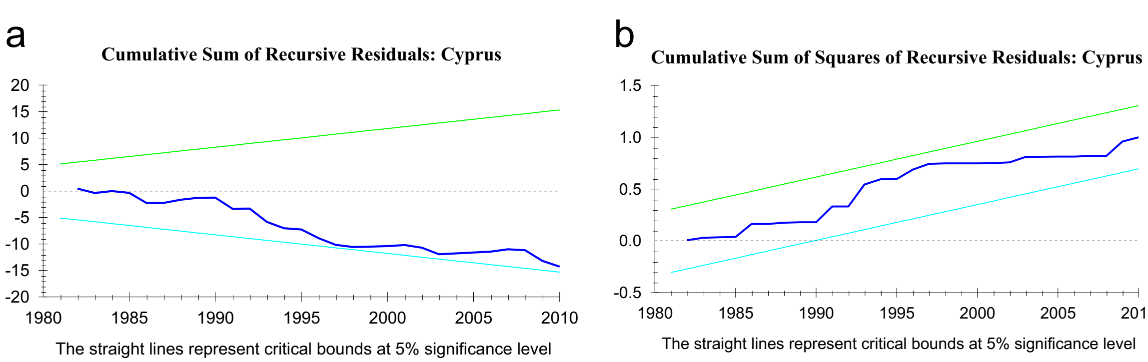

Fig. 4. a: Cumulative sum of recursive residuals: Cyprus, 4b: cumulative sum of squares of recursive residuals: Cyprus.

sectors of the economy.

While these straightforward outcomes are clear, we need to be cautious in interpreting the results. This is because some countries such as Bulgaria, Hungary, Romania, and Albania were former socialistic countries and applied a system of a planning economy. Therefore prices in these countries were administrated by a planning office and not determined by its scarcity. Such kind of allocation mechanism leads usually to the misallocation of resources and ques-

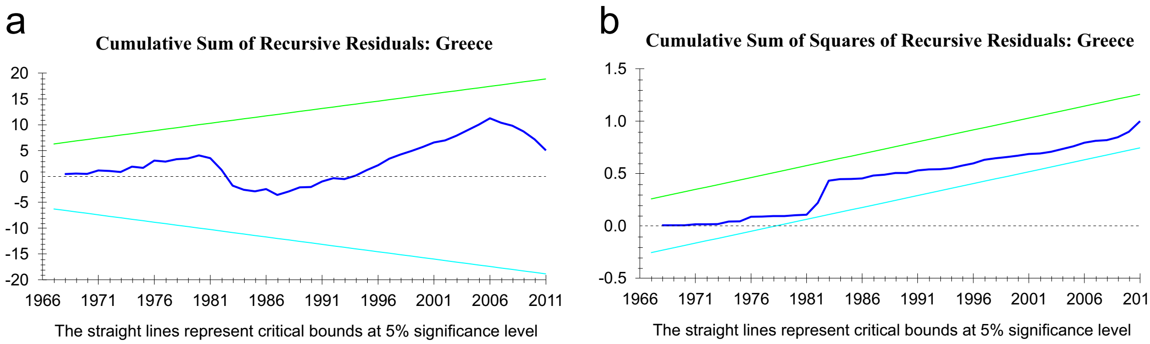

Fig. 5. a: Cumulative sum of recursive residuals: Greece, 5b: cumulative sum of squares of recursive residuals: Greece.

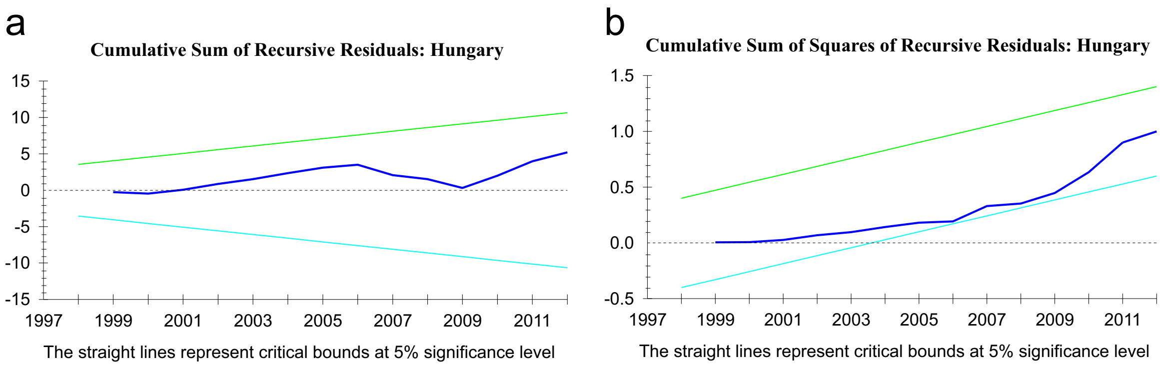

Fig. 6. a: Cumulative sum of recursive residuals: Hungary, 6b: cumulative sum of squares of recursive residuals: Hungary.

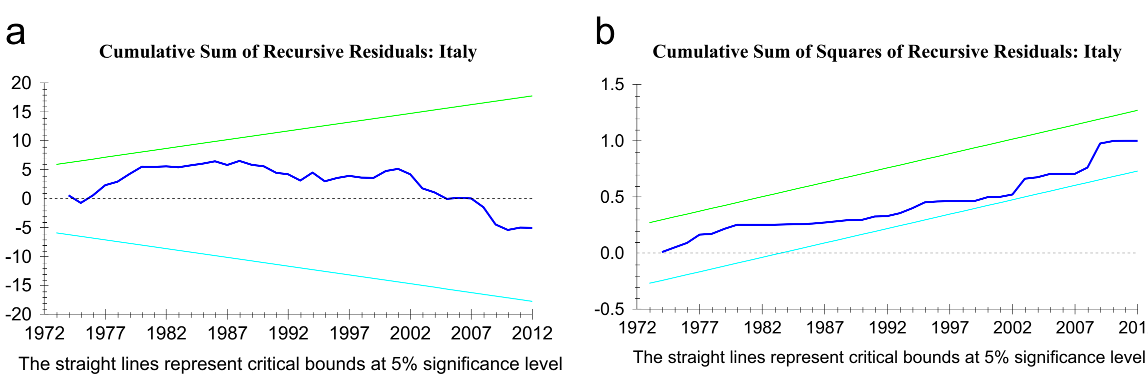

Fig. 7. a: Cumulative sum of recursive residuals: Italy, 7b: cumulative sum of squares of recursive residuals: Italy.

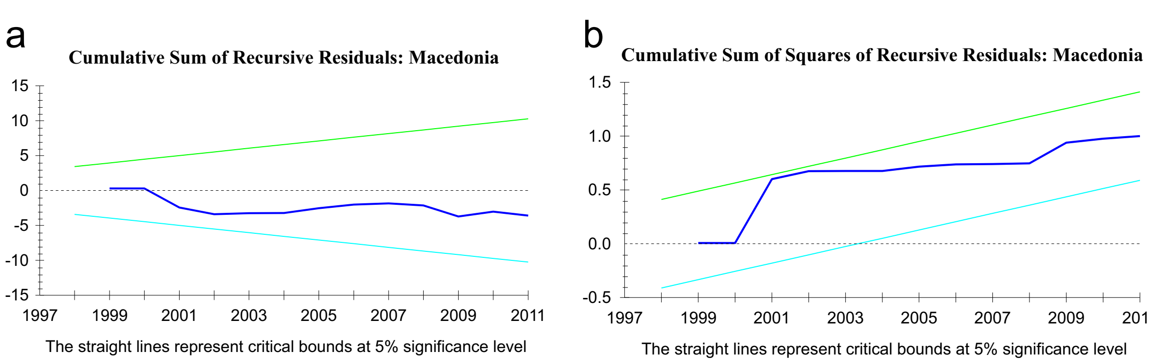

Fig. 8. a: Cumulative sum of recursive residuals: Macedonia, 8b: cumulative sum of squares of recursive residuals: Macedonia.

tionable investment decisions. However, in the case of countries such as Hungary, Romania and Bulgaria, this is aggravated by the fact that they were members of the COMECON (Council for Mutual Economic Assistance), and the international economic planning took place under the leadership of the Soviet Union. This meant that it was predetermined which country had to produce what and how much for the other COMECON member states. This came to an end over the 1989–1991. Notably, Albania was a special case of a socialistic country and at first

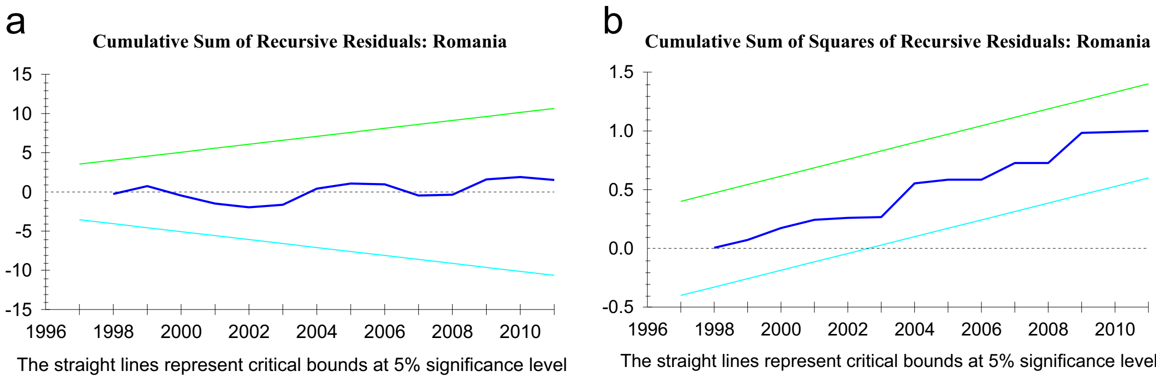

Fig. 9. a: Cumulative sum of recursive residuals: Romania, 9b: cumulative sum of squares of recursive residuals: Romania.

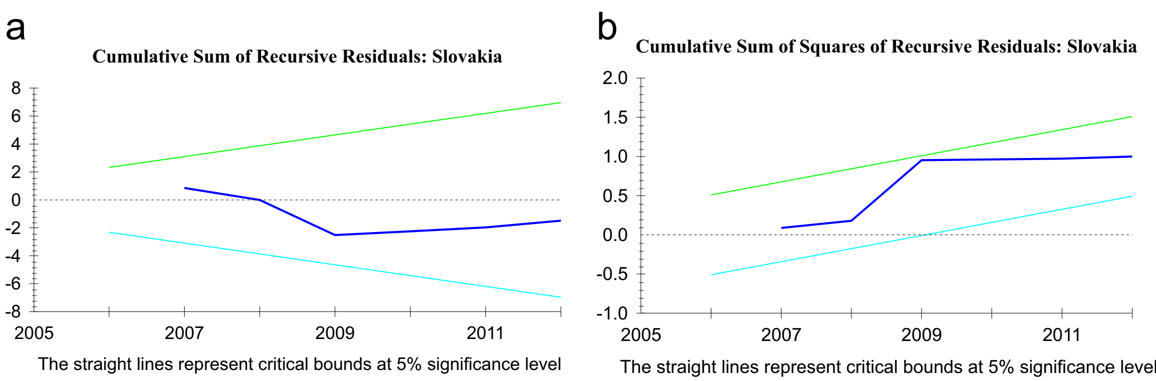

Fig. 10. a: Cumulative sum of recursive residuals: Slovakia, 10b: cumulative sum of squares of recursive residuals: Slovakia.

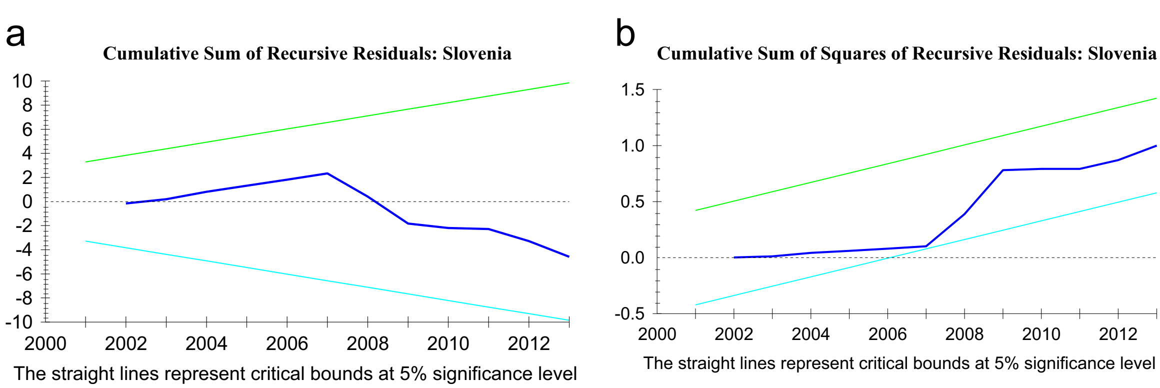

Fig. 11. a: Cumulative sum of recursive residuals: Slovenia, 11b: cumulative sum of squares of recursive residuals: Slovenia.

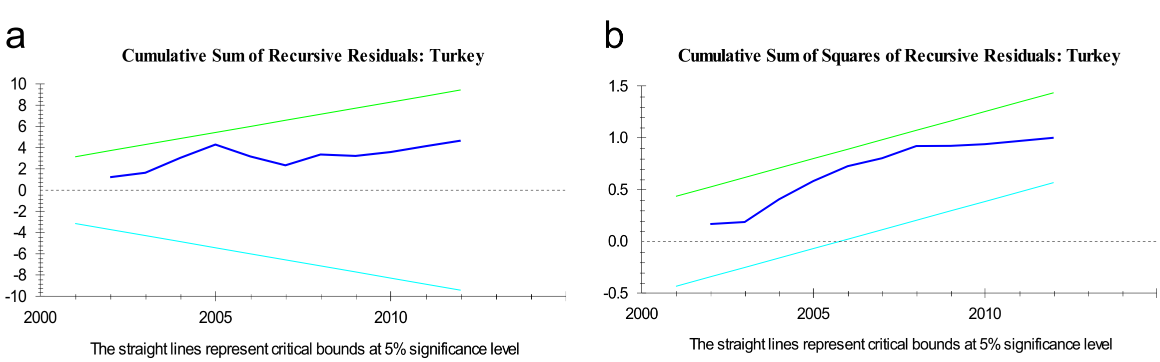

Fig. 12. a: Cumulative sum of recursive residuals: Turkey, 12b: cumulative sum of squares of recursive residuals: Turkey.

strongly related to Yugoslavia, then to the Soviet Union, then to China and an independent socialistic dictatorship from 1978 to 1990. The country made ardent attempts to become economically self-sufficient but to little success. All four countries are still suffering economically and politically in this area. In the time of socialism and thereafter, usually the energy prices for private households were lower than their

Table 7
Estimated long run coefficients & error correction representation for each country.
Source: Authors' estimation using Mfit 5.0.

Long-run: Dependent variable: $\ln\tilde{y}$				*Short-run: Dependent variable:* $\Delta\ln\tilde{y}_t$			
Panel 1: Albania							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.2205	0.0984	2.2419[B]	$\Delta\ln k_t$	2.4912	0.4029	6.1836[A]
$\ln eng$	0.2871	0.0843	3.4077[A]	$\Delta\ln eng_t$	0.2521	0.0895	2.8177[A]
Constant	3.7583	0.5780	6.5027[A]	$\Delta TREND$	0.0205	0.0037	6.6922[A]
TREND	0.0234	0.0032	7.2300[A]	ECM_{t-1}	−0.8780	0.1243	−7.0608[A]
Short-run dynamics test statistics							
R-squared			0.7962	Adjusted R-squared			0.7554
S.E. of regression			0.0453	F-Stat. F(4,26)			24.4146
Mean of dependent variable			0.0231	S.D. of dependent variable			0.0917
Residual sum of squares			0.0514	Equation log-likelihood			55.2485
Akaike info. Criterion			49.2485	Schwarz-Bayesian Criterion			44.9465
DW-statistic			1.2451	ARDL(1,1,0)			N = 32
Panel 2: Austria							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.4805	0.0579	8.3001[A]	$\Delta\ln k_t$	1.3391	0.2791	4.7987[A]
$\ln eng$	0.1666	0.0757	2.2021[B]	$\Delta\ln eng_t$	0.1205	0.0526	2.2891[B]
Constant	3.7278	0.7705	4.8379[A]	$\Delta TREND$	0.0058	0.0015	3.7554[A]
TREND	0.0080	0.0012	6.5704[A]	ECM_{t-1}	−0.7231	0.1231	−5.8752[A]
Short-run dynamics test statistics							
R-squared			0.6668	Adjusted R-squared			0.6205
S.E. of regression			0.0113	F-Stat F(4,37)			18.0072
Mean of dependent variable			0.0215	S.D. of dependent variable			0.0184
Residual sum of squares			0.0046	Equation log-likelihood			131.8747
Akaike info. Criterion			125.8747	Schwarz-Bayesian Criterion			120.6617
DW-statistic			1.5587	ARDL(1,1,0)			N=43
Panel 3: Bulgaria							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.2220	0.0736	3.0178[A]	$\Delta\ln k_t$	0.8787	0.1787	4.9169[A]
$\ln eng$	0.6650	0.1326	5.0141[A]	$\Delta\ln eng_t$	0.4196	0.0667	6.2905[A]
Constant	0.5626	0.7972	0.7057	$\Delta TREND$	0.0140	0.0017	8.0136[A]
TREND	0.0221	0.0036	6.2054[A]	ECM_{t-1}	−0.6310	0.1120	−5.6368[A]
Short-run dynamics test statistics							
R-squared			0.8135	Adjusted R-squared			0.7762
S.E. of regression			0.0225	F-Stat F(4,26)			27.2590
Mean of dependent variable			0.0241	S.D. of dependent variable			0.0476
Residual sum of squares			0.0127	Equation log-likelihood			76.9292
Akaike info. Criterion			70.9292	Schwarz-Bayesian Criterion			66.6272
DW-statistic			2.2745	ARDL(1,1,0)			N = 32
Panel 4: Cyprus							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.2419	0.0590	4.1004[A]	$\Delta\ln k_t$	0.1385	0.0660	2.0985[B]
$\ln eng$	0.3327	0.0905	3.6760[A]	$\Delta\ln eng_t$	0.1904	0.0660	2.8850[A]
Constant	4.5271	0.6056	7.4751[A]	$\Delta TREND$	0.0055	0.0017	3.2968[A]
TREND	0.0096	0.0019	5.1795[A]	ECM_{t-1}	−0.5724	0.1546	−3.7036[A]
Short-run dynamics test statistics							
R-squared			0.7475	Adjusted R-squared			0.7139
S.E. of regression			0.0215	F-Stat. F(4,30)			22.2068
Mean of dependent variable			0.0379	S.D. of dependent variable			0.0401
Residual sum of squares			0.0138	Equation log-likelihood			87.4950
Akaike info. Criterion			82.4950	Schwarz-Bayesian Criterion			78.6066
DW-statistic			1.5992	ARDL(1,0,0)			N = 36
Panel 5: Greece							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.4290	0.0742	5.7772[A]	$\Delta\ln k_t$	1.4602	0.1831	7.9740[A]
$\ln eng$	0.2711	0.0663	4.0903[A]	$\Delta\ln eng_t$	0.1416	0.0228	6.2012[A]
Constant	3.3307	0.364	9.1482[A]	$\Delta TREND$	0.0010	0.0006	1.8467[C]
TREND	0.0020	0.0009	2.2608[B]	ECM_{t-1}	−0.5222	0.1054	−4.9554[A]
Short-run dynamics test statistics							
R-squared			0.8084	Adjusted R-squared			0.7871
S.E. of regression			0.0186	F-Stat F(4,46)			47.4548
Mean of dependent variable			0.0259	S.D. of dependent variable			0.0404

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Table 7 *(continued)*

Long-run: Dependent variable: $\ln\tilde{y}$				*Short-run: Dependent variable:* $\Delta\ln\tilde{y}_t$			
Residual sum of squares			0.0156	Equation log-likelihood			133.9356
Akaike info. Criterion			127.9356	Schwarz-Bayesian Criterion			122.1401
DW-statistic			1.8730	ARDL(1,1,)			N=52
Panel 6: Hungary							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.6711	0.0452	14.8586^{A}	$\Delta\ln k_t$	1.4753	0.2588	5.7001^{A}
$\ln eng$	0.5503	0.2473	2.2257^{B}	$\Delta\ln eng_t$	0.2201	0.1067	2.0622^{C}
Constant	−1.9543	2.0110	−0.97183	ΔTB_k	−0.0374	0.0114	−3.2788^{A}
TB_k	−0.0935	0.0432	−2.1657^{C}	ECM_{t-1}	−0.4000	0.0978	−4.0880^{A}
Short-run dynamics test statistics							
R-squared			0.8527	Adjusted R-squared			0.8036
S.E. of regression			0.0130	F-Stat F(4,16)			21.7131
Mean of dependent variable			0.0191	S.D. of dependent variable			0.0293
Residual sum of squares			0.0025	Equation log-likelihood			64.9609
Akaike info. Criterion			58.9609	Schwarz-Bayesian Criterion			55.8274
DW-statistic			2.7725	ARDL(1,1,0)			N=22
Panel 7: Italy							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.3733	0.1355	2.7551^{A}	$\Delta\ln k_t$	0.3409	0.1254	2.7192^{A}
$\ln eng$	0.5962	0.2039	2.9245^{A}	$\Delta\ln eng_t$	0.4968	0.0512	9.6983^{A}
Constant	1.5194	0.5078	2.9924^{A}	ΔTB_y	−0.0271	0.0071	−3.8031^{A}
TB_y	−0.1145	0.0367	−3.1208^{A}	ECM_{t-1}	−0.2367	0.0536	−4.4179^{A}
Short-run dynamics test statistics							
R-squared			0.8428	Adjusted R-squared			0.8218
S.E. of regression			0.0112	F-Stat. F(4,47)			60.3012
Mean of dependent variable			0.0232	S.D. of dependent variable			0.0265
Residual sum of squares			0.0056	Equation log-likelihood			163.6108
Akaike info. Criterion			156.6108	Schwarz-Bayesian Criterion			149.7815
DW-statistic			1.8160	ARDL(1,1,1)			N=53
Panel 8: Macedonia							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.7157	0.0626	11.4327^{A}	$\Delta\ln k_t$	1.7485	0.6428	2.7203^{B}
$\ln eng$	0.4512	0.2231	2.0226^{C}	$\Delta\ln eng_t$	0.0615	0.0827	0.74347
Constant	−1.7766	1.7656	−1.0062	ΔTB_y	−0.0682	0.0325	−2.0982^{C}
TB_y	−0.1319	0.0560	−2.3564^{B}	ECM_{t-1}	−0.5172	0.1187	−4.3557^{A}
Short-run dynamics test statistics							
R-squared			0.83121	Adjusted R-squared			0.75886
S.E. of regression			0.019365	F-Stat. F(4,16)			17.2352
Mean of dependent variable			0.0068631	S.D. of dependent variable			0.039435
Residual sum of squares			0.0052498	Equation log-likelihood			57.2902
Akaike info. Criterion			50.2902	Schwarz-Bayesian Criterion			46.6344
DW-statistic			2.0809	ARDL(1,1,1)			N=22
Panel 9: Romania							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.2650	0.0985	2.6895^{B}	$\Delta\ln k_t$	1.1437	0.2950	3.8768^{A}
$\ln eng$	0.5675	0.1540	3.6856^{A}	$\Delta\ln eng_t$	0.4624	0.1330	3.4878^{A}
Constant	1.4973	1.1390	1.3146	$\Delta TREND$	0.0186	0.0083	2.2469^{B}
TREND	0.0229	0.0092	2.4724^{B}	ECM_{t-1}	−0.8149	0.0918	−8.8695^{A}
Short-run dynamics test statistics							
R-squared			0.8870	Adjusted R-squared			0.8493
S.E. of regression			0.0247	F-Stat F(4,16)			29.4382
Mean of dependent variable			0.0198	S.D. of dependent variable			0.0637
Residual sum of squares			0.0092	Equation log-likelihood			51.4394
Akaike info. Criterion			45.4394	Schwarz-Bayesian Criterion			42.3058
DW-statistic			1.4643	ARDL(1,1,0)			N=22
Panel 10: Slovakia							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.3688	0.0425	8.6828^{A}	$\Delta\ln k_t$	0.1708	0.0510	3.3433^{A}
$\ln eng$	0.6718	0.0519	12.9380^{A}	$\Delta\ln eng_t$	0.3111	0.0765	4.0653^{A}
TB_y	0.2070	0.0411	5.0296^{A}	ΔTB_y	0.0958	0.0293	3.2739^{A}
				ECM_{t-1}	−0.4631	0.1175	−3.9418^{A}
Short-run dynamics test statistics							

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Table 7 *(continued)*

Long-run: Dependent variable: $\ln\tilde{y}$				*Short-run: Dependent variable:* $\Delta\ln\tilde{y}_t$			
R-squared			0.5081	Adjusted R-squared			0.4158
S.E. of regression			0.0254	F-Stat. F(3,16)			5.5084
Mean of dependent variable			0.0403	S.D. of dependent variable			0.0332
Residual sum of squares			0.0103	Equation log-likelihood			47.3515
Akaike info. Criterion			43.3515	Schwarz-Bayesian Criterion			41.3600
DW-statistic			1.7172	ARDL(1,0,0)			N=21
Panel 11: Slovenia							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.5662	0.0339	16.6587^A	$\Delta\ln k_t$	2.6280	0.3541	7.4216^A
$\ln eng$	0.1840	0.0747	2.4629^B	$\Delta\ln eng_t$	0.1771	0.0817	2.1685^B
Constant	1.0955	0.9825	1.1150	ECM_{t-1}	−0.9624	0.1530	−6.2897^A
Short-run dynamics test statistics							
R-squared			0.8826	Adjusted R-squared			0.8465
S.E. of regression			0.0143	F-Stat. F(3,14)			32.5800
Mean of dependent variable			0.0225	S.D. of dependent variable			0.0364
Residual sum of squares			0.0026	Equation log-likelihood			53.8985
Akaike info. Criterion			48.8985	Schwarz-Bayesian Criterion			46.6726
DW-statistic			1.7797	ARDL(1,1,0)			
Panel 12: Turkey							
Regressor	Coefficient	Standard error	t-ratio	Regressor	Coefficient	Standard error	t-ratio
$\ln k$	0.2327	0.0791	2.9413^A	$\Delta\ln k_t$	1.7212	0.3970	4.3353^A
$\ln eng$	0.7247	0.1490	4.8642^A	$\Delta\ln eng_t$	0.5802	0.1198	4.8438^A
Constant	1.3690	0.3961	3.4565^A	ΔTB_y	0.0381	0.0124	3.0703^A
TB_y	0.0476	0.0165	2.8830^A	ECM_{t-1}	−0.8006	0.0689	−11.6158^A
Short-run dynamics test statistics							
R-squared			0.9245	Adjusted R-squared			0.9056
S.E. of regression			0.0144	F-Stat. F(4,21)			61.2148
Mean of dependent variable			0.0253	S.D. of dependent variable			0.0470
Residual sum of squares			0.0042	Equation log-likelihood			76.7219
Akaike info. Criterion			70.7219	Schwarz-Bayesian Criterion			66.9476
DW-statistic			1.2845	ARDL(1,1,0)			N=27

Notes: A, B and C denote statistical significance at the 1%, 5% and 10% levels, respectively. TB_k and TB_y refers to break points derived from lnk and lny series, respectively.

Table 8
Granger non-causality test based on χ^2 for each country.
Source: Authors' estimation using Eviews 8.

Excluded variables	***Dependent variable***					
	$\ln\tilde{y}$	lnk	lneng	$\ln\tilde{y}$	lnk	lneng
	Panel 1: Albania			***Panel 2: Austria***		
$\ln\tilde{y}$	–	5.1402^C [0.077]	14.7241^A [0.001]	–	0.6982 [0.705]	2.4999 [0.287]
lnk	2.3345 [0.311]	–	4.1605 [0.125]	10.5102^A [0.005]	–	0.6417 [0.726]
lneng	0.2835 [0.868]	0.0814 [0.960]	–	9.3581^A [0.009]	9.0259^B [0.011]	–
	Panel 3: Bulgaria			***Panel 4: Cyprus***		
$\ln\tilde{y}$	–	14.4832^A [0.001]	5.1325^C [0.077]	–	0.8710 [0.647]	14.2370^A [0.001]
lnk	2.0231 [0.364]	–	3.3035 [0.192]	10.1949^A [0.006]	–	13.7634^A [0.001]
lneng	0.0047 [0.998]	4.9642^C [0.084]	–	0.4018 [0.818]	2.0105 [0.366]	–
	Panel 5: Greece			***Panel 6: Hungary***		
$\ln\tilde{y}$	–	6.6259^B [0.036]	16.0388^A [0.000]	–	6.5255^B [0.038]	10.6185^A [0.005]
lnk	5.3481^C [0.069]	–	7.2141^B [0.027]	6.8323^B [0.033]	–	14.3735^A [0.001]
lneng	4.9414^C [0.085]	0.4451 [0.808]	–	0.3937 [0.821]	5.8166^C [0.054]	–
	Panel 7: Italy			***Panel 8: Macedonia***		
$\ln\tilde{y}$	–	2.8525 [0.240]	6.2112^B [0.045]	–	1.3974 [0.237]	0.6729 [0.412]
lnk	0.4376 [0.804]	–	3.8177 [0.148]	1.0678 [0.301]	–	0.5856 [0.444]
lneng	0.9458 [0.623]	3.2290 [0.199]	–	4.3807^B [0.036]	0.4075 [0.523]	–
	Panel 9: Romania			***Panel 10: Slovakia***		
$\ln\tilde{y}$	–	0.9243 [0.630]	9.4135^A [0.009]	–	1.6454[0.439]	5.2089^B [0.074]
lnk	9.1021^B [0.011]	–	6.9655^B [0.031]	7.3794^B [0.025]	–	15.2489^A [0.001]
lneng	0.5053 [0.777]	0.0327 [0.984]	–	4.9147^C [0.086]	0.1970 [0.906]	–
	Panel 11: Slovenia			***Panel 12: Turkey***		
$\ln\tilde{y}$	–	13.4565^A [0.001]	33.5400^A [0.000]	–	4.8241^C [0.090]	7.9636^B [0.019]
lnk	3.0631 [0.2162]	–	27.8360^A [0.000]	6.4310^B [0.040]	–	5.6660^C [0.059]
lneng	9.1145^B [0.0105]	12.7511^A [0.001]	–	3.0829 [0.214]	3.2728 [0.195]	–

Notes: Based on the maximum order of integration (p) and the maximum lag of the ARDL estimation, the maximum lag in the Toda-Yamamoto non-causality test are (p+m): 2. A, B and C indicates the presence of causality at the 1%, 5% and 10% level of significance, respectively. [ ] denotes p-values are in parenthesis.

production costs, however, there were problems of power shortages. With exception to Albania, the other three countries are now members of the European Union and benefit directly from subsidies, with its citizens having the possibility to migrate to richer European countries –the latter has contributed to the decline of population between 1990 and 2011 in these countries.

Given this background, one must be cautious that the observed growth per capita is not a consequence of a significant increase in production, but probably a result of other circumstances. Additionally it should be noted that all four countries have a relatively huge agricultural sector, which in most part are not mechanized. Therefore, it is not surprising that the causality for majority of the countries in the region runs from income to energy consumption. Additionally, the conservation hypothesis for Italy, Cyprus and Turkey can be validated by the industrial structure of these countries, which in most part relies on less energy intensive industries like cloth industry, a relatively huge service sector such as tourism and in the case of Turkey, a relatively huge agricultural sector. The case of Greece is a specific case because of fact that it consists of many small islands, which are connected by ferries and airplane. Although, Greece has only a relatively small manufacturing sector, it has a sizeable tourism sector which depends on energy, especially for transportations. The derived growth hypothesis for Austria can be explained by its manufacturing sector which mainly comprises heavy energy-intensive industries, and the tourism industry which is relatively energy-intensive because of the need for heating, excessive use of cable cars and snow guns. However, the expectations that Bulgaria, Romania, Hungary and Albania, and to some extent Greece, Slovakia, Slovenia will become a transit country for gas seems to be exaggerated in the light of the derived results above. Finally, while the paper reviews the economic significance of energy consumption for 12 countries in the Balkan region and presents the linear relationship with respective elasticity and causality dynamics, further studies can consider examining the non-linear and threshold level of energy consumption for these and other industrializing and transitioning economies.

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